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CONTENTS OF VOLUME LXXIII

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Natural History

porating Nature Magazine

Passenger-Carrying FREIGHTERS Are the Secret of Low Cost Travel

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Do you know where to find an island right near the U. S. so nearly like Tahiti in appearance, beauty, and color even the natives say it was made from a rainbow? (And that costs here are so low you can not only reach it but also stay a while for hardly more than you'd spend at a resort in the U. S.?)

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Do you know where it costs less to spend a while, the surroundings are pleasant, and the climate well nigh perfect in such places as Mexico, the West Indies, France, along the Mediterranean, and in the world's other low cost wonderlands?

Or if you've thought of more distant places, do you know which of the South Sea Islands are as unspoiled today as in Conrad's day? Or which is the one spot world travelers call the most beautiful place on earth, where two can live in sheer luxury, with a retinue of servants for only $175 a month?

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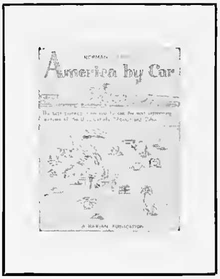

National Parks, the Great Lake
Mississippi, California, the Eas
South or the Southwest, the
country, etc., it tells you road b
the scenic way to go and it alwa
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These Are America's Own Bargain Paradises

Norman Ford's big book *Off-the-Beaten-Path* names the really lo
Florida retirement and vacationing towns, the best values in Texa
Southwest, California, the South and East, Canada—and a dozen
areas which the crowds have not yet discovered.

Fabulous places like that undiscovered region where winters are as
and sunny as Miami Beach's yet costs can be two-thirds less. Or that
that looks like Hawaii yet is 2,000 miles nearer (no expensive sea
trip to get there). Or those many other low-cost exquisitely beautiful
all over the United States and Canada which visitors in-a-hurry ov
(so costs are low and stay low).

Every page of OFF-THE-BEATEN-PATH opens a different kind of
tioning or retirement paradise which you can afford—places as glan
as far-off countries yet every one of them located right near at hand
these:

- France's only remaining outpost in this part of the world—com
  surrounded by Canadian territory . . . or a village more Scottis
  Scotland . . . or age-old Spanish hamlets right in our own U. S.,
  no one ever heard of nervous tension or the worries of modern d
- Resort villages where visitors come by the score, so you always
  new people . . . (*but they never come by the thousands to raise pr*
  crowd you out).
- That remarkable town where a fee of 3¢ a day gives you an almost
  round of barbecues, musicals, concerts, picnics, pot luck suppers, sm
  bord dinners and a fine arts program. That southern island first disc
  by millionaires who had all the world to roam in . . . and now thei
  aways are open to anyone who knows where to find them.

You read of island paradise aplenty in the United States and C
of art colonies (artists search for picturesque locations where cos
low!), of areas with almost a perfect climate or with flowers on every
Here are the real U.S.A.-brand Shangri-Las made for the man or
who's had enough of crowds. Here, too, are unspoiled seashore 'vi
tropics-like islands, and dozens of other spots just about perfect fo
retirement or vacation at some of the lowest prices you've heard of
the gone-forever prewar days. **They're all in the United States and C**
and for good measure you also read about the low-cost paradise in H
the Virgin Islands and Puerto Rico.

Off-the-Beaten-Path is a big book filled with facts that open the w
freedom from tension and a vacation or retirement you can really
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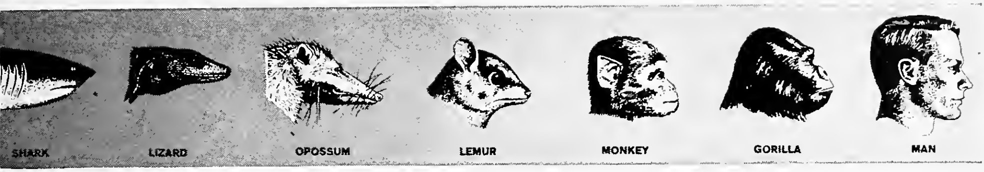

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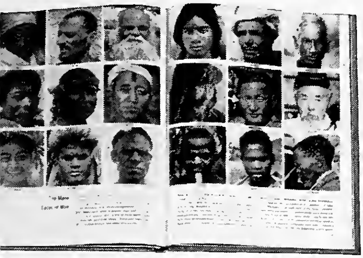
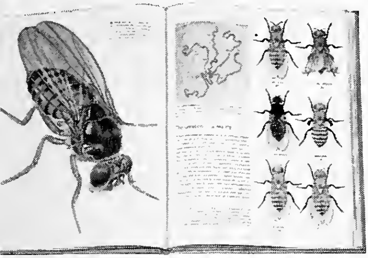


E MANY FACES OF MAN. Although Man is united in one cies, it is racially divided into more than 30 subgroup-s. Over the past 150,000 years, as men searched for new ting grounds over the globe, they gradually developed ts that adapted them to each environment.



E GENETICISTS' GUINEA PIG is the common fruit fly. This nderful insect, 1/8 inch long, produces new generations fusely every 10 to 15 days, takes up little lab space, and a simple genetic make-up of only 4 chromosomes. By nbarding its reproductive cells with X-rays, biologists e produced fantastic new mutants.

Why does man seem so similar to the ape? Why do ancient rocks contain imprints of creatures now extinct? What causes giants, dwarfs, albinos? A little over a century ago, no one really knew.

Then an English biologist, Charles Darwin, published one of the most important books in history. The first 1,250 copies of his *The Origin of Species* sold out in a day, and a storm of controversy broke which has never entirely died.

Now here at last—in the style that LIFE has made famous, so that it makes perfect sense even to school children—is the remarkable story of evolution in this beautiful introductory volume of the LIFE Nature Library.

You retrace the historic voyage that young Darwin made on H.M.S. Beagle, and see the very same phenomena that set his mind ablaze. You see the primitive Indians of Tierra del Fuego, at the bottom of the world, so tough they sleep naked on icy ground. You tour the Galápagos Islands, Nature's own laboratory of evolution, where complete isolation from the rest of the world has resulted in startling species never seen anywhere else.

You see the clues to bygone life—shells, bones, tracks, eggs, imprints or entire mummies—preserved by Nature in tar, coal, ice, and stone. You see a frozen baby mammoth perfectly preserved in Arctic ice for 22,000 years. You share the thrill of the couple in Tanganyika as they uncover the bones of the world's *earliest known man*—over a million years old!

Genetic scientists take you into their laboratories to explain the mysteries of the microscopic genes and chromosomes that determine the inheritance of characteristics. You see a human egg magnified 2,000 times. How a living cell divides.

Obviously so vast and exciting a book cannot be adequately described here. So we invite you to *borrow* a copy from us for 10 days. Then if you wish you may return it and owe nothing. Or you may own it for much less than such an expensively printed and handsomely bound book would ordinarily cost. Thanks to LIFE'S vast facilities and large print orders, you pay only $3.95 (plus shipping and handling). Then you will be entitled to receive another volume of the LIFE Nature Library for free examination every 2 months.

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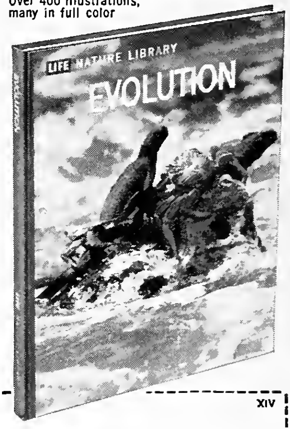

FRIGATE BIRD displays red gular pouch to t females. Attractive aracteristics increase g success, are more to be passed on.

OFF TO BED goes the gorilla with leaves and branches for bedding. Though constantly on the move, gorillas build new nests on ground or in low branches nightly.

SKELETONS OF HORSE AND MAN reveal similar bones in similar positions. In such relationships Darwin saw echoes of a primeval pattern, modified by evolution.

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ARTICLES

DEPARTMENTS

COVER: Coins of antiquity—staters, drachms, didrachms, and tetradrachms—al display varied impresses of Greek city-states, isles, and colonies. Currency i the classical world was thought of as "hard" or "soft," just as today, and th money of Athens was the desired hard currency in which early internationa commerce found a standard for exchange. The intrinsic value of one Greek coin the gold stater of Macedonia, is now about six dollars. For a discussion of th symbolic and the commercial aspects of ancient specie, turn to Joan Fagerlie' article, "Monies of Antiquity," starting on page 20. Photographs by Lee Boltin

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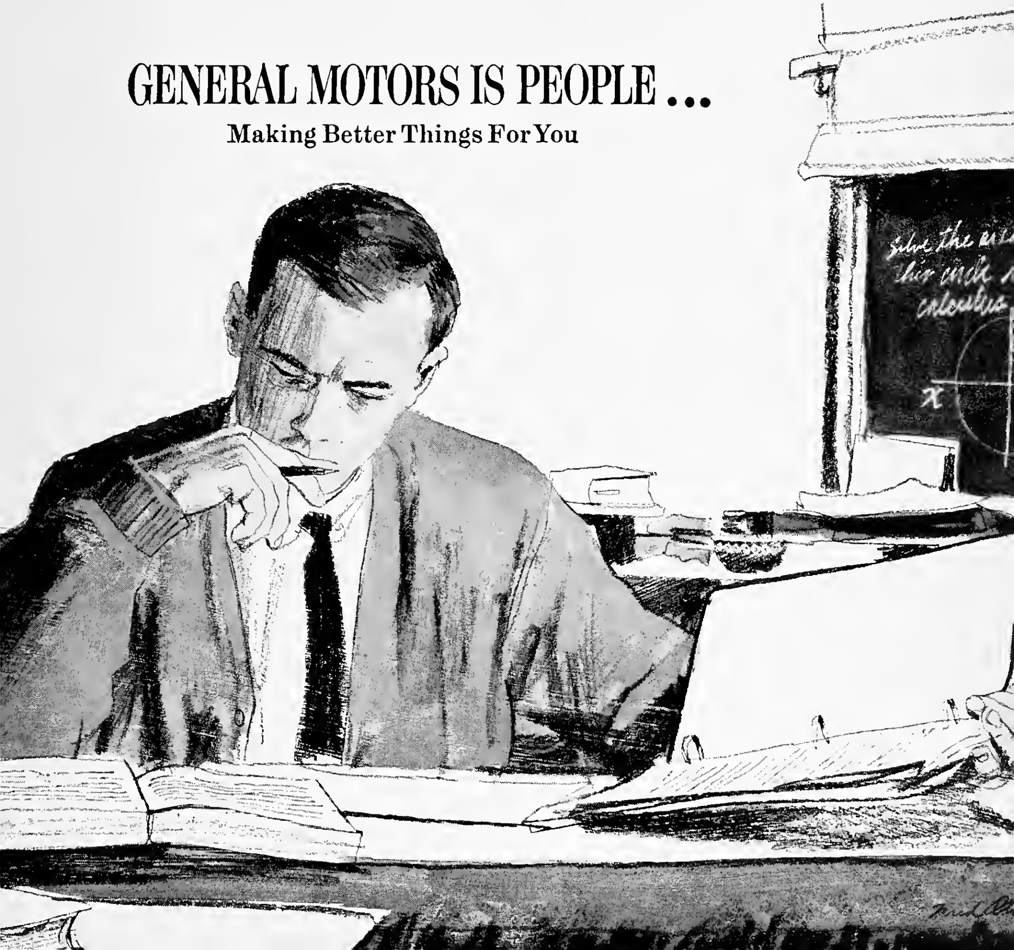
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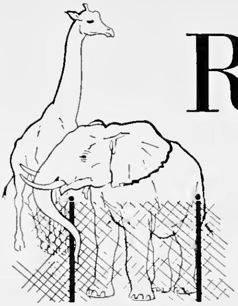

Reviews

Three books survey tl fauna survival proble

By T. Donald Carter

Vanishing Animals, by Philip Street. *E. P. Dutton & Co., $4.50; 232 pp., illus.* Simba, by C. A. W. Guggisberg. *Chilton Books, $6.50; 309 pp., illus.* Animals of East Africa, *by* C. A. Spinage. *Houghton Mifflin Co., $7.50; 160 pp., illus.*

Any thoughtful book on conservation is most welcome today, when the very existence of many forms of the world's fauna hangs in the balance. Philip Street, a British zoologist, gives a very complete picture of the problem in his book *Vanishing Animals.* He discusses the past, present, and possible future of many of these animals and proposes ways in which they might be preserved — controlled exploitation, conservation in national parks and nature reserves, and, as a last resort, protection in captivity. Conservation education is also stressed.

Conservation societies the world over are currently working independently and in concert along the above-mentioned lines. Whale hunting and, to some extent, deep-sea fishing are now under control of governments; numerous national parks and reserves, where animals receive protection, have been established; and relatively recently, a number of animals that were on the very brink of extinction have been placed in zoos in the hope that a breeding stock may be procured. To carry out the latter plan, six specimens of the southern white rhinoceros have been sent to American zoos, and four white oryx antelope were shipped from Arabia to the Phoenix Maytag Zoo in Arizona. The few remaining wild Hawaiian geese have now been augmented by about one hundred specimens that were raised in captivity and later released on the islands. Père David's deer also owes its existence to captive specimens.

Africa, with its great game fields, presents a special problem, although all the continents are affected to a greater or lesser degree. Since Africa's colonization by the white man, the blaauwbok, the quagga, and the true Burchell's zebra have become extinct; others, including the bontebok, the blesbok, and the white-tailed gnu, are now found only on privately owned farms or game reserves.

Most of the large mammals of Africa are in a precarious situation. The great plains and forests are being utilized for agriculture and cattle grazing. Cc quently the animals are becoming r restricted in their habitats. The hope for preservation lies in the nati parks and reserves. Yet there is cons demand to put this land to other use. conservationists are working hard, with some success, to impress on the nations of Africa that the animals mean more to them than so much n Every year thousands of money-spen tourists visit Africa; the chief attract are the country's mammals and birc

Mr. Street has listed and describ number of the mammals, birds, and tiles that are in need of protection cluded are the Przewalski's horse, three Asiatic rhinoceroses, a numbe antelopes including the white oryx, David's deer, the European bison, Indian lion, the Tasmanian wolf (w many people think is already extir the kiwi, the whooping crane, the hama flamingo, the Hawaiian goose Laysan teal, and the Komodo drago

Vanishing Animals is an interes book, full of useful information. thirty-one carefully chosen photogr show many rare animals. There is item in the text, however, to whi would like to take exception. In his cle on the American bison, the au states that there are probably over million living specimens in the w today. I believe he has overestimated population about four hundred time

Since the writings of Aristotle Pliny (and far earlier in the Orient) lion has frequently appeared in li ture, and many strange and fanciful have been told. During the last cent when Africa was being explored when big game hunters began ma safaris into the lion's country, the mal became notorious in the writing the hardy men who went afield. Mo these adventurers stressed the dange lion hunting and the fury of their enr quarry. Only in the past few years the public learned that many of stories they read and heard did not a true picture of this big cat. The es lishment of national parks and rese where the lion could roam at will remain unmolested, have caused it to much of its fear of man. Here it is to live its life as nature intended. A

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vill view the Taj Mahal at sunset, fly over the Himalayas to
Vale of Kashmir, enjoy the peaceful serenity of gardens in
n, perhaps even take lessons, if you wish, in Japanese flower
nging, shop for incredible bargains in Hong Kong, or play
on a championship course.

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terested person, provided he takes certain precautions, is now able to make observations into the daily life of a lion. Such close proximity was hardly possible when lions were constantly wary of the hunter seeking trophies.

Recently, numerous articles and books have been written in which the authors give more accurate information about the lion, based on close contacts. *Simba* is such a book. Its author, C. A. W. Guggisberg, is a medical officer stationed in Nairobi, Kenya, who makes a hobby of nature observation and photography. For many years he traveled around East Africa, and most of his spare time has been spent observing lions. In the Royal Nairobi National Park, situated just a few miles from Nairobi, he became so familiar with the lions inhabiting the region that he came to know their individual "personalities," and even named many of them. For about six years he paid frequent visits to one family, watched the cubs grow to adulthood, and made many interesting observations about their daily life. He also visited the Serengeti Plains, the Ngorongoro Crater, and the Amboseli National Reserve—places noted for their lion populations. Fortunately, Mr. Guggisberg is an expert photographer, and the book contains forty-two of his photographs, seven in color.

But only a portion of this book consists of personal observations. The author has drawn freely from the accounts of others, including many tales of former hunters and explorers. He has thoroughly investigated his subject, a fact proved not only in his text but also in his ten-page bibliography. The scope of the text may be judged by the chapter titles: "History of the Lion"; "The Lion and its Prey"; "Life Cycle"; "Lion Hunting and Lion Hunters"; "Man-eaters"; "Lions and Camera"; "The Lion in Captivity, in Legend and History": "The Lion in African Folklore and Superstition"; "The Lion in Art."

Mr. Guggisberg admires and respects the lion, and his feelings are best expressed in the last paragraph of his book:

"The lion is no 'bloodthirsty brute,' nor by the same token is he the 'King of Beasts.' He is neither 'bold,' 'magnanimous,' nor 'cowardly'—these are epithets designating purely human characteristics and should not—must not—be applied to an animal. True, a lion standing with his head held high definitely looks regal—there is hardly anybody who can escape this impression—but the lion himself knows nothing of it, and you cannot expect 'regal' behavior from him. If Friend Simba is to be burdened with an attribute taken from a purely human sphere, then I think I like Carl Akeley's remark best: 'The lion is a gentleman—if allowed to
go . . . unmolested, he will keep his c
path and will not encroach on yours

C. A. Spinage, author of *Animals*
East Africa, first went to Africa to fu
a two-year contract with the Kenya po
during the Mau Mau uprising. The c
tinent and its fauna proved so inter
ing to him that he remained there for
more years. During this time he visi
national parks and reserves through
Kenya, Uganda, and Tanganyika to p
tograph animals. This collection of fi
four superb pictures (six in color) is
result. Mr. Spinage's text gives infor
tion about the illustrated animals
also about a few other species. The fo
word was written by Sir Julian Hux

Included among the photograph
chiefly of the larger mammals—are th
of two rhinoceroses that are of spe
interest to me. Gladys and Gertie —
latter the most-photographed of the s
cies—are undoubtedly the best-kno
wild rhinos in the world. Both made th
home in the Amboseli National Reser
a place regularly visited by touri
These two rhinos were noted for th
tolerant dispositions and for their
tremely long front horns, which exten
forward from the nose. Until 1955 Glad
horn exceeded Gertie's in length,
during that year the former lost ab
eighteen inches from the tip, giving G
tie the distinction of carrying the long

of any known living rhinoceros. It y pleasure to meet and photograph in January, 1958, when she was panied by her two-year-old calf. t time, T. H. M. Taberer, Warden boseli National Reserve, estimated e horn measured 54¼ inches. On 27 of that same year, she lost about of her horn, and some four weeks he remainder broke off at the nose she was fighting a male rhino. Now ertie has lost her tourist appeal, ill undoubtedly live more quietly, urbed by the constant click of cam- Gladys, regrettably, was recently by poachers.

s to be hoped that all these books e read, for an informed public is ential in any program of preserv- e world's vanishing mammals.

or Emeritus of Mammalogy at The can Museum, Mr. Carter has ed conservation in a world scene.

Science Knows About Life, by Wolterack. *Association Press, 240 pp., illus.*

GEORGE WALD of Harvard closed ne of his lectures on the evolution with the statement that "matter w comprehend itself." This is essentially the theme of Dr. Woltereck's book, in which he briefly discusses the broad aspects of the phenomenon of life—its origin and its relationship to the universe, its many manifestations, and its vital functions. In most places the text is accurate, straightforward, and easy to read. The chapters on nutrition and physiology are particularly good, and there is an interesting discussion of the biological and social aspects of aging at the end of the book. The American reader may even find the European author's statement on the activities of our older men and women somewhat distortedly amusing.

There are forty-eight pages of dramatic photographs of everything from chromosomes to insect eyes. Unfortunately, these do little to amplify the text. The legends do not adequately describe the photographs, and their selection seems to have been based upon art value rather than information. There are many technical errors (which may be in the original or may have arisen in the translation). To correct a few: *Volvox* is not a diatom; proteins are not mainly composed of nitrogen; foraminifera do not have an "exoskeleton" in the strict sense; water does not have a molecular weight of 18 million; and DNA does not contain ribose. The chapter on genetics is rather weak, with several misleading statements. Many biologists would take exception to the author's statement that the building of new species is at an end, and there is a surprising lack of consideration of the accomplishments of microorganisms in view of the author's high regard for insects as dominant or successful forms of life.

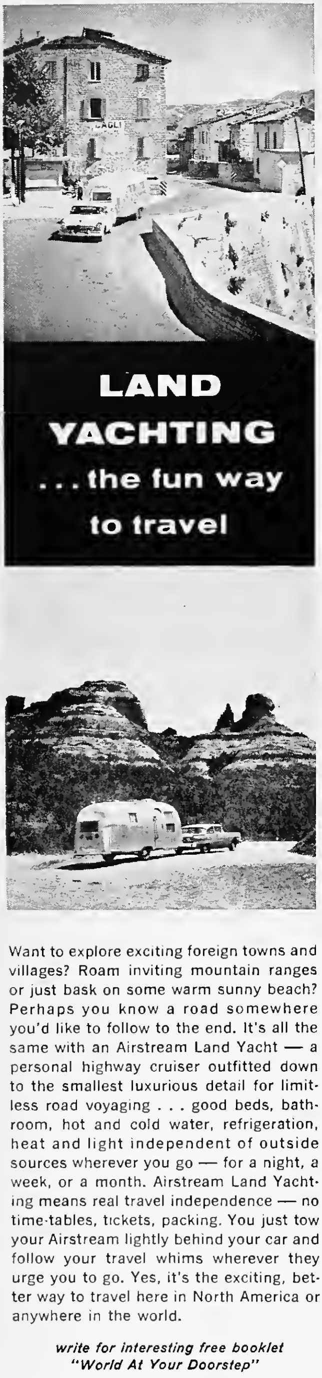
Dr. Woltereck has written a book that the casual reader should find interesting. The critical reader should look elsewhere if he really wishes to learn what science knows about life.

Hugo D. Freudenthal

Song of Wild Laughter, by Jack Couffer. *Simon and Schuster, $5.00; 190 pp., illus.*

It turns out, in the last chapter of Mr. Couffer's book, that the "song of wild laughter" is the raucous chatter of the Tasmanian kookaburra bird, or laughing jackass, and the author speculates as to what he is laughing about.

Anyway, Mr. Couffer knows about them firsthand, being a biologist, a photographer and editor for Walt Disney, and a wide-ranging traveler. He also knows about the birds and animals of the Galápagos, which have never learned to fear man, about penguins and wildcats, spiders and wolves. He produces some very convincing photographs as evidence.



As a research biologist who turned to the cinema arts. he knows what he is talking about, and how to record it on film.

Perhaps the most interesting parts of his book are the passages in which he describes the tricks and techniques used in wildlife photography, about which many viewers of Disney films must have wondered. In photographing a wild animal, says Mr. Couffer, always focus the lens on its eye; the rest of the body will at least *seem* to be in focus. To get an animal to do what you want, bait is good, and a desirable mate is even better. And so on. The secret is out.

Mr. Couffer confesses to being a biologist and a photographer, but the reader will soon discover that he is also a competent writer.

PIETER FOSBURGH

THE LIVING SEA, by Jacques-Yves Cousteau. *Harper & Row, $6.50; 325 pp., illus.*

MAN lives on only one-third of the earth's surface. The rest is covered with the 300.000.000 cubic miles of water that we call the oceans. These are vast and mysterious realms — probably the ancestral home of all living things, a marvelous collection of creatures stranger and more numerous than anything on land, and an immense reservoir of material wealth.

Dramatic and catastrophic events in the earth's history have left their traces in the ocean bottom sediments—the outpouring of volcanoes. the advance and retreat of continental glaciers, the burning dryness of deserts, the destruction by floods, and past climate changes.

The Living Sea, by the noted French undersea pioneer Jacques-Yves Cousteau of *The Silent World* fame. is an outstanding book that adds greatly to our understanding of the sea. It describes scientific underwater explorations and adventurous diving episodes that range over the Atlantic, the Mediterranean, and the Red Sea.

The base for everything recorded in this book was the oceanographic research ship *Calypso*, well equipped with depth-probing devices, scientists, and a professional diving team. Captain Cousteau wrote the book with free-lance writer James Dugan, and it is excellently illustrated with twenty-four pages of color photographs and sixty-four pages of black and white.

There is something along the way for all tastes. Included are the recovery of artifacts from a Greek galley sunk off Marseilles more than two centuries before Christ, and trips to discover ocean-hed oil deposits. There are chapters on the revolutionary "Diving Saucer," an underwater vehicle, accommodating two, which can operate at a depth of one thousand feet. The saucer is self-propelled and descends and ascends at will of the crew. The report on deep-photography carried out under the rection of Professor Harold E. Edger is extremely interesting.

In this fine book you can enjoy, vic ously, submarine marvels like the "The coral took unexpected shapes hues. There were skulls of dwarfs giants; tufts of ocher and mage mingled with petrified mauve bushes red tubiporae fabricated like hon combs. . . . Through this splendid til forest humpbacked sea snails trave their winding ways. In reef reces there were enough tridacna clams furnish the fonts for the churches Christendom."

Most interesting is a report of two r who lived and worked underwater for entire week. Albert Falco and Cla Wesley were based in a submer chamber with a hatch always open to sea, which could not flood the cham because of its internal air pressure. object of the experiment was to h determine the feasibility of some establishing manned underwater a cultural and industrial complexes.

The Living Sea should satisfy most curious amateur, professional, armchair underwater explorer.

GOESTA WOL

THE BIRDS, by Roger Tory Peters *Time, Inc., $3.95; 192 pp., illus.*

IN this, another book in the "Life ture Library" series, the text Roger Peterson is more or less hidden hind the scenes, like the research hall a first rate museum. The volume's il trative exhibits are out front, some sp tacular, some austere, most of them excellent that one discovers with n awe that the prose is equal in excelle Mr. Peterson has a style that ponc over facts without seeming to; it ling over the concept of evolution with ticular grace. Indeed, the entire achieves depth and fluency because o preoccupation with evolutionary proc

The first chapter deals with bird cla fication and the nature of its proble The subsequent sections rehearse basic known information about bird tomy, flight, food-gathering, habitats, gration, communication, and life hist The book closes with an excellent ch ter on conservation that is titled "Tow A Balance With Man."

The editorial staff aided their aut with supplementary picture stories photographs of very high merit; t also supplied a useful bibliography index. In consequence *The Birds* is a popular introduction to ornithology. clusion of a chapter on physiology, a brief subsection on genetics, wo have perfected the work.

WILLIAM GEO

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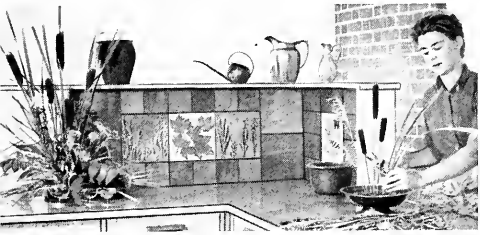
The titles below and the other photographs on this page are from the "Kitchen" booklet shown at left.



LES MADE WITH NATURAL MAPLE LEAVES, ferns and grasses enhance e colorful work center in this handsome country kitchen.

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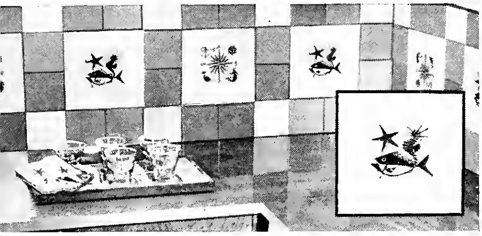
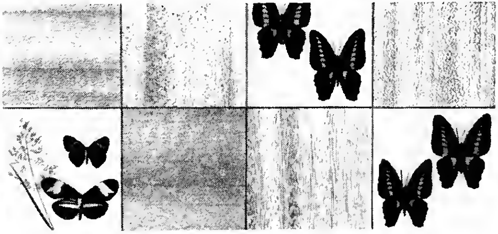
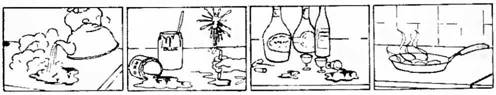


APER NAPKINS LAMINATED TO WOOD TILES WITH CASTOGLAS grace is kitchen wall. Paper becomes transparent and only design remains visible.



CASTOLITE TILES WITH EMBEDMENTS OF BUTTERFLIES are combined with wood tiles. Castoglas-treated Striped Mahogany gleams like burnished gold.

ASTOGLAS IS WATERPROOF, STAIN PROOF, FADEPROOF AND NAFFECTED BY: boiling water, hot pots or pans, alcohol, vinegar, fruit ice, hot grease, tea, coffee, milk, oils, naphtha, cleaning fluids, benzene, asoline, ink, dyes, pigments, wax crayon, lead pencil, to name but just few. Withstands all kinds of abuse. Will not "waterspot" and is as easily eaned with a damp cloth as any glass surface.



OW TO COVER THE KITCHEN COUNTER WITH CASTOGLAS—see photos om left to right: Counter is made of ¾ inch thick flakeboard with border f walnut tiles. Hardener is mixed with liquid Castoglas, poured over clean-sanded wood and covered with laminating film. Castoglas hardens in about one hour. Film is stripped off and finished counter has appearance of plate glass bonded to wood.

Water of the World

Distribution of man's liquid assets is a clue to future cont

By Raymond L. Nace

MOST PEOPLE know that water is unevenly distributed over the earth's surface in oceans, rivers, and lakes, but few realize how very uneven the distribution actually is. It is instructive to consider the total inventory of water on the planet earth, the areas where the water occurs, and the long-term significance of the findings.

The world ocean—139.500.000 square miles of it—contains 317.000.000 cubic miles of salt water. The average depth of the ocean basins is about 12.500 feet. If the basins were shallow, seas would spread far onto the continents, and dry land areas would consist chiefly of a few major a
pelagoes where high mountain ra
projected above the sea.

Considered as a continuous bo
fluid, the atmosphere is another
of ocean. Yet, in view of the
amount of precipitation on land a
in the course of a year, one of the

onishing world water facts is the
y small amount of water in the at-
sphere at any given time. The vol-
e of the lower seven miles of the at-
sphere—the realm of weather—is
ghly four times the volume of the
rld ocean, but the atmosphere con-
ns only about 3,100 cubic miles of
ter, chiefly in the form of invisible
oor, some of which is transported
rland by air currents. If all vapor
e suddenly precipitated from the
onto the earth's surface, it would
m a layer only about one inch
k. A heavy rainstorm on a given
a may remove only a small percent-
of the water from the air mass that
ses over. How, then, can some land
as receive, as they do, more than
) inches of precipitation per year? How can several inches of rain fall during a single storm in a few minutes or hours? The answer is that rain-yielding air masses are in motion, and as the water-depleted air moves on, new moisture-laden air takes its place above the area of precipitation.

THE basic source of most atmospheric water is the ocean, from which it is derived by evaporation. Evaporation, vapor transport, and precipitation constitute a major arc of the hydrological cycle — the continuous movement of water from ocean to atmosphere to land and back to the sea. Rivers return water to the sea along one chord of the arc. In a subterranean arc of the cycle, underground bodies of water discharge some water directly into rivers and some directly to the sea.

Estimated average annual evaporation from the world ocean is roughly 39 inches. The conterminous United States receives an average of 30 inches of precipitation every year, or about 1,430 cubic miles in total volume. Evapotranspiration returns approximately 21 inches of this water to the atmosphere (about 1,000 cubic miles). Obviously, some rain is water that was vaporized from the land areas and is being reprecipitated. Evidently the global hydrological cycle, which sends water from sea-to-air-to-land areas and back to the sea again, has short circuits. These are called subcycles.

There are many complexities and variations in the fate of water that falls as rain or snow. For example, high in

Mississippi River, seen in upstream view at New Orleans, discharges about 133 cubic miles of water annually. At right is Arrowrock Dam on Boise River. Arrowrock Reservoir has a capacity of approximately .084 cubic mile of water.

the central Rocky Mountains of North America, the Yellowstone River heads in Yellowstone National Park just east of the Continental Divide. The river water discharges through the Missouri and Mississippi rivers into the Gulf of Mexico about 1.600 airline miles distant from the head.

On the west side of the Continental Divide, not far from the Yellowstone, rises the Snake River, which flows across Idaho to join the Columbia near Pasco, Washington, and its waters eventually reach the Pacific Ocean about 700 airline miles from their source and about 2,200 miles from the mouth of the Mississippi.

This is a good example of the continuous mixing and transfer of water in the hydrological cycle. An air mass moving eastward across the Rocky Mountains contains water evaporated from the Pacific Ocean. Some of the water falls as rain or snow to the west and some to the east of the Continental Divide. Thus, two drops of rain falling side by side along the continental backbone may end up, one in the Pacific, the other in the Atlantic Ocean, although both were derived from the Pacific.

No one knows how much water moves from the Pacific to Atlantic Ocean by vapor transfer, precipitation, and runoff, but we do know a great deal about runoff itself. Estimated total flow into the sea from rivers in the 48 adjacent states takes place at the rate of about 1,803,000 cubic feet per second (a cubic foot is about 7.48 gallons), which amounts to approximately 390 cubic miles per year. Values for runoff (390 cubic miles) plus evaporation (1,000 cubic miles) do not quite equal the precipitation (1,430 cubic miles) because none of these values is precise. Moreover, some water is discharged into the sea directly from ground-water sources without passing through streams. The missing 40 cubic miles of water, roughly 10 per cent of the valu streamflow, might represent ground-water discharge.

Hydrologists have not gen considered that direct ground- outflow to the sea is so large, but is really no good basis that ca used to dispute or support wha computations seem to indicate. A rate, the data are sufficiently acc for my purpose, which is to sho relative magnitude of water vo involved in the annual water cyc

Some more specific data give a idea of the relative importance of and small rivers in maintaining nental water balances.

The Mississippi, North Ame largest river, has a drainage ar 1,243,000 square miles (about 4 cent of the total area of the 48 c minous states) and discharges average rate of 620,000 cubic fe second. This amounts to some cubic miles per year, or approxir 34 per cent of the total discharge

the rivers of the United States. e Columbia, nearest American petitor of the Mississippi, disges less than 75 cubic miles per . Relatively speaking, the great rado River is a dwarf, discharging about five cubic miles annually.

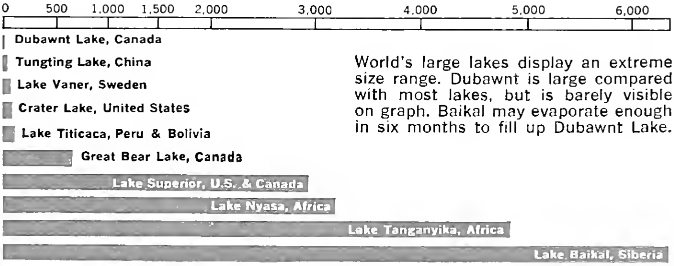
n the other hand, the Amazon, the est river in the world, is nearly six s the size of the Mississippi, and it narges somewhat more than two c miles per day and some 770 c miles per year—about twice the of all United States rivers.

frica's great Congo River, with a narge of approximately 340 cubic s per year, is the world's second est. The estimated annual disge of all African rivers is about cubic miles.

easurements of only the principal streams on a continent afford a s for reasonably accurate estima- of the total runoff item in a conntal water balance. The smaller ms are important locally, but they contribute only minor amounts of the total water discharged. Thus it is possible to estimate the total runoff in all the rivers of the world, even though many of them have not been measured accurately. Sixty-six principal rivers of the world discharge about 3,720 cubic miles of water yearly. The estimated total from all rivers, large and small, measured and unmeasured, is about 8,400 cubic miles yearly (23 cubic miles daily).

Crude estimates have indicated that the total amount of water that is physically present in stream channels throughout the world at a given moment is about 300 cubic miles. Evidently, river channels, on the average, contain only enough water to maintain their flow for about thirteen days.

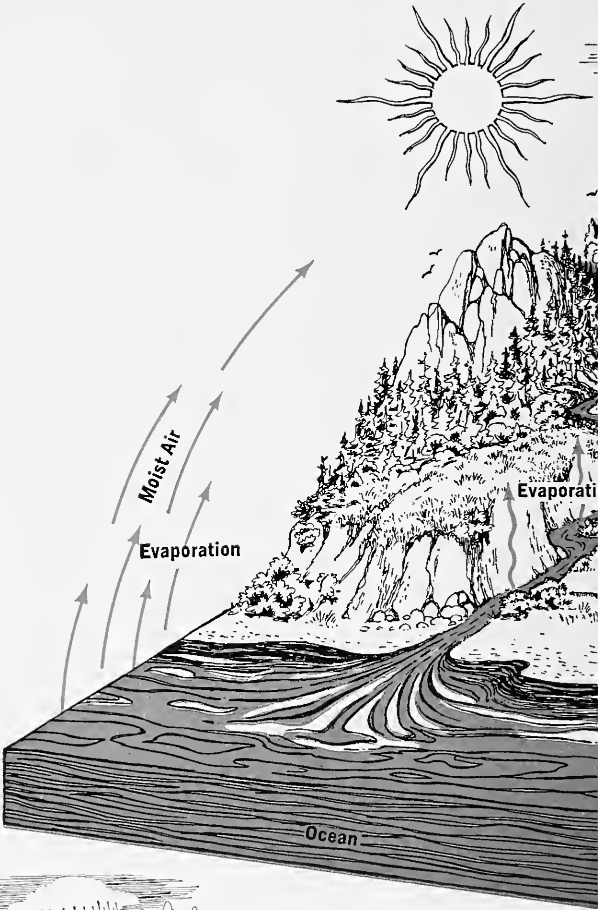
WATER VOLUME OF LAKES IN CUBIC MILES

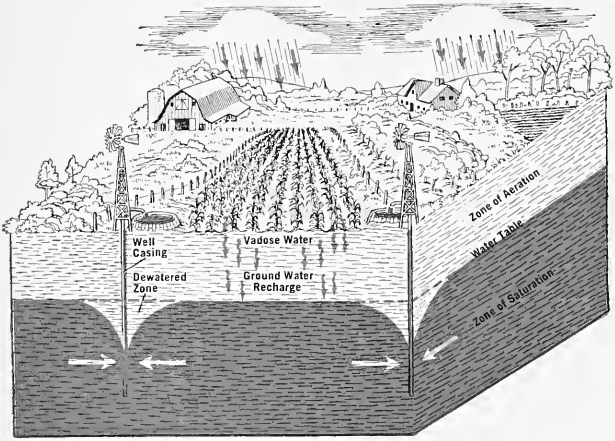


World's large lakes display an extreme size range. Dubawnt is large compared with most lakes, but is barely visible on graph. Baikal may evaporate enough in six months to fill up Dubawnt Lake.

Some have much more water, others much less, but it seems to be a fair average. How, then, do rivers maintain a flow throughout the year, even during rainless periods much longer than thirteen days? The answer to that question will appear later, in the discussion of ground water.

AFTER oceans and rivers come lakes, which can be called wide places in rivers. This is certainly true of the many small lakes that are impounded by relatively minor and geologically temporary obstructions across river channels. Lake Okeechobee, Florida, is a good example of a wide place in a river. But no single, oversimplified metaphor accurately describes all lakes, which are widely varied in their physical characteristics and the geologic circumstances under which they occur. The handsome little tarn occupying an ice-scooped basin in a glaciated alpine area is radically different from the deep and limpid Crater Lake of Oregon, which fills the crater of a now-extinct volcano. Okeechobee is totally different from any of the North American Great Lakes, which occupy huge basins formed in a complex manner by glacial excavation at some places, moraine and outwash deposition at others, isostatic subsidence of that whole region of the earth's crust, and other factors. The Great Lakes of North America, in turn, bear no resemblance to Lake Tanganyika in the great Rift Valley of Af
Poorly understood processes cre
the rift by literally pulling two sec
of the earth's crust apart, leavi
deep, open gash, part of which i
cupied by the lake. And these are
a few examples of wide variatio
the nature of lakes.

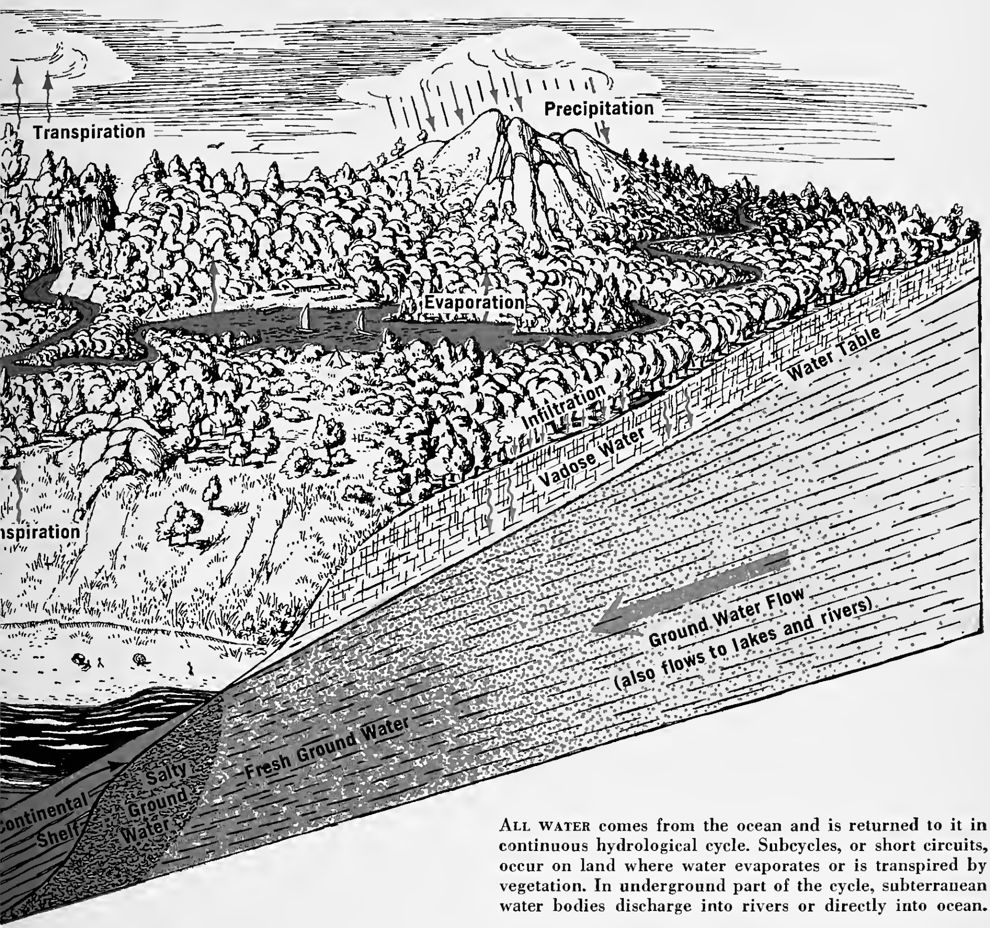




PUMPING DEPLETES ground water, draining curved cones in aquifer at each well. Hydraulic gradient draws water from surroundings. Cones grow as pumping continues. Where many wells work, drained zones unite and water table falls. If pumpage exceeds recharge, depletion may be permanent.

THE earth's land areas are d
with hundreds of thousand
lakes. Wisconsin, Minnesota, and
land contain some tens of thous
each. But these lakes, impo
though they may be locally, hold
a minor amount of the world su
of fresh surface water, most of w
is contained in a relatively few
lakes on three continents.

Whether a lake contains fres



All water comes from the ocean and is returned to it in continuous hydrological cycle. Subcycles, or short circuits, occur on land where water evaporates or is transpired by vegetation. In underground part of the cycle, subterranean water bodies discharge into rivers or directly into ocean.

water makes a considerable differ-
in its usefulness to man, so I shall
ider the earth's greatest lakes in
of the categories, fresh and salt.
he volume of all the large fresh-
r lakes in the world aggregates
ly 30,000 cubic miles, and their
bined surface area is about 330,-
square miles. "Large" is a relative
that requires explanation. For
article I have called a lake large
s contents are five cubic miles or
e. Thus the listing includes Du-
nt Lake, Canada (about six cubic
s), but excludes the Zürichsee of
tzerland (about one cubic mile).
range of volume among the large
s is enormous, from a lower limit
ive cubic miles to an upper one of
0 cubic miles in Lake Baikal in

Asiatic Russia, the largest and deepest single body of fresh water in existence. Some appreciation of its volume may be gained from the realization that Lake Baikal alone contains nearly 300 cubic miles more of water than the combined content of the five North American Great Lakes. The latter loom large on a map, but their average depth is considerably less than that of Baikal.

Nevertheless, North American lakes are a major element in the earth's water balance. The Great Lakes, plus other large lakes in North America (chiefly in the 48 states and Canada) contain about 7,800 cubic miles of water—26 per cent of all liquid fresh surface water in existence.

Similarly, the large lakes of Africa contain 8,700 cubic miles, or nearly 29 per cent of the total fresh-water supply. Asia's large lakes contain about 6,340 cubic miles, or 20 per cent of the total—nearly all of which is in Lake Baikal.

Lakes on these three continents account for roughly 75 per cent of the world's fresh surface water. Large lakes on other continents—Europe, South America, and Australia—have only about 720 cubic miles, or roughly 2 per cent of the total. All that remains to fill the hundreds of thousands of rivers and lesser lakes that are found throughout the world is less than one-fourth of the total fresh surface water.

Saline lakes are equivalent in magnitude to fresh-water lakes. Their total area is 270,000 square miles and

their total volume is about 25 cubic miles. The distribution, ever, is quite different. About 19 cubic miles (96 per cent of the saline volume) is in the Caspian and most of the remainder is in North America's shallow Great Lake is comparatively insignif with seven cubic miles.

All these water sources we hav cussed are the obvious ones. The another—soil moisture—that ma the most significant segment o world's water supply because o key role played by plants in the chain. Some plants grow direct water or marshy ground, but b the greater mass of vegetatio earth lives on "dry" land. This is sible because the land is really d just a few places, and often only porarily. How dry is dust? The of a dry dirt road may contain 15 per cent of water by weight. ever, plants cannot grow and flo with so little water because the

Sentinel Range in Antarctica i of the continent's few land area completely covered by a burden c

VAST EXPANSE of the Antarctic ice sheet, shown in relief model, represents 90 per cent of all the ice in the world.

s small percentages of moisture
naciously that plant roots cannot
ct it. Aside from desert plants,
h store water in their own tissues
ng infrequent wet periods, land
ts flourish only where there is ex-
able water in the soil. Inasmuch as
ite ordinary tree may withdraw
transpire about 50 gallons of water
lay, frequent renewals of soil mois-
, either by rain or by irrigation,
essential. The average amount of
r held as soil moisture at any given
is on the order of 6,000 cubic
s for the world as a whole—an in-
ificant percentage of the earth's
water, but vital to life. Relatively
vegetation receives artificial irri-
on, and practically all of it de-
ls on natural soil moisture, which,
rn, depends on orderly and timely
ation of the hydrological cycle.

OTHER little-considered water res-
ervoir has been known to man for
sands of years. Scripture (Genesis
) on the Noachian Deluge states
"the fountains of the great deep
re] broken up" (cleft open), and
dus, among its many references to
r and to wells, refers(20:4) to "water under the earth." Many other chronicles show that man has known from ancient times that there is much water underground. Only recently has he begun to appreciate how much.

Beneath most land areas of the world there is a zone where the pores of rocks and sediments are completely saturated with water. Hydrologists call this ground water, and the upper limit of the saturated zone is called the water table. The water table may be right at the land surface, as in a marsh, or it may lie hundreds of feet below the land surface, as in some arid areas. Below the zone of soil moisture and above the water table, there is in most areas an unsaturated zone containing water that has passed through the soil zone and is percolating downward toward the water table. This water is called vadose, from the Latin root *vadosus*, shallow.

The world volume of vadose water is probably somewhat more than that of soil moisture—say 10,000 cubic miles. It is highly important because, although it is not extractable by man, it is potential ground-water recharge, and ground water *is* extractable. Each new influx of water from precipitation on the land surface, followed by percolation through the soil zone, provides a new increment of recharge to the ground water.

BELOW the water table, to a depth of half a mile in land areas of the earth's crust, there is about one million cubic miles of ground water. An equal if not greater amount is present at a greater depth, down to some 10 to 15 thousand feet, but this deeper water circulates sluggishly because the rocks are only slightly permeable. Much of the deep-lying water is not economically recoverable for human use, and a good deal of it is strongly mineralized.

Ground water flows through moderately to highly permeable strata, which are called aquifers, at rates of a few feet to perhaps several hunded feet per day: 40 to 50 feet per day would be a rather high rate of flow.

Depending on how far the ground water must travel to reach a surface discharge area, water in shallow to moderately deep zones may remain underground from a few hours to 100 years or longer. Water at great depth may take tens or hundreds of thousands of years to pass through an aquifer, and some is completely stagnant.

The volume of ground water in the upper half-mile of the continental crust is about 3,600 times greater than the volume of water in *all* rivers at any one time, and nearly 20 times greater than the combined instantaneous volume of water in all rivers and lakes. It is easy to see, therefore, that ground-water reservoirs have tremendous importance as equalizers of streamflow. Under natural conditions, most ground-water reservoirs are full to overflowing, and the overflow water provides what is called the base flow of surface streams, enabling them to flow even during long, rainless periods and after winter snows have melted.

According to my calculations, the volume of ground water in storage in the United States to a depth of half a mile is equivalent to the total of all recharge during about the last 150 years. This estimate is crude, but it helps to emphasize the important fact that ground-water reserves, although immense, are not wholly self-renewing annually. At places where they have been depleted by pumpage, they might take many decades to recover, even if pumping were stopped completely.

Consider, for example, a location in the dry southwestern United States, where annual recharge to an aquifer is on the order of only two-tenths of an inch of water. In such areas, it is not uncommon to pump two feet or more of water per year for irrigation or other uses. In this oversimplified example, if the entire aquifer were pumped at that rate, yearly pumpage would be equivalent to 120 years' recharge, and ten years of pumping would remove a 1,200-year accumulation of water. New recharge during the pumping period would be negligible. Mechanical problems and economic factors would prevent complete de-watering of an aquifer, but the example is valid in principle.

The next big items on the water-balance sheet are icecaps and glaciers. They may seem unimportant in the water cycle because, although the ice masses alternately shrink or grow a little from time to time, new ice is added about as fast as old ice melts. The polar ice masses, however, have a great influence on weather, and everything that happens in the polar regions indirectly affects everyone throughout the world (NATURAL HISTORY, October, 1963). Moreover, if a shift in climate led to extensive melting of icecaps, there would be a rise in sea level with important effects in all low-lying coastal areas.

Mountain glaciers, such as those of the Alps in Europe (after which alpine glaciers are named), the Himalayas of Asia, and the Cascades of North America, are like average rivers in some respects. They are important locally, but they contain only an insignificant fraction of the world's water. The total volume of all alpine glaciers and small icecaps in the world is only about 50,000 cubic miles (comparable to the combined volume of large saline and fresh lakes).

An alpine glacier is one that rises in mountainous uplands and, by plastic deformation, flows along a valley. A continental glacier, or icecap, is one that is plastered over the landscape, mountain and valley alike. Icecaps tend to flow radially outward from their center of accumulation. Wastage occurs by sublimation from the surface and by melting or caving away around the periphery. Average icecaps, like those on Novaya Zemlya, Iceland, and Ellesmere Land, are analogous to average lakes. They are locally important, but hold only an insignificant share of the world's water and only a small part of the total volume of perennial ice.

The Greenland icecap is an entirely different matter. About 667,000 square miles in area and averaging nearly 5,000 feet in thickness, its total volume is about 630,000 cubic miles. If melted, it would yield enough water to maintain the Mississippi River for somewhat more than 4,700 years. Even so, this is less than 10 per cent of the total volume of icecaps and glaciers. The greatest single item in the water budget of the world, aside from the ocean itself, is the Antarctic ice sheet.

Since the advent of the International Geophysical Year, a considerable store of information about Antarctica has accumulated. Data on the thickness of the ice sheet are relatively scarce, but there is enough information to permit an approximate estimate. The area of the ice sheet is about six million square miles; its thickness averages somewhat more than a mile; and the total volume therefore is between six and seven million cubic miles, or some 90 per cent of all existing ice and about 64
cent of all water outside the oceans

The hydrologic importance of
continent and its ice may be illustra
quite briefly. If the Antarctic ice
were melted at a suitable uniform
it could feed:

1. The Mississippi River for m
than 50,000 years;
2. All rivers in the United Sta
for about 18,000 years;
3. The Amazon River for appro
mately 9,000 years;
4. All the rivers in the world
about 830 years.

The statistics about water given h
are rather simple, but they are su
ciently important to tabulate in or
to get them more clearly in mind. T
table (*opposite*) gives a comparat
view of the world's water.

About 97 per cent of all water is
the world ocean. Most of the
mainder is frozen on Antarctica a
Greenland. Thus, man must get alo
with the less than one per cent of
world's water that is directly availa
for fresh-water use. Obviously, he m
find much more effective ways of m
agement if he is to prosper.

Water is a global concern, and
water cycle pays no heed to
boundaries that men have drawn
maps. Man has become so numer
and his activities so extensive that
has begun to affect the water cycl
certainly on a regional scale and v
likely on the global scale. "Man a
the hydrological cycle" is a story
itself, but it seems appropriate to s
here that the time is overdue for s
tematic studies of water and the hyd
logical cycle on a large scale in or
to be able to make more rational
of water for the benefit of manki

It is of considerable interest, the
fore, that UNESCO and other speci
ized agencies of the United Natio
assisted by international scientific
ganizations, are currently planning
program of international and glob
studies in scientific hydrology. T
International Geophysical Year a
other programs have shown that int
national scientific co-operation is f
sible and fruitful—so much so that t
studies are continuing. For a resour
as vital as water a single year of
operation would see a useful progra
barely started. Thus, it is planned
have a ten-year program. If all go
well, the International Decade for S
entific Hydrology will begin in 196

DISTRIBUTION OF WORLD'S ESTIMATED WATER SUPPLY

Location	Surface area (square miles)	Water volume (cubic miles)	Percentage of total water
Surface water			
Fresh-water lakes	330,000	30,000	.009
Saline lakes and inland seas	270,000	25,000	.008
Average in stream channels	—	300	.0001
Subsurface water			
Soil moisture and vadose water	50,000,000	16,000	.005
Ground water within depth of half a mile	50,000,000	1,000,000	.31
Ground water—deep-lying	50,000,000	1,000,000	.31
Total liquid water in land areas	50,600,000	2,070,000	.635
Icecaps and glaciers	6,900,000	7,000,000	2.15
Atmosphere (at sea level)	197,000,000	3,100	.001
World ocean	139,500,000	317,000,000	97.2
TOTALS (rounded)		326,000,000	100

Monies of Antiquity

By Joan Fagerlie

Athenian "owl" was most renowned coin in antiquity.

Photographs by
LEE BOLTIN

Acanthus' tetradrachm shows lion attacking bull.

oins commemorate gods, fauna, and civic pride

NYONE WHO HAS EXAMINED ancient Greek coins even cursorily cannot help being impressed with the t variety and frequency of animal representations. n the Greeks chose an appropriate design for age, artistic merits were a primary consideration animals served this aesthetic purpose admirably. ldition, animals or birds were often associated with 'arious deities of the Greek pantheon and thus selected for their religious symbolism. In some ınces, an animal was made a symbol on the coinage locale because it happened to be a conspicuous ıre of the region. Fauna frequently figured in some ıd in the history of a city; they may have been solely rtistic motif borrowed from a past civilization; rs may have been a pun on the name of a ı. But, for whatever the reason, animals of the -legged variety, creatures of the sea, reptiles, birds l kinds, and insects abound on Greek coins, either as nain design of the obverse or reverse, or as a symbol ıbsidiary design. Only a few types can be shown here, but they exemplify the rich variety of the genre.

Representations of the lion are very common. One example, showing a lion attacking a bull, exists on silver tetradrachms of Acanthus in Macedonia. This motif can be traced back to Sumerian times, and it is also found on Minoan and Mycenaean gems. Although the motif is an old one, the appearance of the lion and bull on this coin may be due partly to the great numbers of these animals that roamed in Macedonia in classical times. As recorded by Herodotus, the lions in Macedonia played havoc with Xerxes' camels when he was crossing over to Greece. Herodotus marvels that the lions attacked only camels, creatures that they had not seen theretofore, and refrained from attacking any of the other beasts or man.

On other coins, the lion is shown attacking a stag, again a Near Eastern motif, or it is portrayed with a second lion that recalls the famous Lions' Gate at Mycenae. The scalp of the lion is a common pattern, and some smaller denominations of an Asia Minor mint

Swan of Clazomenae represents Apollo.

Ionian use of stag honors Artemis.

Turtle was badge of city of Aegina.

Metapontum barley ear signifies wealth.

mbolizes sacred animal of Ephesus.

of uncertain location show only the paw of the lion. The labors of Herakles also offered a wealth of material for animal types, not only for the lion but for others, such as the bull, boar, and serpent.

Minoan mythology, in which the bull is so prominent, is the favorite subject matter of the Cretan coin types. One coin, a stater of Gortyna, relates to the trials of Europa, who is represented on the obverse. Europa was carried across the sea by Zeus, who had taken the form of a white bull, and she finally reached Crete, where she bore three children: Minos, Rhadamanthus, and Sarpedon.

Perhaps the best-known animal type from antiquity is the Athenian "owl." The owl was a symbol of Athena, the patron goddess of Athens, and it was also the badge of the city. Athens was not the earliest European Greek state to have a coinage of its own, but without doubt it was the most renowned of its day. Aristophanes' *Frogs* proclaims the fame of the owls:

"These are coins untouched with alloys;
everywhere their fame is told;
Not all Hellas holds their equal,
not all Barbary far and near,
Gold or silver, each well minted,
tested each and ringing clear."

They were widely circulated and accepted, and were also imitated by less civilized peoples, as barbarous pieces from Arabia and other distant places attest. The coinage of Athens was, in fact, an international currency and maintained essentially the same type for centuries. Aristophanes refers to "Laurium owls" in his play *Birds*, for the silver mines at Laurium supplied the bullion for Athenian coinage.

THE earliest coinage in European Greece was that of the island state Aegina, whose commercial enterprise reached Asia Minor and northern Greece long before Athenians took to the sea. Like the Athenian owls, Aeginetan "turtles" attained a universality of their own. Up until the time of Aegina's defeat by Athens, the turtles were the currency of the entire Peloponnesus. They were struck on a heavier standard than the owls, which caused Athenians to call them "the thick drachms." The turtle was also the badge of the city and was sacred to Aphrodite, whose temple stood near the harbor of Aegina. Curiously, the earliest coins of Aegina show the sea turtle, which was superseded for some unexplained reason by the land tortoise sometime in the fifth century B.C.

Ephesus in Ionia was the center of worship of Artemis, the virgin huntress and goddess of wild nature, of whom the bee and stag were cult symbols and the usual types on the coinage. The high priest of the temple was called the "king bee"—the Greeks apparently were unaware that it should have been "queen"—and the priestesses, "honeybees." It was commonly the case that priests and priestesses had titles named after a particular animal sacred to the deity. At Ephesus the cult symbols of the patron goddess became the badge of the city. The same type appears on the specie of Aradus in Phoenicia toward the close of the second century B.C., and perhaps indicates an alliance between the two cities.

Undoubtedly, a seal was chosen for the badge of Phocaea in Ionia because *phoca* was the Greek word for seal. It is one of numerous examples of the punning device evident in the choice of a type for the coinage. In this case, the seal also was an appropriate symbol of Phocaea's sea power in the seventh and sixth centuries B.C. Herodotus said: "These Phocaeans were the earliest of the Greeks to make long sea-voyages; it was they who discovered the Adriatic Sea, Tyrrhenia, Iberia and Tartessus, not sailing in round freight-ships but in fifty-oared vessels."

MANY of the aforementioned coin types were, like the coin type of Phocaea, badges of the cities they represented. The badge or coat of arms offered a quick method for indicating the place of origin. One well-known badge was the barley ear of Metapontum, which symbolized the source of wealth of this Greek colony in Italy. A variety of subsidiary symbols appear on the Metapontum coinage, too, and many of the symbols are animals. They include a grasshopper, ant, lizard, praying mantis, bird, crayfish, cicada, owl, and also a mouse, which is shown on page 23.

The swan on the coinage of Clazomenae was probably locally inspired, for ancient authors attest to the former abundance of these birds in the delta of the Hermus River just across the bay from Clazomen In fact, the name Clazomenae may be derived from the crying of these birds, for the Greek verb can be used in such a sense. The swan was also a sy of Apollo, who appears on the obverse of the coins.

A cock, or a cock and a hen, are the usual types Himera, the Greek Sicilian colony. The name Himera perhaps is derived from the Greek word for day, and thus the cock, which signaled the beginni the day to the Greeks, would have been an appropri badge or symbol. Nearby Agrigentum had the crab and eagle as its coin types; they are symbols of Poseidon and Zeus, respectively. In 482 B.C. Thero tyrant of Agrigentum, gained control of Himera, an it is of interest that the new issue of Himera that then appeared shows a cock on one side and the crab of Agrigentum on the other.

Successive changes in the coin types reflect the political turmoil of still another Sicilian town—Messana, or, as it was first called, Zancle (Greek fo sickle). Zancle's earliest coin type was a dolphin in curved band—a conventional representation of a sickle-shaped harbor. It was first conquered by Samian and Milesian emigrants about 493 B.C. and coinage with Samian types but without ethnic (an inscription identifying the name of the town) w issued. In 489 B.C., Anaxilas, tyrant of Rhegium, g control of Zancle, changed its name to Messana in

Segesta's coin depicts local legend.

Eagle is the symbol of Agrigentum.

Cock is the coin type for H

Hare and dolphin were sacred in Messana.

Ass is associated with Dionysus.

Dolphin represents curve

ıor of Messenia, his birthplace, and later introduced , types on the coinage both of Rhegium and Aessana. This was the mule-car and hare design t Aristotle explains by saying:

> 'Sicily was without hares until the time of Anaxilas of Rhegium, but he imported and preserved them and as about the same time he won a victory at Olympia with his mule-car, he placed on the Rhegium coins the types of a mule-car and a hare."

VHEN Messana expelled the tyrants in 461 B.C. (sometime after the death of Anaxilas), certain lifications of this type were made. The male rioteer of Anaxilas was replaced by the city goddess ssana, and a dolphin often was used as a symbol. ause the hare was sacred to locally worshiped Pan, se head sometimes appears above or below a e, the animal was retained as a coin type.

dog on the coinage of Segesta reflects a local nd. According to tradition, the city was founded by stos, son of the Trojan woman Segesta who was ed by the river god Krimissos in the form of g. Krimissos is shown below in his canine form above is the head of Segesta.

Goats are represented on the coins of several Greek es—often on those of places whose names begin Aegos, from the Greek word for goat. However, the goat imprint also is the standard type from Aenus in Thrace, and perhaps was thought sacred to Hermes, whose head appears on the obverse.

Mende, in Macedonia, was famous in antiquity for its wine, and appropriately used on its coins a symbol associated with Dionysus. The ass was apparently a favorite mode of travel for Dionysus, and we often meet with him in Greek literature riding on one. Shown on these pages is an early coin from Mende portraying an ass with a crow perched on its back, which probably derives from some lost legend concerning Dionysus. Pausanius, the second-century A.D. author, might have heard this now-unknown tale in his travels to Nauplia, although his readers are none the wiser. He inquired about a rock-carving of an ass connected in some symbolic way with vine-growing, but relates that the story was not worth repeating. Later issues show Dionysus reclining on the back of the ass and holding a wine cup; in the background is a crow.

This discussion has by no means been exhaustive; some animal types not shown here are the horse, camel, ram, wild boar, goose, hippopotamus, frog, crocodile, snake, and wolf, as well as some insects. But the reproductions on these pages are proof enough of the interest the Greeks had in the natural world, of their ingenuity in selecting types for places of origin, of their artistic skill, and, above all, of their pride in producing beautiful coins.

oat appears on many states' coins.

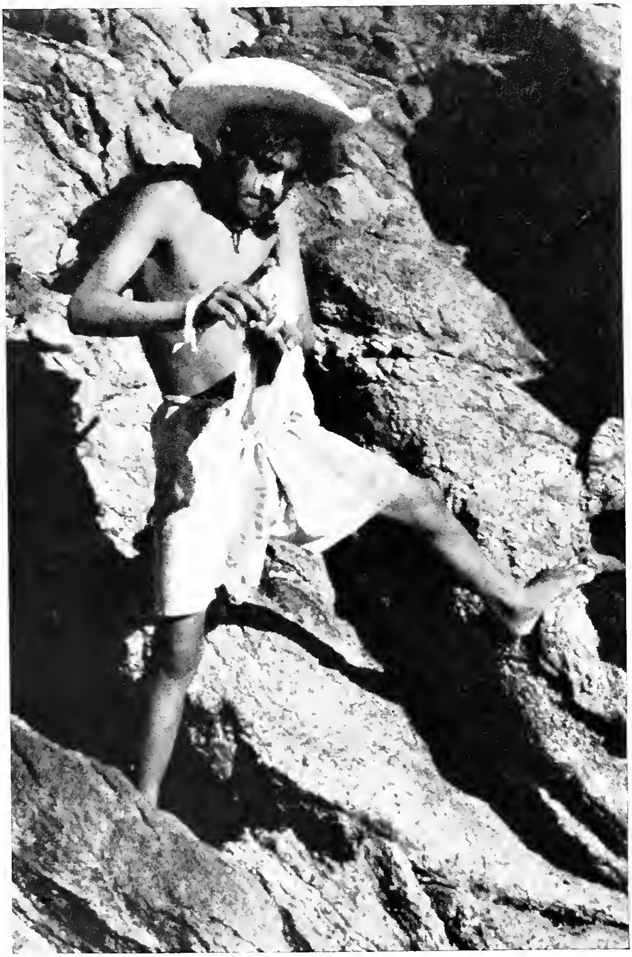
Emperors' Dye of The Mixtecs

Indians tap a snail's "Tyrian purple"

By Peter Gerhard

Mixtec dyer pours dye-bearing fluid of *Purpura patula* onto ball of yarn.

Two Pinotepa villagers move toward rocks where the marine snails cling.



Nearly everyone in the ren Mexican village of Pinotepa Don Luis, in the State of Oaxaca, a hand in making a distinctive p of feminine clothing known as *posahuanco*. Men and boys grow cotton, old women spin it into thr and girls do the weaving. The *p huanco* is a long wrap-around sl the only garment worn by wome much of the hot country of the Lo Mixteca (the region of the Mixtecs Cloud People, so named by their cient Aztec conquerors) in southw ern Oaxaca and southeastern Guerr The skirt's alternate horizontal str of blue, red, and purple make a ticularly pleasing contrast with brown skin of graceful Indian g whose finest *posahuancos* are rese for their weddings.

The bridal costume of a Pino girl may consist of a skirt colored tirely with natural dyes, together an embroidered scarflike huipil w around the shoulders. The red comes from a wood louse (cochine the blue from the indigo plant, and

le from a marine snail. Of these, ır the most valuable is the purple of the snail. While a skirt colored aniline purple is sold for fifty or pesos at most, one with wide s of *caracol*, shellfish purple, can as much as six hundred pesos, t forty-eight dollars.

ellfish dye comes from several lies of marine mollusks, princi- the carnivorous marine snails cidae and Thaisidae; these have nd that secretes a milky, strong- ing fluid that apparently serves r as a defense mechanism irritat- o predators or as a narcotic to obilize the clams, mussels, rock acles, and other bivalves on which nollusks feed. The fluid is known ically as punicin, and the dye of species of murex has been ana- l as a derivative of indigo con- ng bromide. When exposed to oxy- and sunlight. the fluid takes on a red or purple hue that immedi- becomes nearly ineradicable in cs. This substance has been used nan since prehistoric times as a fast-color agent, and was particularly valued in the ancient world when little was known about the use of mordants in the fixing of colors.

MAN'S use of purple shellfish dye seems to have first been mentioned in a legendary account of its discovery by Melkart, the Phoenician equivalent of Hercules. He was strolling along the shore with the nymph Tyros and saw a dog playing among the sea shells nearby. Tyros noticed that its mouth was covered with brilliant purple, and demanded a cloak of the same color. Melkart collected some shells and set to work on the cloak. and thus, says the story, began the industry that eventually made Tyre famous.

It seems likely that in Crete murex was used for dye at least as early as 1600 B.C. By about 1000 B.C., the Phoenicians had made wool and silk dyeing into a thriving business. At the cities of Tyre and Sidon, the shells of the banded murex *(Murex trunculus)* and the spiny murex *(Murex brandaris)* were broken open to obtain a few drops of fluid from each—a wasteful process that greatly depleted the species. The search for new supplies of murex and other dye shellfish was at least partly responsible for the distant voyages of the Phoenicians and the founding of their colonies throughout the Mediterranean.

Under the Romans, the demand for Tyrian purple increased. Rome put dye factories under state control. It was probably the scarcity of the animal, together with the tedious and costly process of dyeing, that resulted first in limiting the use of purple garments to the wealthy. then to the ruling class. and finally to the emperor alone. With the Mohammedan conquest in the seventh century, the Phoenician dye works ceased to operate. Thereafter the extraction process was almost abandoned in the Mediterranean. although as late as the eighteenth century the dye was still used to some degree, particularly to mark linen. in western Europe and the British Isles.

The habitat of the dye-producing marine snails is virtually worldwide.

Snail ejects a colorless fluid that turns purple when exposed to light.

Many species can be found on many shores, exposed on rocks at low tide. In time, any people who lived on a rocky coast would probably become aware of the animal's coloring properties, but whether or not the dye is used in a particular coastal area depends on various factors besides the animals' availability. In some regions the snail is so important as a source of food that its dye is not exploited, while in others the people wear little or no clothing. In our own society, the introduction of cheap aniline purple in the late nineteenth century made the extraction of shellfish-coloring commercially unprofitable. Thus, the use of shellfish purple logically is confined to isolated coastal areas where the snails abound, where people weave their own clothing, and where for some reason the aesthetic or practical advantages of shellfish-coloring are appreciated over other dyes.

However, there may have been subtler reasons for the use of purple dye shellfish than those enumerated. Certain medicinal and magical attributes have been associated with the animal from earliest times. As noted previously, in the Mediterranean area the wearing of purple became a prerogative of royalty, a symbol of godhood, but although the use of purple garments was forbidden to commoners, the aristocracy could not prevent the collecting of the little shells for the special properties with which they somehow became endowed. For instance, in eighteenth-century Europe the purple shellfish was used for curing pustules, ulcers, tumors, earache, and spots before the eyes, and it was commonly thought that placing a snail on a woman's navel would help her become prolific. The association of purple and fertility would seem to be very old, and we may speculate as to whether there is a link between this Old World belief and the use of shellfish purple in the bridal costume of today's Mixtec women.

Indian woman spins cotton into yarn in village of Pinotepa de Don Luis, where molluscan dye industry h
thrived. She will sell yarn to dye

In concluding this brief historical survey of Old World uses of murex, it should be mentioned that the Chinese and Japanese also made use of shellfish dye, although it would seem that they were more interested in eating the snails. Curiously, the wearing of purple in tenth-century Japan was subject to imperial restrictions very similar to those imposed by Rome.

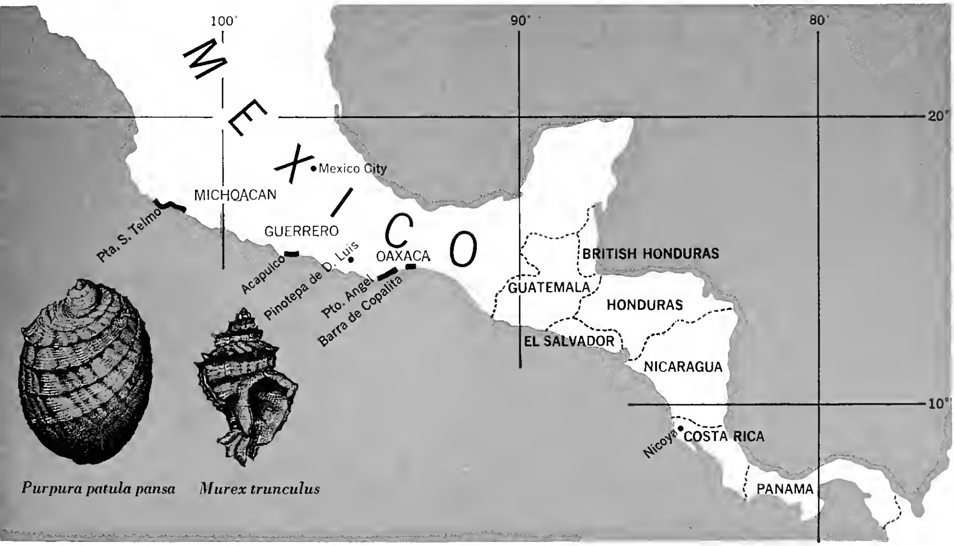
Today there remain numerous representatives of the dye-producing shellfish in America, on both the Atlantic and Pacific coasts. At the time of the Spanish Conquest in the sixteenth century, the natives of Ni
on the west coast of Central Ame
were using shellfish dye on their c
fabrics. The practice was probabl
cient, common to coast dwellers
Mexico to Peru. In Peru, shellfisl
has been identified by spectrop
metric analysis on cotton mu
wrappings that date from the first
tury before Christ. The ancient I
vians applied dye as a pigmen
woven fabric, making designs of h
prints and, sometimes, of dots
Mexico and Central America, p
from as yet undetermined source
pears in early codices, in pre-Co
bian pottery, and on one of the
few colored Mayan textiles that
survived to this day. In certain
minated codices, purple pigme
used to color the clothes and sk
deities, priests, and rulers appea
in the manuscripts.

Noticing the esteem for purple
in America, the Spanish soon ga
control of the native industry for

HEN DYERS return to Pinotepa, they ll their hanks of purple thread to skilled women weavers like this one, *shown above*, wearing a *posahuanco.*

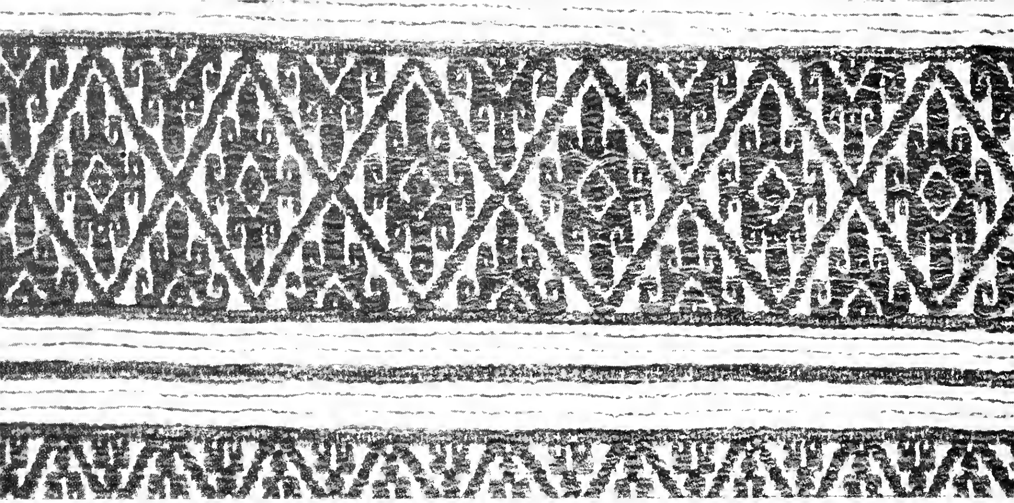
own profit. By the end of the sixteenth century, *hilo morado,* or *hilo de caracol,* as shellfish-dyed thread was called, had become a well-established, if minor, article of commerce in the Spanish dominions of New Spain and Peru. It brought a higher price than thread dyed from any other source, ranging from six to fourteen pesos a pound. The principal colonial centers of this industry were on the west coast — Oaxaca in Mexico, Nicoya in Costa Rica, and Ecuador. Marketing was handled only by the Spaniards. They first acquired the fiber, then hired Indian dyers who were paid for their labor in goods. The Spanish then had the dyed thread woven into fabric by other Indians. In one year, over a thousand pounds of cotton yarn were dyed with shellfish in the province of Nicoya alone, and the Spanish sold finished sashes at extravagant prices to Indian women from central Mexico to their dominions in Peru.

The mollusk most often exploited for its dye in America was probably *Purpura patula pansa* Gould, found on rocky sections of the Pacific coast from Lower California to northern Ecuador. Related species, some of which produce different colored dyes ranging from dark blue to blood-red, were used to a lesser degree. From the standpoint of conservation, *Purpura patula* had, and has, a great advantage



ISTRIBUTION of centers of marine snail dye extraction nce 1900 is shown on the map of Central America.

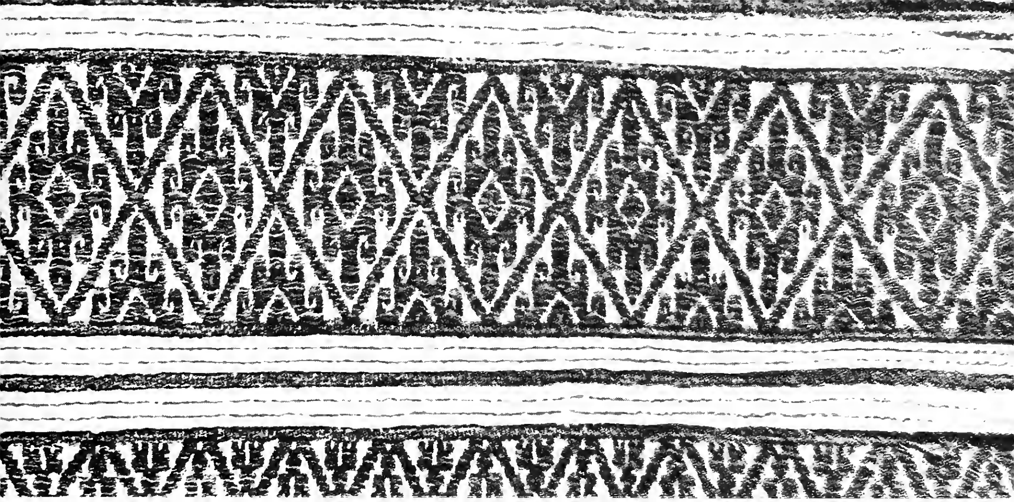
Pinotepa is about 150 miles from Acapulco. The two shell insets are local *Purpura* and Old World banded murex.



over Old World species. The Phoenicians found it necessary to break open or grind up hundreds of murices in order to get a few ounces of liquid, and thousands to saturate a fleece in a vat of shellfish dye. The larger American species, when slightly irritated, ejects its fluid in such quantity that there is no need to break up and kill the animal in order to apply its color to cotton. Thus, the dyeing process in America has always been totally unlike the complicated method employed in the Mediterranean.

Today, in at least three remote sections of the Central American Pacific coast, in Michoacán, Oaxaca, and southern Costa Rica, shellfish dye is still sought and used. Until recently there were two groups of Indians in Oaxaca engaged in these activities — the Chontal and the Mixtec — but in early 1962 the *caracol* industry was nearly monopolized by a dozen men from a single Mixtec village, Pinotepa de Don Luis. These twelve continue to go down to the coast in the dry season, between November and March, each man carrying about fifteen pounds of doubled cotton thread in small hanks bought from the old women spinners. Their favorite working area is the rocky shore between Puerto Angel and Barra de Copalita *(map, page 29)*, which is broken by many sheltered coves where the surf is relatively light and where there is a perfect breeding ground for the *Purpura*. The men usually travel in groups of two to four
set up camp on the beach.

DYEING is done for a few h
daily, at low tide, when the s
fish are helplessly exposed. It is
lieved that better results are obta
in the morning ebb, particularly
the full moon. Each man carries
or three dozen hanks slung over
shoulder, and a pointed stick to
the mollusks loose. Holding a skei
cotton in one hand, the dyer cli
down to the shady undersides of
rocks at water level until he fin
colony of *Purpura*. He dips the co
in the sea, then pries off a snail
blows on the operculum, the doo
the animal's shell. This causes the s



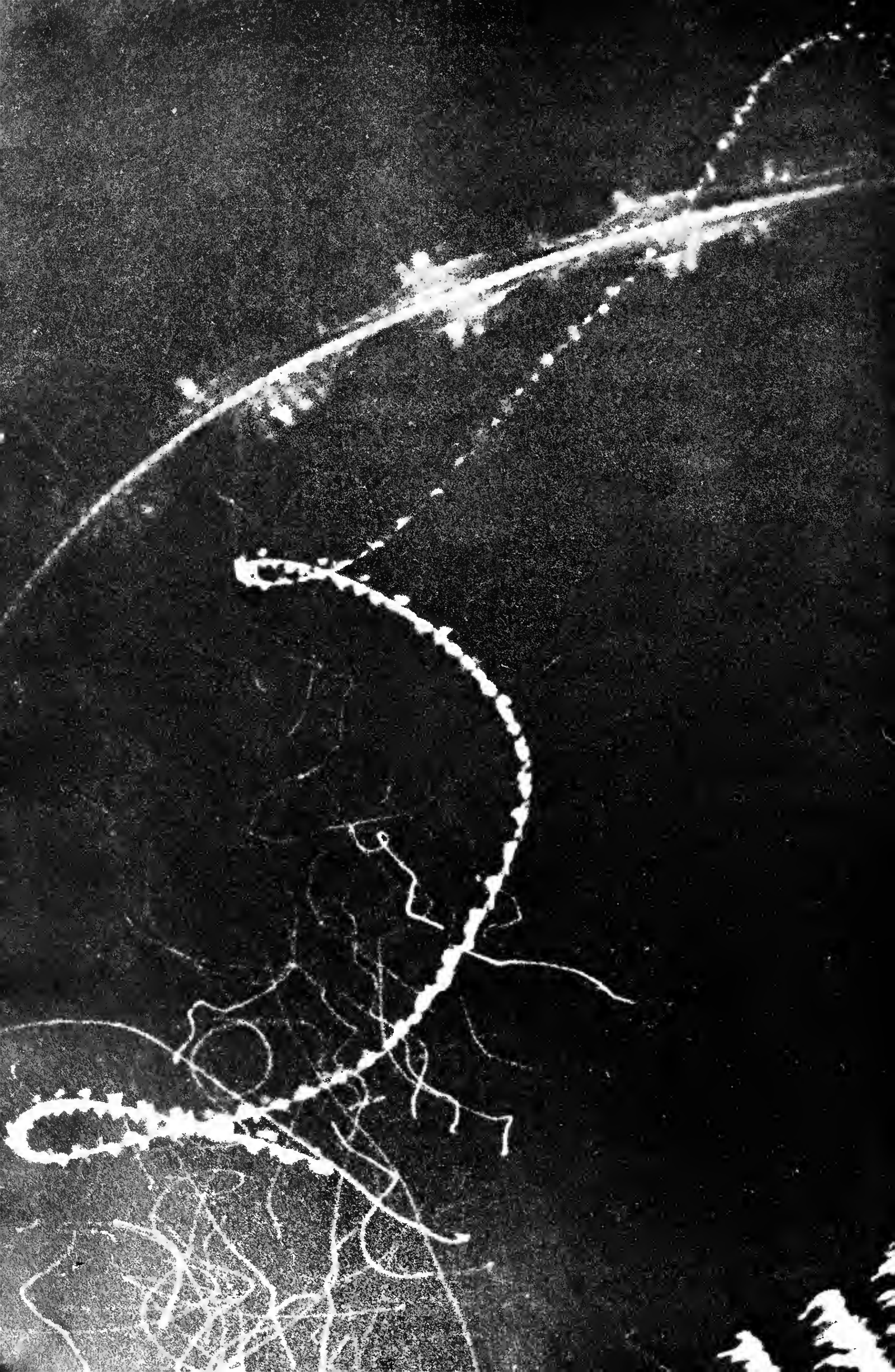
ithdraw deeper into its shell, and
e same time a frothy juice wells
nd fills the shell's mouth. This
d is poured and dabbed directly
the cotton threads. The fluid,
h is colorless at first, soon
ges in sunlight to a dirty yellow,
to a brilliant green, and finally
rich, if somewhat uneven, purple.
n all its liquid is gone, the dyer
ully places the animal back on the
so that it can be "milked" again
e next moon. The process is re-
d until all the skeins are satu-
with dye, after which they are
dipped into the sea in the belief
salt water acts as a mordant.

hen they return to the camp, the
s spread out the treated skeins in
the sun, where they are left all afternoon and overnight, on the theory that sunlight and dew act to make the color more even. Shellfish-dyed thread has a pronounced odor reminiscent of garlic, which it retains until the cotton has been washed several times. After two months on the coast — slowly moving from one bay to the next, then retracing their steps during the following moon — the men shoulder their ill-smelling burdens and trudge some 150 miles back to Pinotepa. There they sell the purple hanks to women weavers for thirty to forty pesos a pound. Prices are determined by the relative evenness of the dye. A good dyer can earn six hundred pesos in a season, a small fortune in that part of Mexico.

With the dyed threads in hand, a Pinotepa girl will weave a *posahuanco* four yards long in two or three weeks. After the best *posahuancos de caracol* have been set aside for use in the village as wedding dresses, many others are sold in nearby villages. A few, later remodeled, are acquired by buyers for the tourist trade.

Recently a jeep trail was opened to remote Pinotepa de Don Luis. It is possible that the thrust of progress may soon obliterate old Mixtec customs and write an end to the ancient *caracol* industry of the Lower Mixteca.

END PRODUCT of the villagers' collective effort is shown in the delicately woven designs that appear above and below.



Night Fighters in a Sonic Duel

cent research confirms moth's use of hearing to evade bats

By Kenneth D. Roeder

)THS ARE ONE of the main food sources of certain families of They are attacked on the wing ı darkness in a contest in which and maneuverability are the pre- qualities. That this nocturnal ;" has probably continued for millions of years tells us that it alanced contest: all bats locate ıpture some moths; some moths and evade all bats.

ile in flight, insectivorous bats ı series of brief chirps pitched l octaves above the highest note e to human ears. Each chirp is rasonic tone that lasts only a few econds. In many bats the tone in pitch by about one octave g this brief interval, so that if it udible to us it would sound very like the chirp of a bird. A bat these chirps about ten times per l when cruising in the open; if ounters any object in its flight ts chirp rate may go higher than er second.

Harvard the precise and ingenxperiments of Donald Griffin and udents have shown that echoes ing to the ears of the bat inform etail about the size, distance, and on of objects in its flying path. orld of a flying bat must be a of single and multiple echoes of tlety that we still do not com- appreciate. If a man walks opening and closing his eyes y, the visual world becomes a of still pictures interspersed ntervals of darkness. However, bat's world discontinuities in otion are far more complicated because sound travels extremely slowly compared with light. For a bat, the spatial dimensions of the visual world are temporal dimensions in an acoustic world; a flying moth becomes an intermittent, fluctuating point in time.

About 100 years ago it was suspected that moths could evade bats through a sense of hearing. The sonar system used by bats was then unknown, so this was a truly inspired guess. Since then, studies of the anatomy of the tympanic organ in various species and families of the Lepidoptera, and observed changes in the behavior of moths in the presence of man-made ultrasound, have confirmed the suspicion that members of certain moth families can hear the chirps of echo-locating bats. Several families of moths possess tympanic organs, including the largest families of common, medium-sized moths — the Arctiidae, Phalaenidae, and Geometridae. It seems probable that tympanic organs have evolved more than once.

DR. Asher E. Treat, of The City College of New York (NATURAL HISTORY, August-September, 1958), first introduced me to the moth ear, and we worked together on tympanic nerve experiments. Field experiments with free-flying bats were carried out at his summer home in Tyringham, Massachusetts. Without his enthusiasm and skill in dissection we probably never would have tried to discover the defensive role of moth hearing.

The ear of a moth may seem to be a somewhat esoteric subject for a study of the form in which environmental information is coded in nerve impulses. But in some families of moths, notably the owlet moths, or Noctuidae, the tympanic organ contains only two acoustic sense cells. Electrodes placed on the tympanic nerve containing the axons (impulse conductors) from these sense cells can intercept all of the impulse-coded information this sense organ is capable of delivering to the moth's central nervous system.

THE ear of noctuid moths is found on the thorax near the "waist," where thorax and abdomen join. A thin eardrum, or tympanic membrane, is directed obliquely backward and outward into a cleft formed by flaps of cuticle, and is normally covered by a thin layer of fine scales. Viewed from outside, the tympanic membrane often shows interference colors, indicating its extreme thinness.

Dissection under a microscope shows that the tympanic membrane forms the outer wall of the tympanic cavity, which is an air-filled, expanded portion of the moth's respiratory system. A fine tissue strand, the acoustic sensillum, is suspended across this cavity, and is supported near its midpoint by a minute ligament attached to another part of the skeleton *(diagram, page 35)*. The sensillum contains the pair of acoustic receptors, or sense cells. Each acoustic sense cell (*A* cell) bears a fine distal process ending in the scolops, a minute refractile structure that extends toward the tympanic membrane. From the central end of each *A* cell an axon (impulse conductor) passes within the sensillum toward the skeletal support; this pair of *A* axons continues in the tympanic nerve to the thoracic ganglia. Passing the skeletal support, the *A* axons lie close to a large, pear-shaped cell (*B* cell) that may have numerous fine, finger-like extensions reaching into the surrounding membranes. The *B* cell gives rise to a larger axon that runs parallel to the *A* axons in the tympanic nerve, eventually reaching the central nervous system.

ND MOTH "DOGFIGHT" is illumined hing lamp. Both enter from right; escapes in looping dive. Tangled, racks are made by insect swarm.

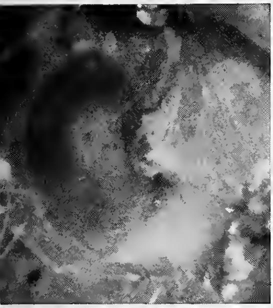
EXTERNAL OPENING of right ear in moth *Agrotis ypsilon* is indicated by arrow. Moth is actually ¾ inch long. Close-up of tympanic membrane seen through opening is show opposite page at top; sketch is of moth's tympanic or

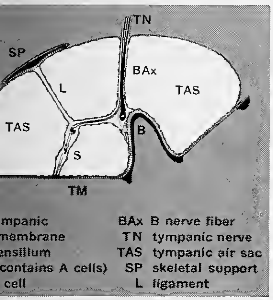
An experiment will usually begin with the capture of a noctuid moth—perhaps one of the common army worms whose larvae do so much crop damage or, better still, a larger red underwing. Under temporary anesthesia, the moth is decapitated and firmly restrained with small strips of Plasticine on the stage of a dissecting microscope. It is kept in such a position that the tympanic openings have an unrestricted sound field. The scales on the thorax are removed with a small paintbrush, and the dorsal part of the thorax, including one of the main sets (horizontal) of flight muscles, is dissected away. The tympanic nerves run forward on either side of the cavity thus revealed, passing from the tympanic organs at the back of the thorax to the large pterothoracic ganglion that supplies all organs of the thorax.

THERE are several nerves in this region, all small and transparent. However, the task of hooking a tympanic nerve on an electrode is not as hard as it might seem. One electrode is a silver wire inserted anywhere in the tissues of the moth. The other is a silver wire tapered to a fine point that is bent into a minute hook. This active electrode is manipulated mechanically. Both electrodes are connected to an amplifier and cathode-ray oscilloscope, and also to a loud-speaker. Since nerve impulses cause minute brief current pulses at the electrode, they can, when amplified, be made audible as clicks in the loud-speaker. When the tympanic nerve has been hooked, the loud-speaker replies to ultrasonic sounds with a rapid sequence of clicks. These same nerve impulses can be photographed when displayed as spike potentials on the screen of the cathode-ray oscilloscope.

When the silence is broken by continuous, pure ultrasonic tones of various intensities, the typical response of the *A* cells is shown on page 37 (*top*). At the onset of a very faint tone (1), one *A* cell generates a small burst of spikes that immediately tails off into an irregular sequence. At a higher intensity (2), the initial frequency of *A* spikes is greater, and a regular discharge continues during the tone, though with declining frequency. At a still greater sound intensity (3), the *A*-spike frequency increases again, but it still declines as the tone continues and occasional spikes appear to have double peaks. At the highest sound intensity used in this experiment (4), the nerve response becomes quite complex—there are many spikes, double peaks, and spikes that appear to have double the normal height. These extra spikes are generated by the less sensitive *A* cell. In all the records the n larger spike potential of the *B* cell pears infrequently but at regula tervals, and is completely unaffe by the ultrasonic stimulation. This periment demonstrates, for one, the intensity, or loudness, of the is encoded in the tympanic nerve charge as spike frequency in th axons. The evidence also shows faint sounds are detected only by *A* cell, while louder sounds are tected by both.

IN the top figure on page 37 it ca seen that a decrease in spike quency takes place as the sound tinues. This decrease in frequency the passage of time must mean that sound is represented to the moth as coming progressively fainter, e though it has remained physically changed. Such a progressive loss sensitivity is known as sensory a tation and is actually widespread familiar in everyday experience adaptation did not occur in most ceptors registering changes in outer world, the impact of our roundings often would be unbeara The brilliance of a lighted room tered after dark would remain bl ing, and the contact of our cloth would irritate our skin the through. The speed with which re





dapt varies greatly: the moth's *A*
adapt relatively rapidly; other
cells adapt slowly, if at all.
nother experiment an ultrasonic
was generated artificially at reg-
ntervals *(chart, page 38)*. It was
r to a bat chirp except that it
l the frequency modulation of the
l sound. A microphone was
l near the tympanic organ of the
The intensity of the sound pulse
djusted until it just failed to pro-
n response in the *A* cells. The in-
y was then increased in measured
of 5 decibels; the microphone
erve response were recorded at
tep. Part of the findings were al-
familiar, but there were two ad-
al ways in which the *A* response
ed as a result of increased inten-
Although each sound lasted only
liseconds, at the higher intensi-
e spike discharge continued for
l milliseconds after the sound
eased. It was as if the more in-
sounds caused in the sense cells
overaccumulation that then con-
l to generate impulses after the
itself had stopped. Second, the
nse time (the interval between the
lus and the first *A* spike) became
er as sound intensity increased.
is important to note that the
-mentioned *A*-cell properties are
r to those reported many times previously in many animals by many observers. Heretofore, however, such observations have dealt mainly with single units that were isolated for experimentation from a complex sense organ containing many thousands of receptors. The behavior of the *A* cells is significant because the cell represents the whole sense organ, not merely a small part of it. Therefore, the *A* cell defines the total sensory input being communicated to the effector mechanisms for the evasion of bats.

Other experiments with artificial sounds showed that the tympanic organ can detect sounds ranging from 3 kc/s (kilocycles per second) to as high as 150 kc/s. The upper limit of human hearing is 15 to 20 kc/s. Even with this great range, moths appear to be tone deaf. They seem to have no mechanism for discriminating one frequency or pitch from another; the tympanic organ is mainly concerned with discriminating differences in sound intensity, or loudness. With only one ear, a moth could measure loudness from the *A*-spike frequency, and from activity in one versus both *A* axons. By using both ears, the moth could "compare" two different hearings of the same sound, which might register with more intensity on one side than on the other.

These experiments with artificial sounds have introduced the elements of vocabulary and grammar of the neural language. Fortunately, the tympanic organ communicates with the moth's central nervous system only in the simplest form of this language, so that even after this elementary instruction it is possible to interpret some biologically significant messages. These messages are the chirps made by bats in their natural occupations.

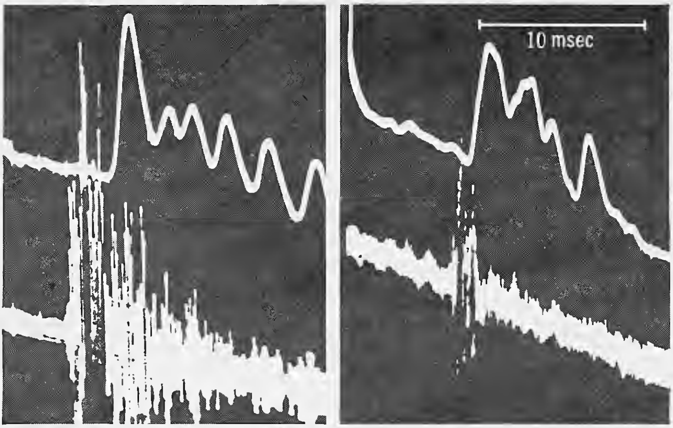
Our first record of a tympanic nerve response to the chirps of a flying bat was obtained in the laboratory, and almost by accident. Experiments with artificial sounds were in progress during January, a time of year when New England bats are deep in hibernation. A student making a week-end exploration of a New Hampshire cave found a hibernating bat and brought it back to the laboratory, where it was placed in a refrigerator and almost forgotten for several weeks. When removed and held in the hand of an experimenter near a tympanic-nerve preparation and microphone, the bat recovered sufficiently to deliver a few angry and audible shrieks, and an energetic bite. This last naturally brought about its release, whereupon it flew "silently" around the laboratory close to the ceiling. Throughout the flight the prepared tympanic nerve delivered a rapid series of short bursts of *A* spikes. When the bat flew sufficiently close to the experimental table, the microphone joined in with its electronic version of the ultrasonic chirps.

This impromptu experiment showed not only that the tympanic organ responds as expected but also that it is highly sensitive to bat cries. One or both of the *A* fibers continued to respond at times when the bat was too distant for its cries to register in the microphone. The moth could hear the bat at all points within the laboratory, and we were most eager to go beyond its walls and into the field.

This turned out to be somewhat more than the carefree jaunt it suggests. The next summer a load of about 300 pounds of electronic gear was hauled up a grassy hillside in the Berkshires of Massachusetts, and reassembled in a spot where bats were known to feed. At dusk a moth was captured at a nearby light and mounted so that one tympanic organ had an unrestricted sound field. Its tympanic nerve was hooked on an electrode and the *A* and *B* fiber activity was followed continuously on an oscilloscope and loud-speaker. Spikes were also recorded on magnetic tape.

The high excitement of listening for the first time to night sounds through a moth's ear was tempered by the thought that we had no independent evidence that they were being caused by bats. They were inaudible to us, and in this first field experiment we had with us no ultrasonic microphone to provide a separate record. A floodlight was rigged so that we were able to observe bats flying within 20 feet of the preparation. It then became clear that the range of the moth ear was much greater than that of the light, so that the appearance of a bat in the lighted area could often be predicted by listening to the rising pitch of successive *A* bursts from the moth ear.

It was difficult to establish the range of this biological bat detector, since it depended upon the species of moth and bat as well as the relative angle of their flight paths. In another experiment a moth preparation was set up at dusk about 200 yards distant from an old barn where bats roosted. It was



Sound audible to a human ear affects moth ear and a microphone equally, as shown at left. Ultrasound has effect mainly on moth ear, as shown top right.

known that at this hour the bats usually left the roost singly and flew on a straight path directly over the site chosen for the preparation to other feeding grounds. An observer, wearing headphones connected by a long cord with the amplifier, walked "upstream" toward the barn while listening for the first signs of regular *A* bursts from the moth ear behind him and watching the bats pass overhead. The maximum distance for *A* responses lay between 100 and 120 feet from the moth ear while the bats were flying toward the ear at an altitude of about 20 feet.

All information heard by the observer came from one ear of a moth. What could be learned by recording from both ears simultaneously? This project had to wait until the following summer, for it was necessary to learn how to insert and manipulate two hooked electrodes within the small space of a moth's thorax, and to duplicate most of the amplifying and recording equipment. The activity in right and left tympanic nerves was recorded on stereo magnetic tape and was subsequently photographed by replaying the tape into a dual-beam oscilloscope.

A binaural nerve response to a flying bat is on page 37 (*bottom*). The bat's approach is initially signaled, in the upper trace in the first panel, by a group of spikes (the first is a B spike, the rest A spikes). The second ear (lower trace, same panel) does not detect the bat until its next chirp, when the number of spikes indicates less intensity compared with spikes displayed by the first ear. This difference persists in the third response, but by the fourth (all of which is shown) there is little difference between upper and lower traces. This suggests a bat approaching from one side, then moving directly overhead.

It is interesting to listen through stereo headphones to the taped responses of right and left tympanic nerves to a moving bat. The human ear interprets these spike differentials as giving direction to the source, and one can almost imagine oneself inside the nervous system of the moth as the source of clicks appears to move from one side to the other. This illusion of direction is not continuous, and much of the time the source of sound seems to be in the center of one's head. The explanation is that the spike differential is greatest at low chirp intensities, becoming less and disappearing above a certain loudness. This saturation of the acoustic response above certain sound intensities indicates that a moth would be better able to determine the bearing when a bat was near the moth's maximum range of hearing.

A differential response would be possible only if the ears of a moth were somewhat directional, responding better to sounds on one side of the body than on the other. A polar graph showed that, while there was little difference fore and aft, a click on the near side of the moth was heard at about twice the distance of a symmetrically placed click on the far side.

This information extracted from the tympanic-nerve responses makes possible a crude prediction of the moth's behavior upon detecting an echo-locating bat. If it is assumed a bat is first detected at a distanc 100 feet and then approaches o straight path at right angles to moth's course while making chirp constant intensity, the differe tympanic response would decline f a maximum at about 100 feet to at 15 to 20 feet. Within this range moth would have sufficient infor tion to enable it to turn away from direct path of the oncoming bat. range of less than 15 to 20 feet neural information reaching moth's central nervous system w make possible only non-directi responses vis-à-vis the bat's positio

This is as far as we can go at pre in assessing the acoustic informa coded and transmitted to the mo central nervous system by the *A* c Until we know more about the a omy and neurophysiology of moth's pterothoracic ganglion brain we must redirect our curio

It is easy to show that some m respond to high-pitched sounds, s as the squeak of a glass stopper, jingle of keys or coins, the high n of a violin or flute, and a variety rustling and hissing sounds. But somewhat harder to describe just w they do. Some fold their wings fall to the ground; the flight of ot becomes faster and more erratic; s fluttering individuals become mot less; inactive moths may take fligh

Similar reactions can readily be served in moths being chased by b As a bat comes "silently" out of darkness the flight pattern of the m suddenly changes to any one of a n ber of maneuvers—dives, rolls, peated tight turns, or rapid flight above the ground. The bat may m a single pass, or turn at once to m another, or it may attempt to fol the moth through its gyrations. a dizzy "dogfight." Extrapolation string of acoustic dots in time is pi against unpredictability; power speed against maneuverability. The tails may be difficult to discern, but outcome is seen either as a bat ar moth going their separate ways, o a departing bat and moth wings tering slowly to the ground.

We made an attempt to find out extent to which the odds in this test are influenced by the avoida tactics of the moth. We observed encounters between bats and m and scored for the presence or sence of a sudden change in the fl rn of the moth as the bat ap- :hed, and for the outcome—cap-)r escape of the moth. Analysis of ooled data showed that for every reacting moths that survived an k, only 60 non-reacting moths ved. Thus selective advantage of ve action was considerable.

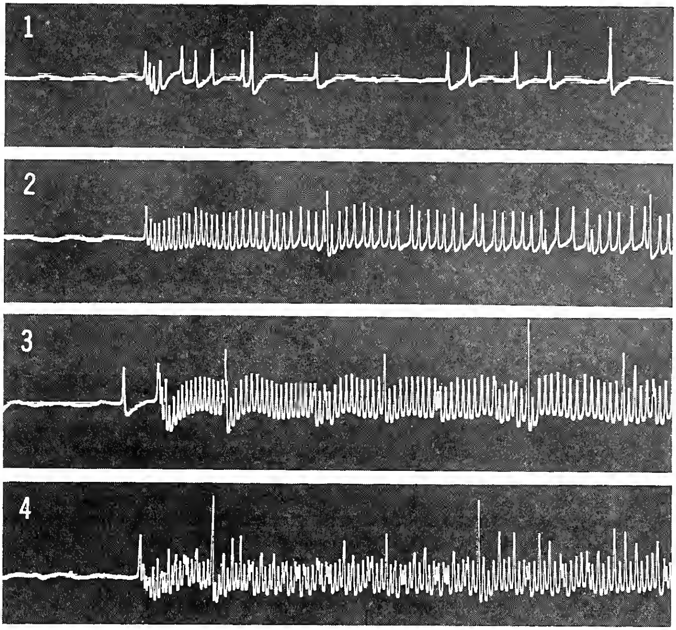
:H procedures focus upon only)ne instant in the life of a moth, ugh certainly it is an important lt is possible that at other times)ossession of tympanic organs vasive mechanisms weigh differ- even negatively, in survival, so measure does not describe the ıll survival advantage of posses- tympanic organs. Nevertheless, ld account for their evolution.

passing, it is interesting to note ome species of moths are prone to ation of the tympanic cavity by These parasites have been found est only one ear, however, and by ehavior pattern appear to insure)wn survival.

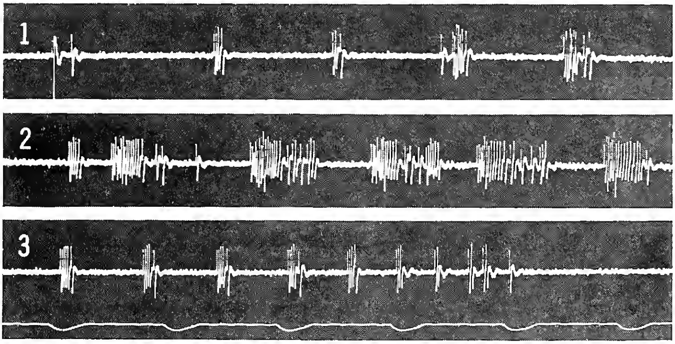
s not easy to tell at what instant sing bat first detects a medium- moth and turns to the attack. It unlikely that the bat makes tic contact at distances greater .0 to 15 feet. The tympanic-nerve s showed that within this range erage bat cry is capable of satur- both ears of a moth, so that the can make only non-directional ıses in attempting escape.

the tympanic organs can detect cry at distances of 100 feet and ps even more. At this range there arked difference in the nerve re- es of the right and left ears when earing of the bat is to the right of the moth. There would seem little survival advantage to the in making erratic turns and when the predator was still so t, although they could be of at close quarters when the small ıl moment and short turning of the moth is pitted against of the more massive bat.

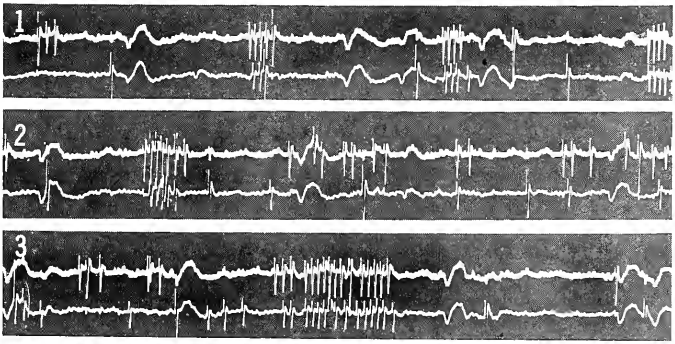
complexity of the natural situa- n which both sound source and or are continually on the move, educed by replacing the bat with ionary multidirectional trans- of ultrasonic pulses. The trans- was mounted on a 16-foot mast edge of a lawn surrounded by egetation. The observer was 25 feet behind a floodlight that ıated a broad area of garden and

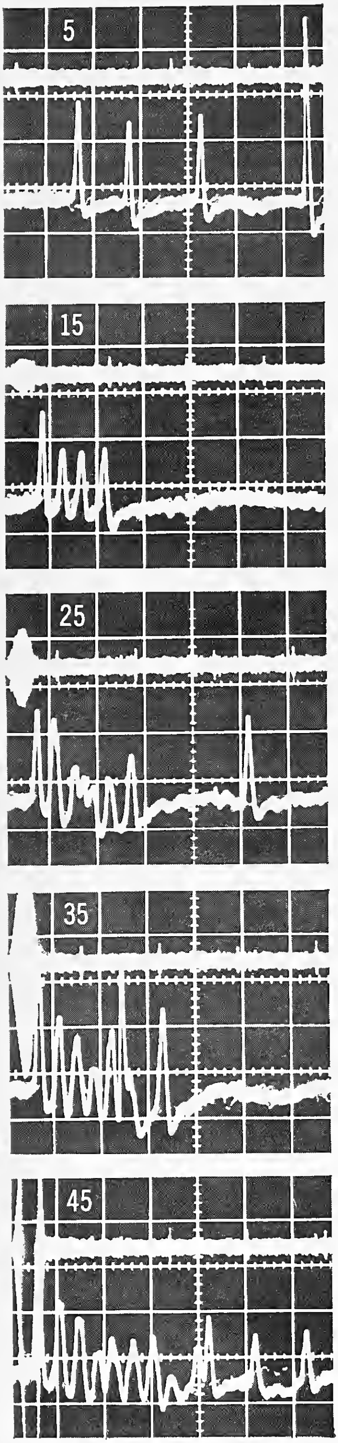


MOTH EAR RESPONSES to electronically generated tone increasing in intensity, from 1 to 4, are shown above. Pictures of responses to real bat appear below.



ELECTRONIC PICTURES of the way a moth using two ears hears a bat approaching and then moving directly overhead are reproduced in the series shown below.





Volume increases (decibels indicated) cause augmented neural activity of the moth ear, as shown by spikes. The bars are microphone's parallel responses.

silhouetted the transmitter on its mast against the night sky. This view of the transmitter was also framed in the field of a 35 mm. still camera.

The observer had at hand two switches, one controlling the ultrasonic signal and the other the camera shutter. When a moth was seen to move into the field of the camera the shutter was opened and the moth's track was recorded as a continuous line against the black background of the sky. Undulations on the line were caused by the moth's wing movements. After a stretch of flight track had been recorded the switch controlling the ultrasonic signal was depressed. This released a train of ultrasonic pulses, commonly at a rate of 30 per second, each 5-millisecond pulse having a frequency of 70 kc/s. The pulses were "shaped" as much as possible to resemble bat cries, but they lacked the frequency modulation of the bat's natural sound.

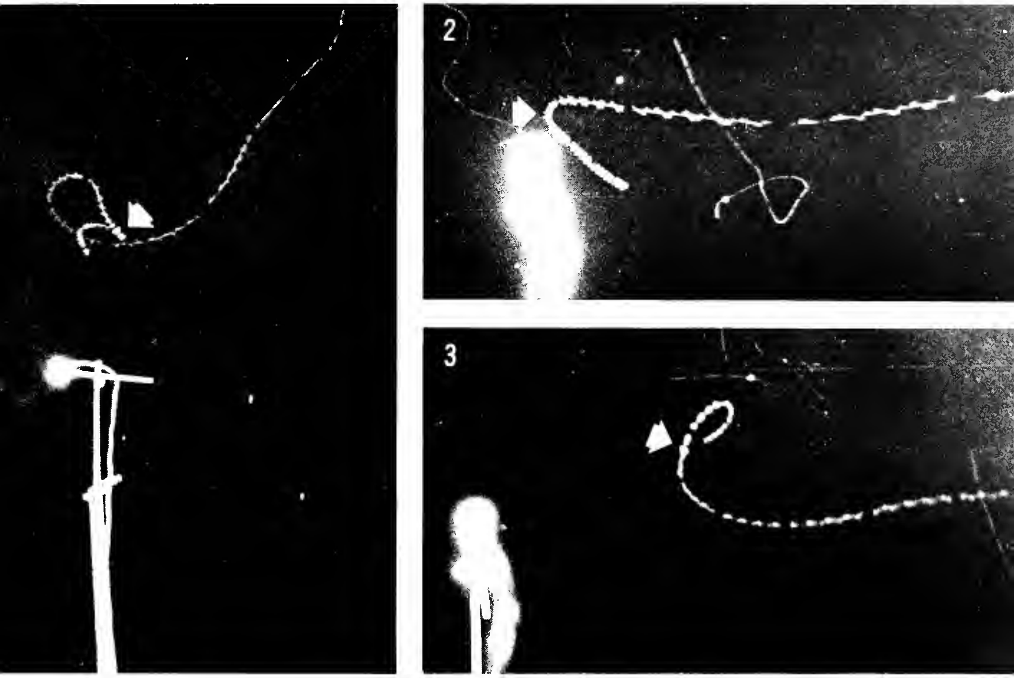
By the above means, the moth's flight path was recorded before and during ultrasonic stimulation. The onset of the pulse sequence is shown by an extra-bright spot on each photographic record, while the timing of events is indicated by gaps repeated at quarter-second intervals throughout the track *(photographs, opposite page)*.

The worst defect of the method is the large amount of light needed to secure a satisfactory photographic record. Light, we were afraid, might have altered the responsiveness of moths to a signal they normally encounter only in darkness. However, visual observers working with illuminations too low for photography, and with yellow and red light to which moths are much less sensitive than is man, reported no substantial differences in moth behavior. Another problem lay in the difficulty of identifying the moth species producing the tracks. Many flew away before they could be captured, while others dived into the vegetation and could not be found.

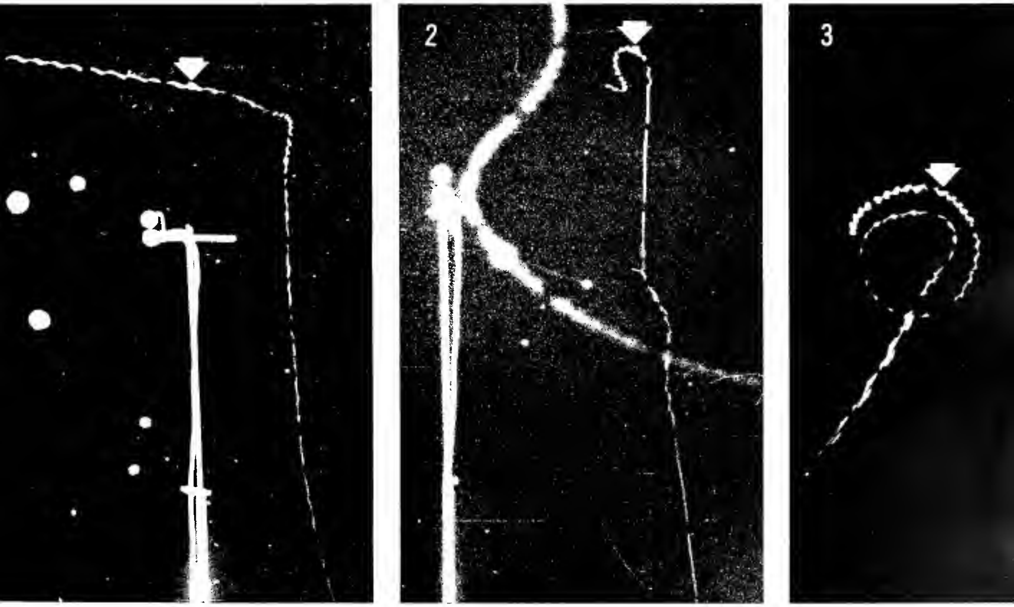
Moths that reacted within 10 feet or so of the transmitter showed a bewildering variety of reactions, usually ending in a dive, irrespective of whether the moth was above, below, or to one side of the transmitter at the time of the stimulus. The simplest
action seemed to be an abrupt
with wings closed. Moths reacting
greater distance from the transm
showed a distinct tendency to
away from the source of ultraso
and continue in level, although o
accelerated, flight.

Thus, the prediction of the ne
physiological observations seems t
confirmed by behavioral observati
high sound intensities produce
directional responses; low sounc
tensities result in directional
sponses. The great sensitivity of
tympanic organs must provide m
with an "early-warning" signal
prompts them to move out of the
eral area in which bats are feeding
the number of impulses in the
panic-nerve transmission increase
the saturation point the message
be thought to change to the "
cover" signal, at which point the m
dive for the ground.

Like most biological observat
this one raises a dozen ques
for every one it answers. Most o
moths making these tracks cert
belonged to the families Arcti
Phalaenidae, and Geometridae.
do the several families lacking
panic organs, some containing
mon and successful species, su
without ability to hear bat cries?
cently, two British workers, D.
and D. Pye, have shown that ce
tropical arctiids produce trains
trasonic clicks when teased or sh
It will be interesting to see how
ability to make noises audible to
fits into the contest between prey
predator. Tympanic-nerve resp
recorded from different moth sp
are generally consistent and sin
except perhaps for sensitivity. O
other hand, the variety of non-
tional maneuvers released by hig
tensity ultrasonic stimulation
any attempt at orderly descrip
Does each species have its charac
tic pattern of response? Or does it
a repertoire upon which it can
in random order? Does soun
tensity or some other sensory c
tion play a part in the pattern
sponse? There is some comfort i
thought that this unpredictal
however determined, is probab
confusing to the bats as it is to tl
perimenter, and therefore may a
of considerable importance in th
vival value of moths' evasive beh



T PATHS of moths responding to artificial ultrasonic sequence at night are shown here. Sound source is on : pole. Dotted appearance of paths is result of light flashing every $\frac{1}{4}$ second. The flare surrounding the sound source is result of overexposure and is not a light source. Arrows mark onset of stimuli. Note moths' evasive moves.



D EVASIVE RESPONSES stimulated by the pulse sequence monstrated above. One moth (1) goes into power dive r (2) drops passively toward the ground by folding in its wings, which it uses again briefly about halfway down; last moth (3) banks into a looping dive. White dots, and indistinct track (2), are caused by insects near camera.

SKY REPORTER

gnitude scale of stellar brightness had its origin in 120 B.C.

By Thomas D. Nicholson

WINTER SKY is always impressive. The brilliant stars
he winter constellations – Taurus, Auriga, Orion
Canis Major, and Gemini—dominate the early eve-
in the south and east, and the west usually appears
comparison. But this January the western sky con-
o objects—Venus and Jupiter—that are more than a
or the stars in the east. The map of the January sky
3) shows the position of Venus on the western hori-
he end of the month and the position of Jupiter
he month. The positions of Venus earlier in Janu-
not be shown on the map because the planet will
before 9:00 P.M. and will be below the map's west-
zon. In the illustration on page 42, however, which
n drawn to show the southwestern sky at one and
hours after the sun has set, the path of Venus is
hroughout the month.

ap or illustration can do justice to the brilliance of
nd Jupiter, or, for that matter, to that of the bright
tars such as Sirius, Rigel, and Capella. Stars of dif-
agnitude must be represented on maps by symbols.
stars may be distinguished from fainter stars by
mbols of different shape or of different size, or by
ination of both. In any case, the symbols serve
to identify the stars and can only approximately
t the visual impression of their brightness. Part of
lem is that the stars do not vary in size and shape
e map symbols, but part also lies in the way our
ct to objects of different degrees of brightness.

human sense responds to its stimulus according to
hophysical law formulated in 1869 by the German
ental psychologist Gustav Theodor Fechner. Fech-
rved that the apparent difference in brightness be-
he bright and dark portions of a cloud remained
t when the cloud was viewed through filters of vari-
sity. He thus concluded that the eye, when it observes
fferences in the brightness of objects, reacts to equal
f intensity rather than to equal differences of inten-
he light sources. Expressed in another way, when
nsity of the stimulus increases geometrically, the
y of the visual sensation increases arithmetically
m, page 42).

ier's law provided a psychological basis for some-
tronomers had already known for some time—that
nitude scale used for the stars did not represent con-
fferences in brightness from one magnitude to the
t rather constant *ratios* of brightness between the
des. And astronomers had already obtained a rea-
accurate estimate of the ratio represented by a
gnitude difference.

nagnitude scale astronomers use has its origin in the
logue compiled about 120 B.C. by the Greek astron-
ipparchus. He identified the brightness of the stars
talogue by dividing them into six groups, of which
comprised the brightest stars he could see and the
e faintest. Stars belonging to each successive class
e first to the sixth appeared to be one-half the brightness of those in the preceding class. The use of the term "magnitude" for these brightness classes implies differences in size, and may have arisen from the assumption that the brighter stars were larger and the fainter stars smaller, although we know today that this is not necessarily so.

The invention of the telescope radically altered the meaning of star magnitudes. It was seen telescopically that there were many stars fainter than Hipparchus' lowest magnitude, the sixth. For identification purposes it was desirable to extend the magnitude groups to include them. Furthermore, stars within the same magnitude class were not at all the same in brightness. It became necessary to add a decimal to the magnitude of a star to distinguish it from other stars of its class. Some very painstaking observers found it imperative to add a second decimal to represent the differences they could see. With these modifications of the original classification scheme, the magnitude of a star became a quantitative measure of the star's radiation, and it became important to know how much of a difference in light intensity one magnitude represented.

WILLIAM HERSCHEL, working in England near the turn of the nineteenth century, and his son John Herschel, observing from South Africa in 1834-1837, were both convinced that the average first-magnitude star was very nearly 100 times brighter than the average sixth-magnitude star. C. A. Steinheil, a contemporary of John Herschel, found that the average ratio of intensity from one magnitude to the next was about 2.83. The ratio between first and second magnitude was higher, but many of the brightest stars, all classified as first magnitude, differed so greatly from one another that they were really not all of a class. Between the less bright magnitudes, Steinheil found a more constant ratio of approximately 2.5.

Another English astronomer, N. R. Pogson, pointed out in 1850 that the Steinheil ratio of 2.5 between magnitudes represented a difference of brightness of 2.5 raised to the fifth power for five magnitudes, which was very near to the factor of 100 times that the Herschels had observed between the first- and sixth-magnitude classes. Pogson proposed that the ratio of 100 be adopted as an exact standard for a five-magnitude difference. The ratio between successive magnitudes would therefore become the fifth root of 100, or 2.512. Pogson's proposal is the basis for the magnitude values that are assigned to the stars today.

The stellar magnitude scale may seem confusing because the lower numbers are assigned to the brighter stars. But the system has a long tradition and offers a scale that astronomers, its principal users, find convenient. It has been easily extended to fainter objects as these became known, and to objects brighter than first magnitude as well, simply by maintaining the constant ratio between magnitudes. Ob-

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Star symbols illustrate arithmetic *(top)* and geometric *(bottom)* area increases. Upper symbols grow by a constant increment and lower ones increase by constant ratio (1:2).

jects fainter than the sixth magnitude are designated seventh, eighth, ninth, and so on. Those brighter than first magnitude are designated by numbers that decrease from one to zero and then increase to higher negative numbers.

Polaris, the familiar North Star, is almost exactly second magnitude—it served as a standard reference star to establish the starting point of the magnitude scale until its very slight variability was detected.

The brightest star we observe is Sirius, with a magnitude of —1.42. Sirius is therefore about 3.42 magnitudes brighter than Polaris. Its light intensity, or luminosity, is approximately 23.3 times as great as the luminosity of Polaris. (The figure 23.3 is obtained by raising the ratio 2.512 to the power 3.42, which may be done most conveniently by making use of logarithms.)

The brightness of the planets, of the moon, and of the sun are also represented as numbers on the magnitude scale. The brightness of Jupiter this month varies from —2.1 at the beginning of the month to —1.8 at the end of the mc The difference between Jupiter's magnitude at the start at the end of the month is three-tenths of a magni which represents a loss of light intensity of about 13 cent. This occurs because the distance between Jupiter the earth is increasing.

The magnitude of Venus is —3.4 in early January. is about two magnitudes brighter than Sirius, the brig star, so that Venus this month is about 6.3 times as l nous as Sirius. By the middle of May, however, Venus brighten to magnitude —4.2, or very nearly double its l nosity in the sky this month, and it will display thi times the luminosity of Sirius.

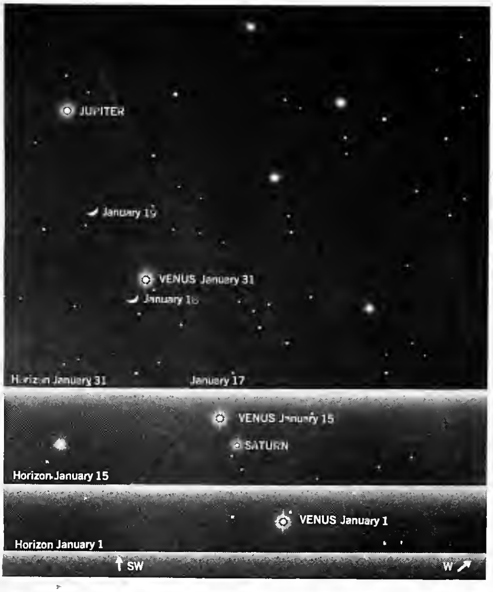
These differences illustrate the impossibility of re senting the visual impressions of celestial object star maps. To show Venus in correct relationship to S on this month's map, its symbol should have an area r than six times that of the symbol for Sirius, which sh be, in turn, about twenty-three times the area of the sy for Polaris. The map would be so cluttered with large bols that it would make no sense.

The magnitude of the moon, on the same scale as stars, is about —12.6 at its brightest; the sun is about — The difference in magnitude between the sun and S corresponds to a luminosity difference of about ten bi times. In other words, to equal the sun in brightness, sky would have to contain ten billion stars as brigh Sirius. The difference between the magnitude of the sun that of the moon is about 14.1. The sky would have to l more than 430,000 full moons to equal the illuminatio receive from the sun.

The interesting analogy between the luminosity of sun and that of Sirius suggested to Christian Huyge Dutch astronomer of the mid-seventeenth century, a of estimating the distance to the stars in terms of the s distance, probably the first serious attempt to find st distances. By viewing the sun through a series of pinh of diminishing size, Huygens reduced its apparent bri ness to his estimate of Sirius' apparent brightness. He succeeded in obtaining a value for how many times fai than the sun was Sirius. Knowing that the intensity of l falls off in proportion to the square of distance, Huy could then determine how many times farther Sirius from the earth than was the sun.

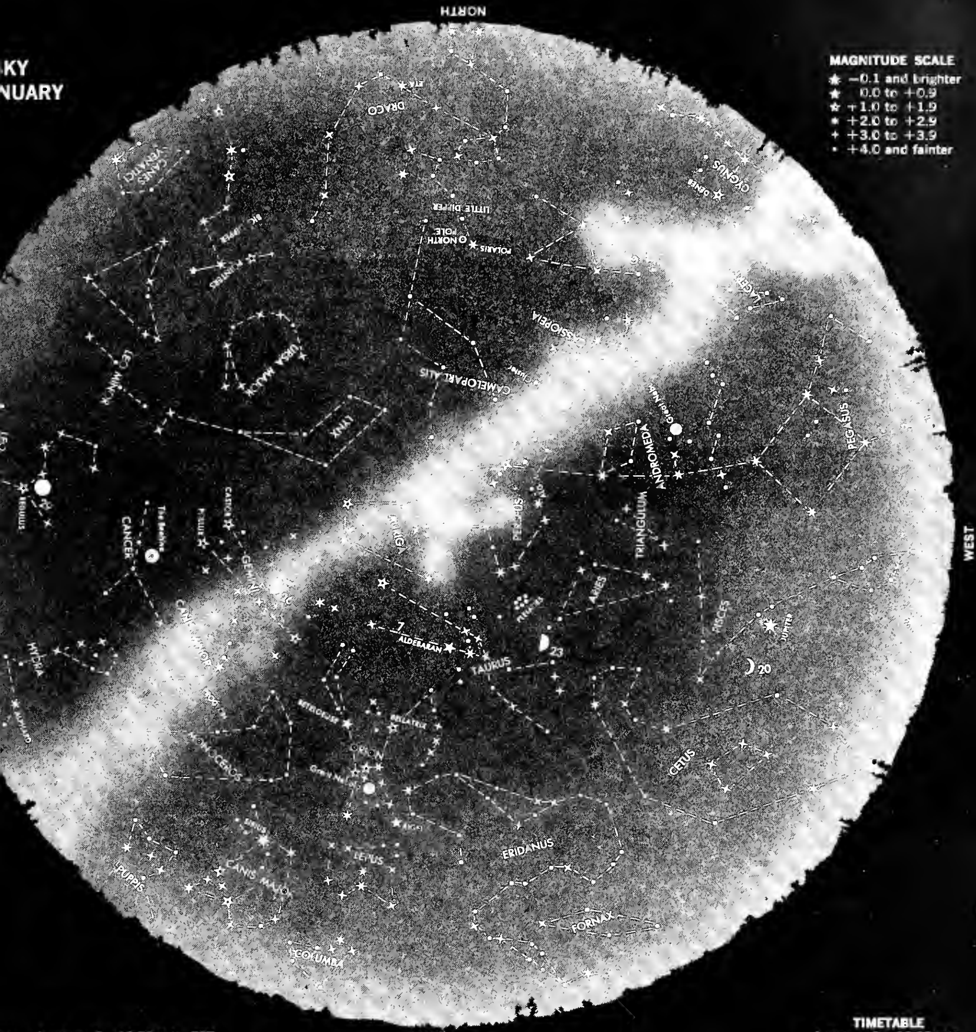
Huygens' estimate of the distance to Sirius was too s by a factor of twenty times. Part of the error was ca by inaccuracies in his measurement of the brightnes the sun and of Sirius. But part also resulted from the f as we now know, that Sirius is intrinsically a much brig star than the sun—almost twenty-three times brighter. Huygens known this and allowed for it, his result w have been surprisingly accurate.

In the centuries that followed Huygens' work, techni were developed for accurate measurements of star bri ness by visual methods, later by photographic, and later by photometric methods. And today we have crit that indicate the intrinsic brightness of the stars, so careful measurements of apparent brightness are very ful in estimating stellar distances, using the fundame principle that Huygens used almost three centuries ago. next month's "Sky Reporter" we shall consider the relati ships that are found between visual and photographic m nitudes, and between apparent and absolute magnitu



Planets in western sky are shown relative to horizon 90 minutes after sunset January 1, 15, and 31. Venus, moving toward the east, appears higher up in the sky each night.

KY
NUARY



er January 6, 10:53 A.M., EST
January 14, 3:44 P.M., EST
er January 22, 12:29 A.M., EST
January 28, 6:23 P.M., EST

TIMETABLE

January 1	10:30 P.M.
January 15	9:30 P.M.
January 31	8:30 P.M.

(Local Standard Time)

ary 2: Earth is at perihelion, its shortest distance from for the year—about 91,342,000 miles.

ary 2-4: The Quadrantid meteor shower, radiating from east of the Big Dipper's handle, reaches its brief m rate, an expected twenty-five meteors per hour. The gibbous moon will impede observations after midnight.

ary 9: Venus and Saturn are in conjunction at approxi- 5:00 P.M., and they will be quite close in the evening k for Saturn about a degree from Venus, slightly above o the right.

ary 11: Tonight observers with binoculars may see s four brightest satellites, arranged two on each side planet and very nearly equidistant from one another m the bright central planet. Callisto and Europa are est of Jupiter, Io and Ganymede to the east.

ary 14: A partial eclipse of the sun, the first of six for 1964, takes place in the Southern Hemisphere.

ary 17: Venus and the early crescent moon are in con- at noon. By sunset the moon will have moved to the Venus, but the two are still an interesting sight in the twilight (illustration, opposite page).

January 20: Jupiter and the moon are in conjunction about 2:00 P.M. By dark, Jupiter is slightly below and to the right of the crescent moon, two days before first quarter.

January 26: Mercury reaches greatest westerly elongation from the sun and may be seen in the morning sky.

Venus, Jupiter, and Saturn are all in the evening sky, toward the southwest, in early January. Venus and Jupiter are bright enough to be seen in the early twilight. Venus is the brighter and lower of the two (magnitude —3.4 early in January and slowly brightening through the month). Jupiter, magnitude —2.0 at midmonth, is still brighter than any star. Saturn, at magnitude 1, cannot be seen until dark.

Throughout January, Venus remains in the sky from two and a half to three hours after sunset. Jupiter sets about midnight at the start of January, and progressively earlier through the month. It sets about 10:00 P.M. by month's end. After the middle of the month, Saturn is too close to the sun to be seen in the evening sky.

Mercury is in the morning sky at the end of January. For a few days before and after January 26 it may be seen low in the southeast about one and a half hours before sunrise.

Adult male chimpanzees in Budongo Forest, Uganda, of the subspecies *Pan troglodytes schweinfurthii*, are sh in habitat. Mainly eaters of fruit,

able of diet adaptations. These
ants picked from tree barks.

The "Man of the Woods"

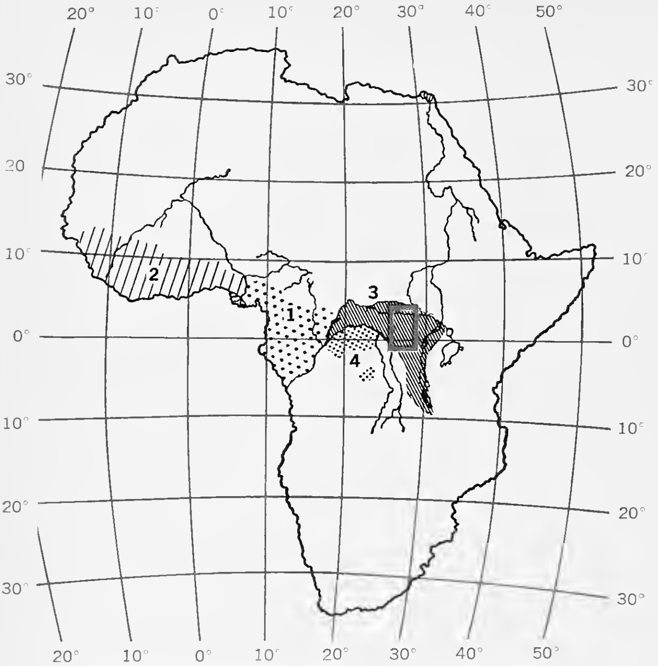
New studies outline chimpanzee behavior

By Vernon Reynolds

The chimpanzee *Pan troglodytes* occurs throughout the vast equatorial rain forest belt of Central and Western Africa, a continuous distribution measuring three thousand miles from end to end. Several forms of the species are found in this area, of which the following three are generally recognized as subspecies: *Pan troglodytes schweinfurthii* of Central Africa, *Pan troglodytes troglodytes* of the West Congo, and *Pan troglodytes verus* of West Africa. A fourth type of chimpanzee, *Pan paniscus,* is found south of the Congo River and is often taken to be a second species. The last is popularly known as the pygmy chimpanzee. (Morphological differences between the forms are minor except in the case of *Pan paniscus,* which is a true dwarf.) The various chimpanzee types are separated by the great rivers of Central and West Africa *(map, page 46).* Outside the rain forest zone, chimpanzees have pushed the borders of their habitat into the surrounding areas of woodland, gallery, and montane forests, showing a wide variety of dietary adaptations.

My wife and I studied the eastern form, *Pan troglodytes schweinfurthii,* from March to October, 1962, in the Budongo Forest, Uganda—a rain forest environment at the eastern edge of the animals' range. Here we set up a base on a hillock overlooking the forest, and made daily forays in search of the elusive chimpanzees when their immensely loud vocalizations made it possible for us to track them. Food is plentiful during most of the year, and when it is, the animals are vociferous to a degree that usually makes it possible to find them. There was a scarce period, however, in May, during which they were widely scattered and silent most of the time.

Adult chimpanzees are fairly large animals. Males weigh approximately 110 pounds and females about 90 pounds, and their size alone helps to account for many aspects of their behavior. Although they are primarily frugivorous, like the smaller redtail monkeys *(Cercopithecus ascanius schmidti)* and blue monkeys *(Cerco-*



Distribution of subspecies is indicated by the shadings on the map: (1) *Pan troglodytes troglodytes,* (2) *P. t. verus* Schwarz, (3) *P. t. schweinfurthii* Giglioli, (4) the pygmy species *P. paniscus* Schwarz. Square marks the study area.

pithecus mitis stuhlmanni) with which they share this forest, the chimpanzees' needs are so much greater than those of the monkeys that they cannot lead a treetop existence as the monkeys do.

Almost every day (the exceptions occur when many fruiting trees are found in a small area) chimpanzees move around on the ground over considerable distances, from one tree to another. While on the ground they feed on the fleshy stems of certain shrubs and creepers, a diet more characteristic of the gorilla. We estimated that in the Budongo Forest up to 75 per cent of the chimpanzees' daytime was spent in the trees, and that about 90 per cent of the total bulk of their food consisted of fruits. There is no factor limiting the height at which chimpanzees feed. Every day they climb into the crowns of trees to heights of 120 feet to 180 feet, depending on the type of forest. In the slack season, however, more time is spent on the ground, and the young, tender leaves of saplings and vines become important dietary items.

One aspect of our study was on locomotion, eleven forms of which we recognized in chimpanzees *(table, page 48).* Because they are primarily fruit eaters, they must be able to move about in the tracery of fine branches at the edge of tree crowns. The animals are too heavy to do so by standing on the branches as monkeys do, so they have developed ways of supporting their weight from branches less than one inch thick. They can hang for several minutes from one or both arms, or any combination of arms and legs. When walking on the ground or on sturdy branches one hundred feet up or higher, they walk on the knuckles and do not grasp the branch with the hands. The backs of the second phalanges are provided with a special development of thickened skin in connection with this form of locomotion. The hallux, or big toe, is used in opposition to the other toes to grasp the branch. Perhaps the most striking facet of chimpanzee locomotion is the diversity of forms it takes. No acrobatic is too difficult for this amazingly long, loose-limbed creature, which combines arboreal specializations such as brachiation and h
ing upside down from branches
the more common locomotor patt
of walking and running on all fou

For adults some six to eight h
of the twelve-hour equatorial day
occupied in the food quest. Young
up to the age of about six years re
less food, and while they generall
along after their mothers, they s
much time playing, either alon
pairs, or threes, while the adults
feeding. Their games consist of
ing and wrestling matches and cl
ing and swinging games, in which
youngster follows the route take
another. During the non-feeding h
usually at midmorning after a bo
intensive feeding, or at any time
ing the heat of the day when fo
abundant, the adults either settle
in quiet little groups to groom
other or sit looking out over the f
doing absolutely nothing.

One prominent feature of chim
zee social life is the absen
any clear dominance hierarchy ar
males or females. Females were
observed to show dominance o
male, and among the males, tho
confident bearing and larger size
dominant in food competition. D
nance, did not, however, extend
clusive rights over receptive fen
Quarrels were rare: during three
dred observation hours, only seve
quarrels were seen, and none of
lasted more than a few seconds.
competition was the usual cau
strife. There was, however, som
dence of leadership by large, conf
males: when they left a tree, the
chimpanzees followed. They woul
pear first at track crossings and
sometimes go back across the
against the direction of progress,
to bring up the rear. Also, whe
disturbed a band in the fores
they fled, such a big male would
times remain behind watching us
lessly from low down in a tree.

The age of sexual maturity c
easily be determined in the wil
evidence based on captive spec
shows that males reach pube
seven to eight years, while female
menstruate between seven an
years, averaging eight years,
months. When a female is in o
and her sexual swelling is at its h
nearby males are often attract
her, and several of them may
her around. But we only rarel

INGING MALE, *top picture*, **can move more swiftly than the thers shown transporting young,** *below*. **Speed and agility often the bases for chimpanzees' coalescence into groups.**

served copulations, which occur far less frequently than in baboons or macaques, but more frequently, it seems, than in gorillas.

As in most primates, the closest social bond is between a mother and her offspring. During the first few months, the infant clings tightly to its mother's belly (cf. gorillas, where the mother supports the infant with one arm, NATURAL HISTORY, August-September, 1963). As it ceases suckling and becomes independent, the infant's early efforts are directed at exploring the immediate environment. By two years of age it is already supplementing its diet with leaves. At three years it can swing by its arms. Whenever there are two or more mothers together, the juveniles wrestle, chase, kick each other, and indulge in other strenuous play. Periodically they return to the mother for a while, often to suckle or to be groomed. The way in which a mother carries her young depends on its size, the place, and the speed of travel. The smallest infants cling to the mother's belly and can suckle in this position. Juveniles older than one year, but less than three, are usually carried on the belly through the trees and on the back when the mother is moving along the ground. The young also move around independently when there is no hurry and occasionally are carried by females other than the mother. Juveniles over three years of age are not normally carried through the trees, but are carried on the mother's back when she is traveling fast or crossing a road. At other times they trot along behind or near the mother. This continues until they are five or six years old, and a third of the mother's size. By then she sometimes has a second infant, in which case she carries the two, one on the belly and one on the back. When a mother wants to move off, she conveys the idea to her infant either by looking at it, or by stretching out one or both arms toward it.

WE once saw a mother make a tree bridge high above the ground by pulling a branch from a second tree to enable her juvenile to cross: she herself swung over the gap on the branch. At other times, it seemed that a juvenile was left to fend for itself, particularly if it was the first of the group to spot us. Often it would then begin to scream, but the mother and other adults nearby did not investigate.

The chimpanzee makes a nest to

FORMS OF LOCOMOTION

Movement	Characteristics	Ground Trees	Approximate distance covered
 Quadrupedal walk	Typical quadrupedal limb movements, with weight of body's fore part supported on knuckles; hind feet are placed flat on ground; relaxed in confident animals.	Both	Any
 Quadrupedal run	Typical quadrupedal movements; at one point all feet are off ground.	Both	Any
 Rapid run	Legs move forward alternately while arms move forward together.	Ground	30 feet, plus
 Gallop	Fastest run; it is used when animal hurries to catch up with others or is frightened; limb movements are unclear.	Ground	30 feet, plus
 Vertical climb	Arms and long hands keep secure grip on tree while legs provide upward thrust; feet are placed on side of tree chimpanzee faces; big toe is splayed to increase traction.	Trees	10-100 feet
 Bipedal walk	Rarely used; arms may not be swung in time with legs but hang loosely down.	Ground	Maximum seen, 9 paces
 Bipedal walk on legs with use of arms	Independent arm and leg movements; overhead branches allow chimpanzee to use its arms for added support as it walks on a branch.	Trees	15 feet
 Ground leap	Legs are swung forward under chimpanzee and land before arms do; e.g., over ditches.	Ground	6 feet
 Vertical leap	Animal uses its limbs merely to check its fall as it drops from branch to branch.	Trees	30-foot leaps
 Swing	Arms are extended forward to grasp a branch; whole body is then swung across; used for moving from tree to tree.	Trees	10 feet
 Brachiation	Hanging from a branch, animal moves along by means of alternate arm movements, swinging body forward, backward, and to each side in turn.	Trees	20 feet

ADULT starts across a jungle roac
employing the typical quadrupedal

sleep in at night—a behavioral c
acteristic that it shares with the c
great apes. First, the site is selecte
the basis of the availability of spr
branches an inch or less in diam
The animal squats on a branch,
pulls other branches toward itself.
breaking many of them. It traps t
under its feet and holds them in p
Then it turns around *in situ*, s
speak, intertwining the branche
some extent, and so makes the l
nest structure. A final layer of l
branchlets, picked around the nest
or collected from a few yards awa
then added. The chimpanzee
climbs into the nest and makes i
comfortable. It is now completely
den from the view of an obse
standing on the ground—all one se
an arm or leg dangling over the e

NEW nests are ordinarily made
night, and we never found
dence that any nest was re-used
sleeping. However, one observer
seen frightened chimpanzees hid
an old nest (in the Maramaga
Forest). We once saw a mother
frightened by us, made a nest
cially to hide in. Of the 259 nest
found, only two were on the gro
all the rest were in trees. Of the
ground nests, one was a large struc
made of masses of broad-leaved g
and the other was made mainly
pithy shrub, with the addition of s
branchlets taken from nearby sapl
The commonest height (30 per ce
the total number observed) was t
to forty feet, but nests were foun
all levels, and 15 per cent were hi
than ninety feet. This indicates
while there is no fixed rule, chim

op, employed by this adult male, atively rare form of locomotion.

In quadrupedal run, animal's hands and feet leave ground simultaneously.

Rapid run, with arms synchronized but legs in a trot, propels another animal.

prefer to make their nests in the
rstory or lowest tree canopy, and
in the tops of relatively low sap-
Several reasons can be advanced
is preference. First, at this height
opmost branches of saplings are
er and springy, easy to intertwine,
comfortable to lie on. Second,
is less disturbance from wind at
levels than in the treetops. Third,
gs may provide a measure of
ction from leopards, which are
le to climb them without rocking
est and disturbing the chimpan-
they could creep silently up to a
uilt in a big tree.

opards do not, however, provide
at problem for today's Budongo
anzees, judging from available
nce. They are common in the
t, but on each occasion we en-
ered them, they were either chas-
r eating one of the two species of
rs (small African antelopes of
enus *Cephalophus*), which are
common in the area, and which
ntly are the leopards' preferred
Probably there is no systematic
tion by any animal on the Bu-
Forest chimpanzees. Man pro-
a threat in certain areas, but not
No interactions with elephants
observed. Once a chimpanzee vo-
d loudly as a buffalo charged
That leaves only the snakes. Of
, the only potential predator is
ython; one that I shot had a
r in its stomach. Other snakes,
as cobras and the Gaboon viper,
ommon in the forest and could
inly kill a chimpanzee in self-de-
, but are too small to eat one. We
came across lone, young chim-
ees, wandering about some distance from any others, which suggests that they are able to survive without the protection of a group.

The word "group" introduces the most complex and perhaps the most interesting aspect of chimpanzee behavior in the forest. Our observations showed that there is no single, distinct social unit in chimpanzee society. Not only is there no "family" or "harem" organization; neither is there a "troop" organization—that is to say, no particular chimpanzees keep permanently together. On the contrary, individuals move about at will, alone or in small groups best described as bands, which sometimes form into large aggregations; they leave their associates, if they want to, and join up with new ones without conflict. This surprising observation resulted from careful identification of individual chimpanzees as they came day after day to feed on particular ripe fruit trees, or as they crossed forest tracks. In each case, we found that specific known individuals were associating with unknown ones, or known ones with other known ones with which they had not associated previously.

However, we did notice some consistencies in band composition. We met four distinct *types* of bands frequently: one consisted only of adult males; one was made up only of mothers, their offspring, and a few other females; one contained adults and adolescents of both sexes, not including mothers with young; one contained all classes of animals mixed together. The male bands were the most mobile, often traveling fast and noisily and covering many miles in a day. Mothers' bands, as one might expect, were the least mobile, and tended to occupy a limited area for several days. Both of these types were usually fairly small (fewer than seven individuals), but often would join others to form mixed bands in trees that offered plentiful fruits. The adult and adolescent bands were more mobile than the mother bands, but less so than the male bands. None of the bands was permanent, but we did notice one made up of four adult males that were together frequently during a four-month period.

An area that contains a year-round supply of food trees may be called the range of the chimpanzees inhabiting that area. Two such ranges that we knew, each about six to eight square miles in area, contained about sixty to eighty chimpanzees each. While the activities of these animals were largely confined to their home ranges, they often crossed into the neighboring range, and in the early stages of our study it was not clear to us just how separate the inhabitants of one range were from those of another.

As the year went by, and one fruiting species gave way to another, it became obvious that the prime factor determining the movements, location, and group size of chimpanzees was the distribution of the available food supply. We started our study during the fig season. There are many species of figs, some of which have very small fruits. The preferred ones, however, all have large, juicy, yellow fruits when ripe, and exude a copious flow of white latex. During this season, animals in bands of a dozen or so were dotted about the forest, mainly along valley sides where the fig trees grow. Each band fed on a giant, fruiting fig tree and moved along the valleys from one such tree to another. There followed a distinct three-week period during May when comparatively little fruit was available. Then the chimpanzees were scattered widely and foraged on their own, or in twos and threes. They kept low in the saplings, moved frequently, and were quiet.

When we saw them, which was not often possible, they were eating leaves, especially of *Celtis spp.* In addition, examination of their feces showed that they were subsisting largely on leaves, as the feces were green and contained no seeds. Later came the *Pseudospondias* season. This fruit is something like a wild damson plum in appearance. It is almost an inch long, smells of turpentine, and hangs in dense blue-black clusters from gnarled trees that are found only in areas of swampy forest. At this time chimpanzees, attracted from surrounding areas by the fruit, gathered in larger bands that were strung out along the swamp forest zones where *Pseudospondias* was to be found. In due course, during early July, their fruits, too, failed, and the chimpanzees began switching their attention to a new tree, *Maesopsis*, which was just beginning to ripen. This fruit is the size and shape of an olive; it is black when ripe, and bitter to the taste. (The wood of the *Maesopsis* tree has a distinct odor of cold, cooked chicken!) The species occurs in stands where the forest is either regenerating or is growing out into areas previously occupied by grasslands. During the *Maesopsis* season, chimpanzees gathered in the trees' vicinities in large groups of fifty or more.

The fluid social organization can thus be seen as an adaptation to the needs of large fruit eaters in a forest environment. Let us contrast them with gorillas. The latter are even larger and need as much or more bulk to eat, but they are herbivorous rather than frugivorous and so are constantly surrounded by food. As a result they can wander along slowly, feeding as they go. Groups of wandering gorillas may spread out in the food quest, but there is no *need* for them to split up into subgroups in order to exploit the food supply. With chimpanzees in the Budongo Forest, this is not the case. There are times when there is insufficient fruit in an area to support chimpanzees unless they are very scattered, each one foraging for itself or in company with one or two others, at most. At other times, food is concentrated in a relatively small part of the total range, and so it is necessary for all the chimpanzees in the area to congregate. The absence of permanent groupings may be an adaptation to these conditions.

Food availability is communicated by wild and piercing vocal choruses of bands of excited chimpanzees that have, perhaps, found a gloriously full-ripe fig tree. Comparison with the gorilla reveals the interesting fact that the latter, which is far less vocal than the chimpanzee, also has much smaller ears. The chimpanzee chorus can carry over a measured two miles. On hearing cries from another part of the forest, feeding chimpanzees will look over in the direction of the calls, and pause discernibly in their chewing, as if thinking. Then, sooner or later, they will start toward the direction of the calls. As they move along the forest floor, they announce their whereabouts by repeated hooting and fierce drumming on tree trunks, especially those of the ironwood *(Cynometra alexandri)*. These expressive outbursts have a most intimidating effect on humans who witness them at close range.

Local Africans are not frightened of the chimpanzees, however. One word for the animal means "man of the woods," and the chimpanzee is tolerated as a neighbor living in the same area. This neighbor does not arouse anger, for it does not raid crops. It is not regarded as a good meal and, indeed, is seldom even seen. Chimpanzee hunting is prohibited by law in Uganda, so fortunately there is no immediate danger to the continued existence of these fascinating creatures. There is only one cause for concern. Many of the trees, such as the fig, that provide the chimpanzees with their staple foods during part of the year, are at present being poisoned off to make way for more economically valuable timber species, such as mahogany. This trend, if continued at the present rate, could lead to a substantial reduction of the Budongo Forest's chimpanzee population (now between one and two thousand) before the end of the century. However, the Uganda Forest Department is at present considering the possibility of excluding figs from the poisoning program. They, too, are quite concerned about the preservation of these chimpanzees.

NT evidences burden borne by nd phalanges of chimpanzee's s. Thumb left no trace in mud.

ND NESTS, like one shown at right, are finds in study area. Treetop are safer from jungle predators.

LE ADULT feeds on figs (*Fiscus sis*), which are the primary food mpanzees in the Budongo Forest.

Index to ext Spring's Growth

d system controls tree development

By Virgil Argo

ED FIDDLEHEAD, leaf producer of *Osmunda cinnamomea,* is shown at Leaf unrolls as growth proceeds p of the innermost spiral. Many leheads, *above,* come up from root.

For aesthetic, economic, and scientific reasons, flowers, fruits, seeds, leaves, and roots have long attracted a goodly portion of man's interest in the natural world. The dormant buds that occur on leafless twigs of deciduous woody plants have hardly a single characteristic fetching enough to attract the casual eye of the passer-by, however, and these buds have been largely ignored by all except botanists, who find them of great value in identifying species of woody plants in the leafless state. It was in an effort to aid students to make use of these highly efficient keys to the species of woody plants that we first prepared photographs of dormant twigs for study in the classroom. Students were able to see taxonomic characters, and to carry with them into the field fully visualized concepts, including knowledge of color, relating to plant structures they had never examined before in vivo. About thirty different species of woody twigs were photographed in an effort to illustrate the different structures referred to in the keys.

Any twig with its bark, leaf scars, buds, and bud scales is surprisingly photogenic. The only cosmetic treatment necessary is a gentle, careful wash in soapy water to remove soot and dust. Once this unnatural shell is taken away, one finds attractive external colors, textures, and structures.

If we want to inquire into internal makeup, a simple razor blade dissection of any fair-sized bud will show it to be a highly intricate and ingenious device for the protection of a dormant plant part that will, upon the onset of proper growing conditions, provide immediate and adequate leaf supply. What one finds inside the bud is an embryo branch, with stem, leaves, and sometimes flowers already recognizable. The basal leaves of this foreshortened new branch have been modified into tough scales that overlap each other and give physical protection to the tender tissues of the rest of the twig. Often these bud scales are hairy or woolly on the inner faces, and have a waterproof varnish on the outside; these two features prevent the living tissue from being desiccated by dry, windy weather or penetrated by rain. If the downy fuzz so abundant inside many buds is kept dry, it forms an efficient insulating material to guard the embryonic meristematic tissues against too rapid and too frequent changes of temperature during the winter.

The light and warmth of spring stimulate the movement of food and water through the capillary tissues of the plant and cause growth to begin in these embryonic tissues. The twig in the bud swells and elongates, the bud scales fall off, and in a remarkably short time a young but fully formed branch is visible. Along any branch there is at least one bud in the axil of each of last year's leaves, and each bud has the ability to produce a new branch with leaves of its own.

If all buds developed with equal vigor, in a few years the tree would become an astonishing, inefficient mass of branches and leaves. Such confusion is avoided through the exercise of a priority present in the developing buds and leaves. The bud at the tip of the stem shows greatest growth vigor, and the buds below it display vitality on a descending scale, until after a certain distance below the terminal bud we find axillary buds that normally never develop further.

Leaves also are larger near the tip of the branch than at its base. These gradients of development are of utmost importance to the well-being of the growing tree; they maintain a most efficient mosaic of leaves in which there is a minimum of overlapping that could result in shading photosynthetic tissue and rendering it ineffective.

This axial gradient of bud vigor along a stem has long been recognized by horticulturists, who have used it when they deemed it advisable to alter the natural shape of a woody plant without causing functional damage. When the tip of a twig with its terminal bud is removed, the bud next below the cut is raised to the priority of vigor and growth capacity of the missing terminal bud; the next lower buds are also promoted in status. The new terminal bud will of necessity send out its branch at an angle to the original stem axis. Judicious pruning can cause a tree to assume an almost unlimited number of forms: conical, cylindrical, funnel-shaped, tubular, or espaliered. A large book is required for descriptions of the recognized and accepted practices of pruning grapes, alone.

The possibilities of improving quantity and quality in fruit crops are almost limitless. Vergil gave sage advice in this matter in his *Georgics*. Speaking of winter chores, he says: "the active farmer reaches his care into the coming year, and presses on to lop the bared vine and trim it into shape with the crooked tooth of Saturn [pruning knife]." Trees produce, for
example, branches that range
slender switches up to sturdy
Silkworms still require leaves
duced on young branches spro
from pollarded mulberry tree
some Mediterranean regions one r
sees a tree that has been left to
its own way unguided. If a tree m
said to be dedicated to a certain
ral purpose, then pruning is its t
ing to assume a form in which i
best accomplish its work. It is
ished and kept in this growth
throughout its life, which may
span measured in centuries. Over

Pollarded trees, pruned with the intent to effect heavy branch production, yield a crop of switches, *above*. Same process is used, *below*, to lessen shade and permit gr
of grapes on trellises fixed to trunks in Italian orch

in some European countries, and branches are harvested as r crops. Highly efficient pruning ds have been used along the erranean for centuries.

E have been considering buds with predetermined places of , either at tips of stems or at the along the stem. Somewhere in istory of structural evolution appeared another type of bud ould develop from embryonic anywhere on a stem or root if oper stimulus was present. Such itious branching may be a nat- unction of the plant's habit of 1 or it may be the result of me- al injury or the attack of some organism that causes abnormal erations of the abortive branches e known most commonly either as witches'-broom, or as hexenbesen.

Pollarding is an extreme case of heavy pruning to stimulate increased branch production. In the mountains of southern Italy one sees chestnut trees that have been cut down flush with the ground to permit a harvest of regular crops of branches that sprout up from the stumps. The branches range in size from withes that are used in basketry up to poles large enough to be used in building construction. The redwood, *Sequoia sempervirens*, will produce a circle of new trees that sprout up from the rim of a cut stump. Olive trees are famous for their ability to produce vigorous adventitious buds as long as there is living cambium anywhere under the bark. Around the Mediterranean one sees venerable olive trees producing full crops of fruit from normal, leafy tops made up of young, vigorous branches. These have sprung from ancient, gnarled, and fragmented trunks that have been nurtured by many generations of horticulturists. In this region an olive tree is considered "young" for the first three hundred years of its life!

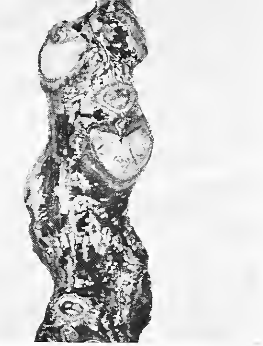
The bud of the woody, deciduous

IERED pear trees near the Rhone rown vertically flattened, with sult that light spreads equally 1em, allowing dense blossoming. train young fruit trees, *right*.

plant as we see it today appeared late in the evolution of the land plants. First, it was necessary for leaves to evolve and then for plants to be subjected to environments in which cold winters or dry periods interrupted the growing season annually. The first, and leafless, land plants lived under conditions of annual temperature and moisture supply much more equable than those confronting the vast majority of modern plants. Their pattern of stem tip growth was an advancing mass of embryonic tissue that divided at intervals and gave rise to a dichotomously branched plant. The delicate tissue of the growing tip was exposed to the elements at all times, but in the mild climate that then prevailed the arrangement was adequate. In the "whisk fern" we find one of the few living survivors of this primitive way of life. It is a small plant made up of leafless green stems bearing sporangia, and can be found in warm, humid environments in tropical and subtropical regions of the Western Hemisphere. It is named *Psilotum nudum* and is a living survivor of the Psilophytales, which had their beginnings in the Devonian Period—about 350 million years ago.

The overwintering bud was evolved as a survival mechanism when cold seasons appeared in the life of the land plants. Another development that has served to protect the complicated structures of a developing young leaf is found in the ferns, cycads, and a few of the flowering plants. This is popularly known as the "fiddlehead." The new leaves first appear as spiral coils of embryonic tissue. The leaf slowly unrolls as the structural details are formed in successive order from the base. In many cases the fiddleheads are thickly covered with a layer of felted, woolly, epidermal hairs that offer protection from temperature changes and mechanical injury. One genus of flowering plants—*Drosera*, the sundew, which traps insects on sticky epidermal hairs—uncoils its leaves from a similar circinate arrangement of embryonic tissue. Clearly, it took a long, long period of evolutionary time for the perfection of these remarkable survival devices.

Leafless twigs of eight species, each having characteristic buds, are shown enlarged about one and one-half times.


Kentucky Coffee Tree, *Gymnocladus dioica*


Winged Elm, *Ulmus alata*


Black Ash, *Fraxinus nigra*


Sumac, *Rhus canadensis*


Chinese Tree of Heaven, *Ailanthus al*


Tulip Poplar, *Liriodendron tuli*


Sassafras, *Sassafras alb*

Dogwood, *Cornus florida*

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About the Authors

Dr. Raymond L. Nace, the author of "Water of the World," is Research Scientist in the Office of the Chief of the Water Resources Division, Geological Survey, United States Department of the Interior. Dr. Nace's time is devoted to research, writing, and activities related to the proposed International Hydrological Decade. He is a member of UNESCO's Advisory Committee on Arid Zone Research and has represented UNESCO at international meetings. In 1959 the Department of the Interior presented Dr. Nace with the Distinguished Service Award.

Greek coinage is the subject of Miss Joan Fagerlie, Assistant Curator of Roman and Byzantine Coins at The American Numismatic Society. Miss Fagerlie, who became involved in numismatics through an interest in ancient history, spent 1958-59 in Europe, principally in Sweden and Denmark, gathering material for a doctoral thesis on late Roman and Byzantine solidi, gold coins first minted under the Emperor Constantine.

Mr. Peter Gerhard based "Emperors' Dye of the Mixtecs" on a paper he presented at a meeting of the International Congress of Americanists that took place in Mexico City in June and July of 1962. Mr. Gerhard has traveled extensively and is a serious student of native Indian industries of the Americas.

How certain moths' ultrasonic hearing helps them evade insectivorous bats is outlined in "Night Fighters in a Sonic Duel," by Dr. Kenneth D. Roeder. The author is Professor of Physiology and Chairman of the Department of Biology at Tufts University. This article draws heavily on material that Dr. Roeder originally presented in his book *Nerve Cells and Insect Behavior*, Harvard University Press, copyright 1963 by The President and Fellows of Harvard College.

Dr. Vernon Reynolds and his wife spent eight months in the Budongo Forest observing the behavior of wild chimpanzees, which he describes in "The 'Man of the Woods.'" Dr. Reynolds studied anthropology at University College, University of London. He has been a Fellow at the Center for Advanced Study in the Behavioral Sciences, and is writing a book about the Budongo Forest chimpanzees, assisted by Mrs. Reynolds.

The role of buds in plant growth is examined in "Index to Next Spring's Growth," by Dr. Virgil Argo, recently retired Associate Professor of Biology at The City College of New York. Dr. Argo, an entomologist, took the photographs that illustrate his article.

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NATURE IN

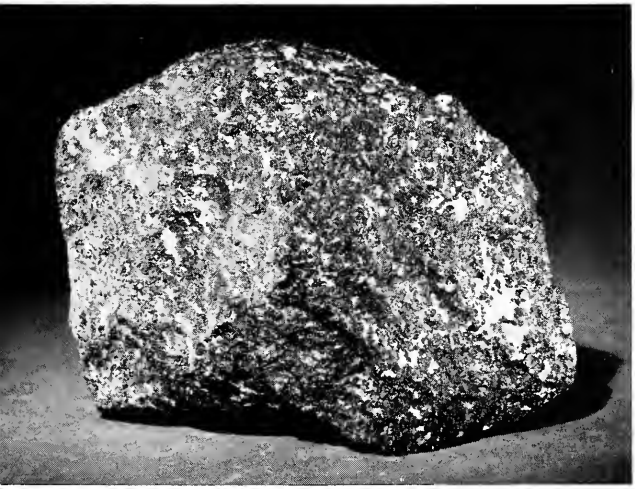
ROCK & MINERAL

By PAUL MASON TILDEN

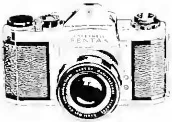
ME YEARS AGO I had occasion to visit a number of the early iron- ce sites of northern New England, in some cases to investigate the es of the iron ores that fed them. ng such pleasant excursions was a to Tyson, in Windsor County, Ver- . There I poked and probed in the y ruin of the Tyson Furnace, which e early part of the nineteenth cen- did a thriving business in iron; its alty was stoveplate castings.

the time of my visit, the name n seemed of no particular signifi- e, nor was there anything spectacu- be unearthed in the vicinity of the urnace. Its ruin held to a familiar rn: the massive, crumbling founda- tones were under trees, shrubs, and ; the surrounding dark soil was ated with the carbon of hardwood oal; there were blobs of glassy slag delicate, swirling blue patterns; lying about were lumps of discarded or forgotten ore, leached and rotted with the passing of the years.

But recently I was again confronted by the name Tyson, during a reconnaissance of the old chromite mines ("chrome mines," as they are called locally) of the "serpentine barrens" in north-central Maryland and southeastern Pennsylvania. Was there a connection between the decayed iron furnace in the tiny Vermont village and the chrome mines of the serpentine outcrops? There was, indeed. It turns out that Isaac Tyson, of Baltimore, had not only owned and operated the Vermont furnace, but was also the operator—by purchase, lease, or other arrangement—of every important or promising nineteenth-century chromite mine in the Maryland-Pennsylvania complex of serpentine exposures. In fact, he was very nearly the sole supplier of the mineral for the entire



IVE CHROMITE specimen, mined in ce, contains flecks of disseminated, talcose serpentine. Serpentine can range in color from white to green or near black.



world between the years 1828 and 1850.

In Isaac Tyson's day, the element chromium—for which the mineral chromite was, and still is, the only commercial source—was used almost exclusively as a constituent of chemical compounds. Lead chromate, for example, was the "chrome yellow" of the paint trade. Potassium bichromate was a powerful oxidizing reagent for the laboratory. Chromium compounds were widely used in the ceramics industry as decorative pigments. Various chromium chemicals then, as now, were used in cloth-dyeing and leather-tanning; in its oxide form, chromium has long been the basis for bricks and the linings of high-temperature furnaces.

Stainless Steel Days

TODAY, more than half of the nation's total consumption of chromium is connected with the production of so-called stainless steels. There are many of these steels, each designed to meet some special need; in general, such needs are for high-strength metals that will withstand extreme conditions of temperature or corrosion. Jet-engine components, gas turbines, and spacecraft propulsion units require stainless steels immune to the effects of high temperature; tanks and piping used to store or transport powerful, chemically active liquids and gases demand great quantities of the metal. Steels of this kind, built around a basic alloy of iron carbide, chromium, and nickel may require the addition of other elements such as cobalt, columbium, tantalum, aluminum, tungsten, or copper to meet specialized requirements.

The uses of chromium that are most familiar to the public include the chrome-plating of various household utensils and plumbing fixtures, as well as stainless steel cutlery; the metal is a toughener in the high-speed drill bits used by the man of the house in his electric drill; its use in the plating of those ever changing stripes and streaks that distinguish modern automobiles must be chromium's most renowned role.

As a mineral, chromite is not spectacular to the eye. In theoretical composition it would be a straight chromate of iron, but as found in nature small percentages of aluminum and magnesium replace some of the iron. Mere visual inspection of field specimens may easily lead the unwary to a confusion with the common mineral magnetite. Magnetite is black and, of course, magnetic. Chromite is about the same shade of black and—unfortunately for the beginning collector—is also occasionally inclined to be somewhat magnetic. Both minerals, when found as crystals, ordinarily occur as octahedrons, sometimes of very perfect form. Both are of about the same specific gravity (in the neighborhood of 5.0, or quite heavy) and are of about the same

HIGH-GRADE amphibole asbestos of "c
fiber" type commonly fills small fiss

hardness (around 5½ on the
scale). A streak-plate, which can
made from the "wrong," or ungla
side of a broken bathroom tile, is a g
help in field identification; chro
yields a brown streak, while that of
netite is ordinarily a dull black. C
mite and magnetite are, in fact,
close mineralogical relations. Both
long to the spinel group, which is
divided into spinel, the aluminat
magnesium; magnetite, an oxide of i
and chromite, the chromate of iron.

Piedmont Bonanza

CHROMITE deposits in northeas
Maryland and southeastern P
sylvania occur in a rather narrow
of ancient, metamorphosed rocks
curves gently to the northeast arc
the straggling indentation of Chesap
Bay, in Maryland, and goes on to t
the northernmost part of Delaware,
tinuing into the vicinity of Philadel
The total length of this chromite-bea
segment, which is composed of Pre
brian and perhaps early Paleo
quartzites, schists, marbles, and
canic "greenstones," is about 160 m
It is no wider than 40 miles at any p
The eastern border of this so-ca
Piedmont Upland is the Fall Line, w
the younger sediments of the Atla
Coast province lie over the top of
vastly ancient crystallines; to the
of the belt there are various Paleo
limestones and marbles, as well as s
and sandstones of Triassic age.

The curving belt of Precambrian r
of the Piedmont Upland contains nu
ous elongated masses of serpentin
rock type which is essentially a hyd
silicate of magnesium—representing
metamorphosed remnants of an
ultrabasic intrusives; magmas crea
rocks like pyroxenite, dunite, and
dotite, rich in magnesium and iron
erals, and poor in acid components

ctures in the serpentine rocks of the and-Pennsylvania chromite fields.

MAGNETITE mined in the serpentine belt of upper Piedmont region almost always assayed some small amount of titanium, in magmatic segregation, like chromite.

z and certain of the feldspars. ected with these serpentine masses ncentrations of chromite and mag- ; in some of the associated quartz- granitic pegmatites, soda feldspar massive corundum are present. faults in the serpentine are often ied by asbestos of the amphibole y, and sometimes by the carbonate gnesium known as magnesite.

serpentine itself is an interesting with its typical "greasy" feel to uch; its color ranges, through the s outcroppings, from buff and light to emerald green, dark green, and . A variety of rich green rock, ed with "stringers" and veinlets of e, has been quarried here and there district for nearly two centuries, old as an ornamental stone under me of "green marble" or "serpen- arble."

ommercially speaking there can be objection to the term serpentine e, but mineralogically it is a mis- r and is quite misleading. Marble ystalline rock composed essentially lcium carbonate or a mixture of m and magnesium carbonates; ntine, as noted above, is a hydrous esium silicate. A marble containing ntine is properly known as ophical- The unfortunate expression serpen- arble is not wholly confined to the n of trade. It may have originated Dr. A. A. Hayes, onetime State As- of Massachusetts. In discussing the ntines of Vermont in the *Vermont gical Survey, 1861,* Dr. Hayes said: iew of . . . chemical composition . . physical characters, I propose his rock, quarried for ornamental ses, be called serpentine marble.")

s interesting to note that the ser- e areas under discussion can easily tinguished by the rock and mineral tor. The soil of the Piedmont Up- s generally rich, and the farms and woodlands fertile. But in the case of terrain that is underlain by serpentine, the soil is saturated with minerals rich in magnesium and lacking in the potash and carbonate minerals and hence is exceedingly thin and poor. Such areas are quite appropriately called the serpentine barrens. Their appearance today is probably pretty much as it was in the time of Isaac Tyson. Writing about the barrens, an author named H. H. Hayden, Esq., said in 1814 that "the mind seems involuntarily to feel the impulse of melancholy. . . . A gloomy silence pervades around, while every road on the serpentine range bears the most decided marks of sterility. . . ."

Chromite Kings

THIS, then, provides a background for the discovery, between the years 1808 and 1810, of chromite in the United

States. It was no doubt the first important discovery of large commercial quantities of the mineral anywhere in the world. It is difficult to discuss "first discoveries" beclouded by the lapse of many-score years, by insufficient records, or by hearsay. For instance, one prominent American geologist states that the first commercial discovery of chromite was made in Norway in 1820, and the second in Maryland in 1827. These dates are obviously in error. Isaac Tyson was very probably mining chromite in Maryland by 1811, and had actively begun to build his chromium empire by 1817. There must also have been early commercial sources of chromite in Europe.

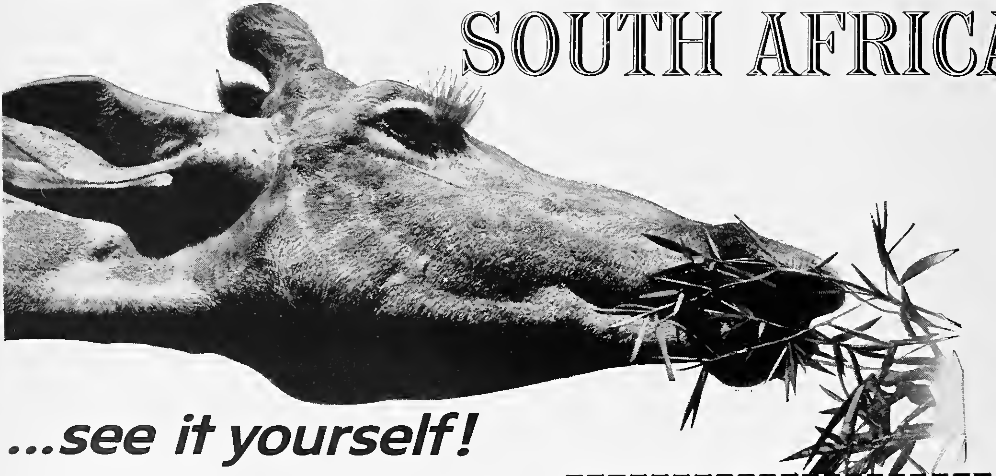
The locale of the first chromite discovery in America was in the Bare Hills, just north of the city of Baltimore. Today, the area is almost a part of the city itself, although still beyond its official limits. The discovery is credited to an Englishman by the name of Henfrey, who had been an employee of a chrome-pigment manufacturing plant in England (which must already have had some reliable source of chromite). Henfrey knew chromite ore when he saw it. Isaac Tyson was at the time spending the summer with his father, Jesse Tyson, at the family estate in Bare Hills. Isaac who had started in business with his father as a grain merchant in Baltimore, had at one time been an apothecary's apprentice, and possessed a keen interest in chemistry. Henfrey drew Tyson's attention to the ore, and the latter became deeply interested in its possibilities. The Bare Hills deposit, which was in a small serpentine mass, was opened—perhaps by Tyson himself—sometime before 1811, and the chromite was reduced to lead chromate for shipment to a Philadelphia paint factory. There it was used in manufacturing paint for chairs and signs.

Mr. Tilden, author and editor, writes regular columns for this magazine both on rocks and minerals and on current conservation legislation in Washington.

This was the birth of Tyson's near-monopoly in the world's market for chromium chemicals in the early nineteenth century. He searched out further deposits of the mineral along the length and breadth of the belt of serpentine outcrops in the Piedmont Upland. Combining his own discoveries with a sense of business that allowed him to let others make discoveries for him, Tyson, by 1828, had gained control of the world's supply of chromite. His Wood Chromite Mine, almost on the Maryland-Pennsylvania line—opened in 1828—was a bonanza, and alone supplied most of the world's chromite needs for several years. Not all of his mine purchases and le were good ones, as might be expec his record books show that some of t were "of no account," or "of no av

In 1845, Isaac Tyson and his son J (old Jesse's grandson) establishe plant known as "Jesse Tyson and C pany" in Baltimore. It assured a fa monopoly on the chromium-chemica dustry in the United States for the lowing forty years. Isaac Tyson die 1861, and six years later his four incorporated the Tyson Mining C pany, and extended their interests far afield as California, where chro was being discovered along the ser tine belts of the Mother Lode cour The Tysons sold their chromite-trea works in Baltimore in 1902, and ret from business. The plant is still oper by a nationally known chemical and corporation, which now imports its

All told, the chromite productio the Maryland and Pennsylvania ser tine bodies has amounted to per 350,000 tons, of which a small perc age has been won as "placer chrom from the streams that flow from across, the barrens. There have beer ports that the total output of the may have been in the neighborhoo half a million tons, but—even allo for the never-recorded production obscure or very small mining operat



a figure is probably questionable.
s interesting that spectroscopic
es of chromite samples from a
r of the Piedmont Upland mines
minute traces of several unex-
elements. Among these are zinc,
nese, cobalt, vanadium, zirconium,
n, and the very rare scandium.
um's existence had been pre-
by the Russian scientist Mende-
ı the basis of his periodic table of
ments several years before it was
ered by Nilson in 1879.
the mineral collector, there are still
good things to be uncovered on the
of the old chrome mines of the
tine belt. Aside from handsome
ens of the chromite ore itself,
ite finds might include colorful
um antigorite of pink or lavender
ıe semiprecious variety of serpen-
lled williamsite, in its shimmering,
cent emerald green; tourmaline;
rerite, which is a purplish, chro-
variety of the mica-like mineral
e; genthite, a hydrous magnesian
e in which some of the magnesium
aced by nickel; or zaratite, a basic
carbonate that sometimes occurs
ll veins in the more massive lumps
omite. Well-mannered mineral col-
always, of course, request permis-
property owners before invading
e of an old mine or mine dump.

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ERRATA

sentence on page 24, column 1
mber, 1963) should have read:
at Mycenae, the city of Agamem-
at Pylos, the city of Nestor; and
ssos, the city of Idomeneus—three
Homeric heroes." The libation
(page 24) is Dictaean. Moses re-
the Law in Exodus, and Africa
nitted from the Phoenician colony
page 27).

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st details the photographer, artist,
er source of illustrations, by page.

Lee Boltin
h Sedacca
rich Hartmann,

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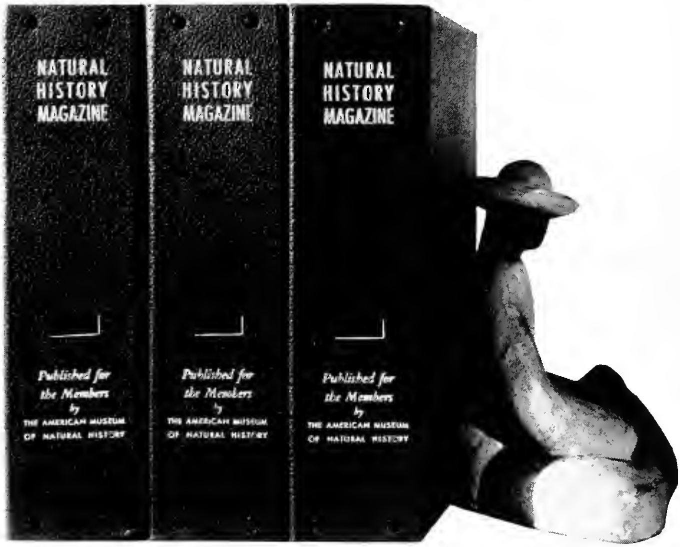
fice of the
Engineers
Geological

MNH after
l L. Nace
tography flown
Navy for U.S.
al Survey
Geological

h Hartmann,

ee Boltin

26-27—Peter Gerhard
28-29—Donald Cordry except 28, left—Muriel Ries
29—bottom—AMNH after Peter Gerhard
30-31—Lee Boltin
32-39—Kenneth D. Roeder
40—Mount Wilson and Palomar Observatories
42—Helmut Wimmer
43—Sky Map, AMNH
44-51—Vernon Reynolds except diagrams, 46-48—AMNH after Vernon Reynolds
52-56—Virgil Argo
59—AMNH
60—Paul Mason Tilden
61—AMNH



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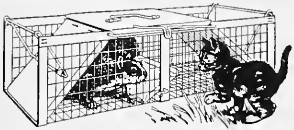

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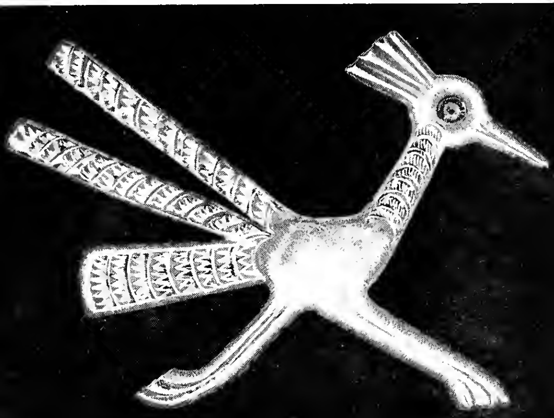

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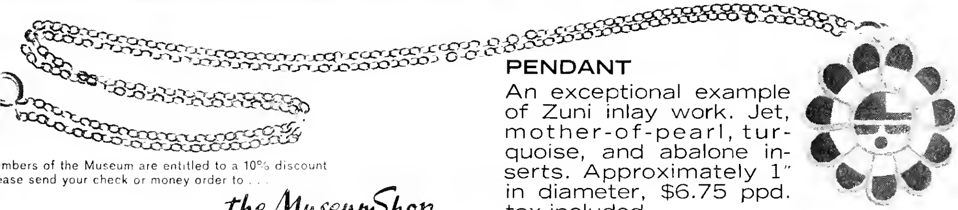

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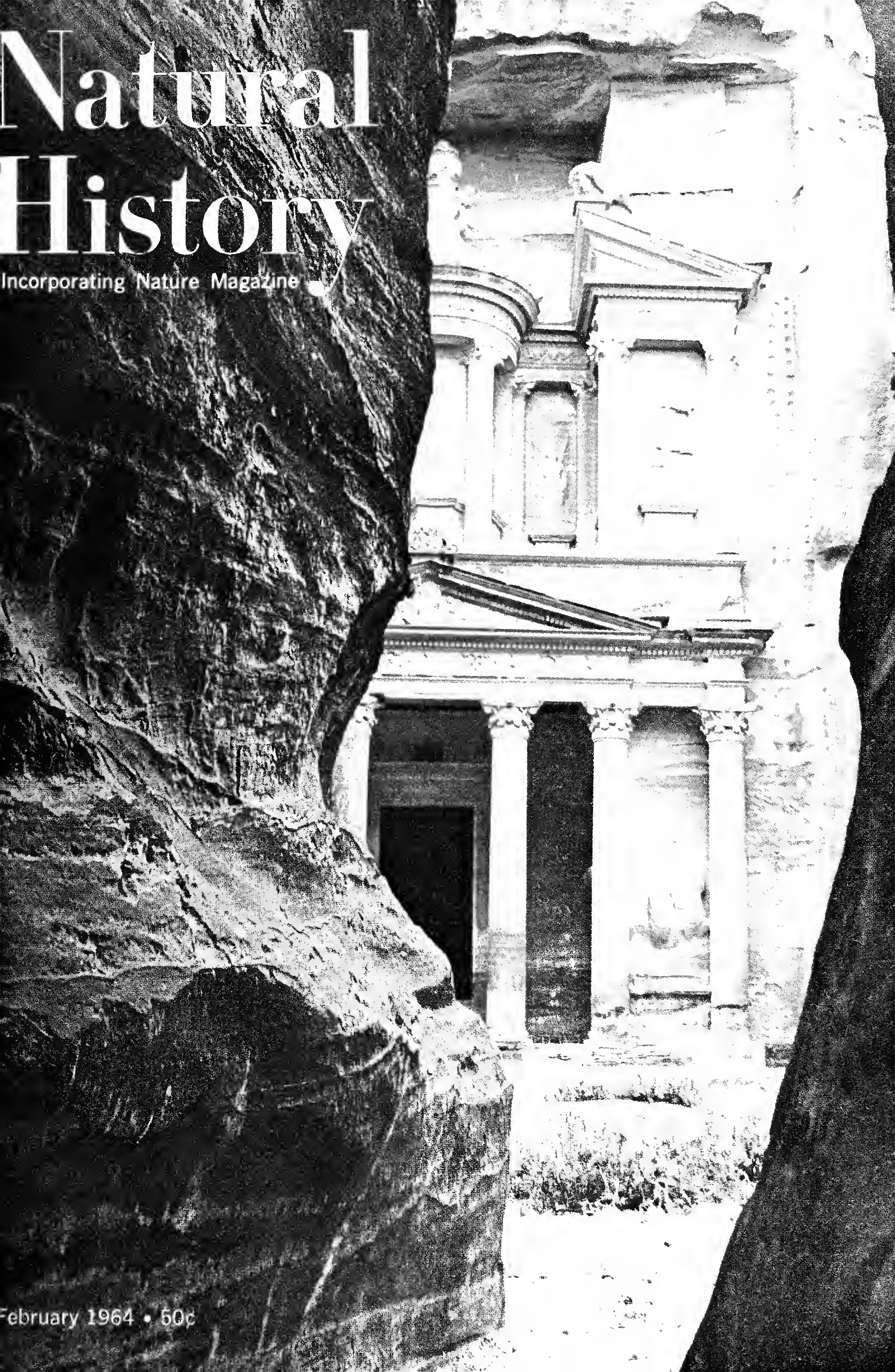

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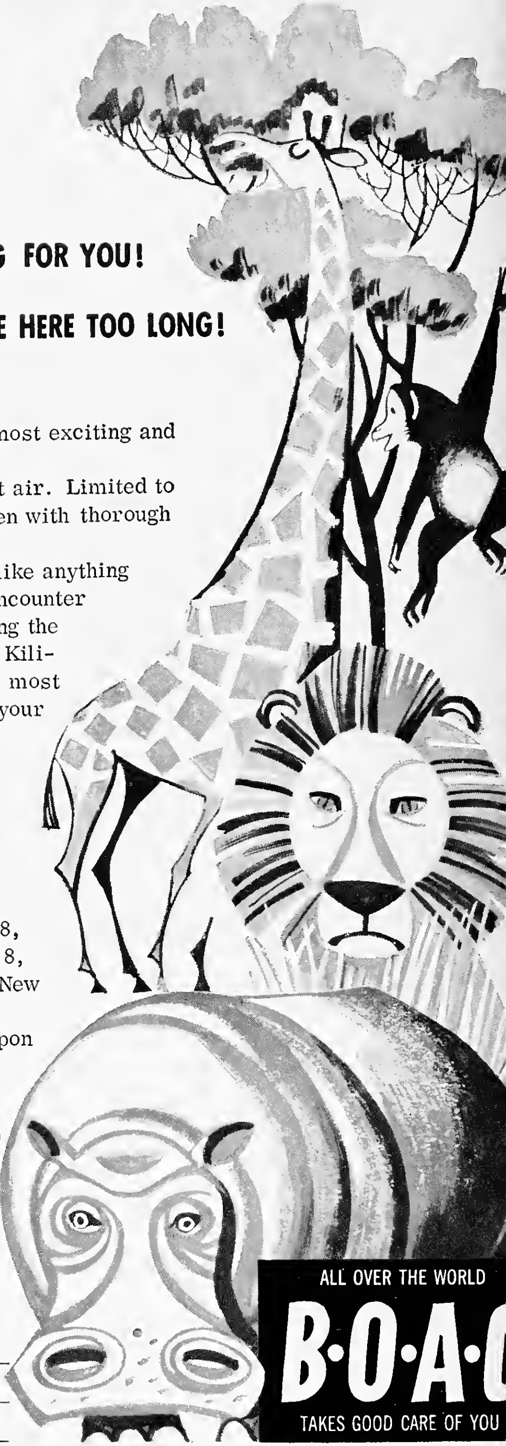

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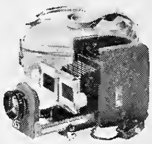

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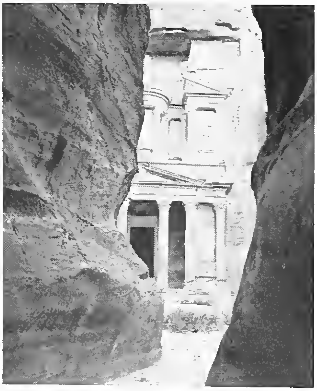

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THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HIST

Vol. LXXIII FEBRUARY 1964

ARTICLES

DEPARTMENTS

COVER: This is the Khazneh Far'un—the Treasury—in the ancient city of
carved, like other buildings at the site, out of the roseate rocks that have
thirty centuries of recorded travel in this part of Jordan. From the time of
to whose wand is attributed a cleft in the mountains, to modern tourists,
interest in the area provides an important source of revenue to the country,
after wave of peoples have lived in the area and have left their own distir
marks. Its history is a significant one, and its description begins on pag
The photograph was taken by George Holton who visited Petra this past

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Reviews

resh approach to man's cultural background

By Alfred Kidder II

ry of Mankind, Volume I: Pre-
ry and the Beginnings of Civili-
, by Jacquetta Hawkes and Sir
rd Woolley. *Harper and Row,*
; 873 pp., illus.

s is the first of a proposed six-
ume history of mankind to be
hed under the aegis of the Inter-
al Commission for a History of
ific and Cultural Development of
nd. The Commission is a part of
CO, and the book is copyrighted
t agency. Miss Hawkes and the
r Leonard Woolley were commis-
to cover more than a million
of human history from its begin-
to the end of the Bronze Age at
1200 B.C. This formidable task was
d, as the Commission's full title
explicit, toward the production
istory stressing scientific and cul-
development rather than that of
al institutions. For this first
e—covering a period ending only
after the invention of writing—
e, which includes political organ-
, must be inferred from archeo-
l data. This means that every scrap
ormation on the social organiza-
f our remote Stone Age ancestors
ived from the imperishable ob-
hey made and used, and from our
dge of the climatic, faunal, and
conditions under which they
Bypassing political history at this
is no real problem, but in later
es it may be most difficult to sep-
the social, political, legal, and
istic aspects of culture.

ume I of this history is thus a com-
nsive treatment of a very long and
road range of prehistory with a
scientific and cultural history de-
from the early writings of the
e East. The first part, entitled
istory," begins with a chapter on
nvironmental conditions of the
ocene Epoch and another on hu-
volution. The latter is apparently
largely on the ideas of Le Gros
; it was written before the appear-
f C.S. Coon's *The Origin of Races,*
oes not become involved with his
hat controversial hypotheses. Miss Hawkes then outlines the history of the Paleolithic and Mesolithic cultures of the world, including the Paleo-Indian of the New World. The latter is surprisingly up to date for a book such as this, the actual production of which must have been long delayed between manuscript submission and publication.

Following the historical chapter there are topical discussions of the development of the human mind, the origins of speech and language, society, material culture (with an appendix on the principal types of tools and weapons), and of art and religion. This scheme is repeated for the Neolithic. Much the same pattern is followed by Woolley for the Bronze Age, with topical discussions of urbanization of society, social structure, techniques (including arts and crafts), and economy. The sciences—mathematics, astronomy, calendrics, medicine, and surgery—are also treated, as are religion and the fine and applied arts. Both parts of the book have excellent photographs and drawings.

As an Americanist with no firsthand experience in Old World archeology, I am not competent to evaluate the inferences drawn from the enormous amount of archeological evidence taken into account by the authors. Other reviewers have been critical of certain of Miss Hawkes's interpretations of the Neolithic and of Woolley's reconstruction of Bronze Age culture in the Middle East. Nevertheless, I feel this work is a great deal more useful than recently published collections of articles on archeology by many authors, in spite of the richness of their illustrations. (Examples are *The Dawn of Civilization* and its sequel, *Vanished Civilizations of the Ancient World,* both published by McGraw-Hill.) Such volumes often suffer from the lack of continuity and multiplicity of authors, a situation Sir Leonard Woolley well appreciated. In connection with the vastness and complexity of the task confronting him, he remarked in his preface: "My reason for attempting it is that in this far-reaching study of civilization's progress, unity of view is more important than detailed analysis, and a volume of essays by different

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lists could hardly fail to lack just
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hole, of which each of these sub-
s but a part." With this I heartily
but the editorial handling of the
e by the Commission has intro-
at least some of the disharmonies
ir Leonard wished to avoid. Both
Hawkes's and Sir Leonard's manu-
s were submitted to all the Na-
Commissions for UNESCO and
nerous specialists. Comments were
incorporated in the texts or in
at the ends of chapters, with the
entators identified by name. The
rs themselves had already con-
a number of specialists of their
hoosing, and it would seem that
interests of speedy publication
this profusion of opinions, much
rom Soviet archeologists stressing
st interpretations, could well have
omitted. Some critics feel that this
o way to write history and that it
the work unimaginative and dull.
ld not go so far as this. Miss
es, as those who have read *The*
know, writes so well that even her
ptions of stone tool types are a
re to read. Woolley also wrote
well indeed. This volume should, I
e, prove interesting and instruc-
specially if the notes are skipped
hose interested in human history
its very beginnings.

idder is an archeologist and is
ate Director of the University
m, the University of Pennsylvania.

AST HORIZON, by Raymond F. Das-
The Macmillan Company, $6.95;
., illus. THE PLACE NO ONE KNEW:
CANYON, by Eliot Porter, edited by
Brower. *Sierra Club, $25.00; 170*
us.

not a pretty picture, this of a world
people who, while unwilling to curb
ocreative urge, continue to exploit
rth's surface with a conflicting
of cleverness and stupidity, of
and foresight, of slavery to habits
ondrous scientific achievement. The
sult of this combination is that we
ays in debt to the future and faced
he grim possibility that the survi-
ally will be lost in a barracks-like
order. Already the more timid phi-
ers wonder how a steady diet of
on may affect their dispositions.
a furtive look over his shoulder
scientific brethren, Mr. Dasmann
apologizes for not pursuing in *The*
orizon a "dispassionate, objective
oint." So far as the reader is con-
, the author need not be alarmed.
he frankly announces that he does
sh to be a detached observer of
f life of which he has grown fond,
nn precisely pinpoints the reason
he has managed to write, from his scientific background and his apparently wide field experience in ecology, a warm and stimulating volume. He feels personally involved: he projects his own sense of loss that lovable and adventurous things should be going out of the world.

And what is the solution? Dasmann knows of nothing beyond an over-all planning that may do something where piecemeal planning cannot. He is not sanguine even of that chance. In such a dilemma, perhaps the reviewer may dare a philosophic simplification of its basic cause. The Greek sage Cleobulus gave as his golden rule: "Nothing in excess." The abuse of the land partly stems from the tragic human illusion that if a little of something is good, a lot is necessarily better. To that fallacy nature says *No!*

While the Dasmann volume puts major emphasis upon the economic aspects of the land surface that man modifies toward its ruin, due attention is given to the necessity of preserving spaces for the satisfaction of human health, both physical and spiritual. These heritages are likewise disappearing before our eyes. A poignant example of the spendthrift making havoc of his patrimony comes to us from the Sierra Club of San Francisco: a sumptuously beautiful volume that chants a threnody for the incomparable Glen Canyon of the Colorado River. Even those buyers who look askance at the waxing number of books of large format and high prices will admit, even if grudgingly, that in this instance the photographs of such a master as Eliot Porter, supported by a sensitive and almost devotional text, and given final integrity through the craftsmanship of typographer and lithographer, may be an exception. It had to be done that way, if at all.

Glen Canyon: hail and farewell! The title of the book says that it was a place nobody knew. Actually, it was known to few: this strange slit in the earth's crust, with forbidding walls, mysterious side-canyons and rock-forms that Eliot Porter's camera has been able to make vocal to our nobler selves, was difficult of access. True, not many Americans knew of its existence, or ever would have looked upon its beauty and pondered on its wonder. But a few professional modifiers of geography knew it only too well, and now the impounded waters are deepening over it. You can hear them saying, "What a wonderful place for a hydroelectric power dam!"

This book puts us on notice that many other precious spots are threatened by the same fate. It will require more than poetic rapture to thwart the despoilers. It takes also those of blunter speech and tougher fiber, who know the language of politicians and can study and try to meet the danger before the knell is tolled.

FREEMAN TILDEN
Author and Conservationist

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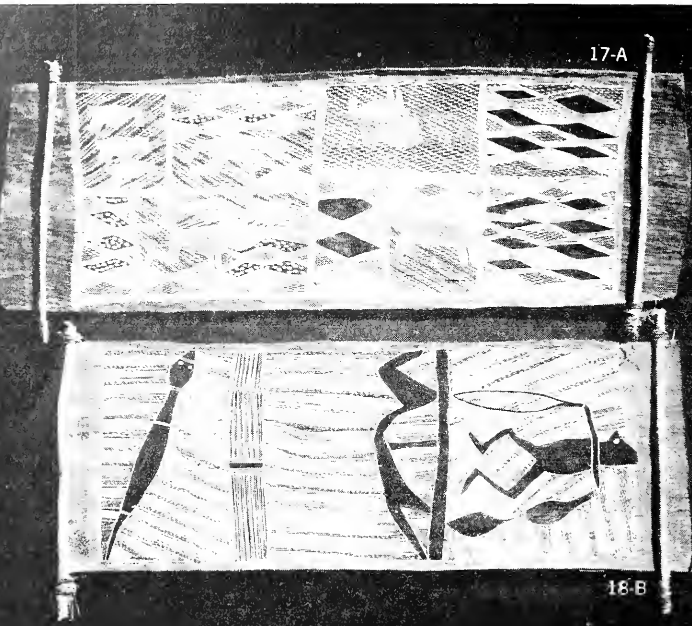

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THE HOUSE SPARROW, by J. D. Summers-Smith. *Wm. Collins Sons & Co., $5.00; 269 pp., illus.*

The "New Naturalist" series of special volumes dealing with the native flora and fauna of Britain, including such widely quoted volumes as Fisher's *The Fulmar*, Tinbergen's *The Herring Gull's World*, and Armstrong's *The Wren*, has achieved an enviable record of presenting scholarly research in a form that can be read and appreciated by the layman. The most recent addition to this successful series is concerned with the origin, distribution, ecology, and behavior of the house sparrow, a species of bird that is probably familiar to more people throughout the world than any other—except the domestic chicken.

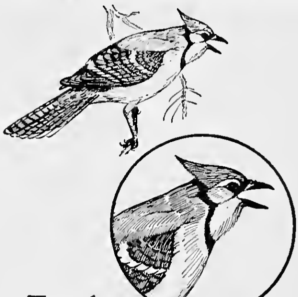
Although confined largely to Europe and southern Asia prior to 1850, the house sparrow has subsequently become well established, through introductions, on all of the continents except Antarctica. The account of this dramatic range expansion and the reasons suggested for the incredible success of the species make for entertaining and informative reading. To most people the house sparrow is a noisy, notorious symbiont of urban and agricultural man and the bane of bird-feeding stations everywhere. Consequently, interest in the species centers upon its elimination rather than its appreciation. Even Summers-Smith, after twelve years of intensive and intimate study of color-banded individuals, is reluctant to admit any affection for his birds. Nevertheless, the information that he has marshaled on various aspects of the life history of the species, including its unique relationships with man, may well provide some of us with food for thought.

Possibly a knowledge of the origin of this feathered rogue, of the history of its unparalleled exploitation of a particular niche in nature, and of its daily and seasonal habits may place the bird in a more favorable or at least tolerable perspective. Regardless of whether or not the book achieves such a prodigious effect, it is highly recommended as another example of the fine contributions that have been made by amateurs to the science of ornithology.

WESLEY E. LANYON
The American Museum

RETURN TO THE WILD, by Norman Carr. *E. P. Dutton & Co., $4.50; 127 pp., illus.*

The lion is perhaps the most respected animal on earth. For centuries it has figured in the heraldry of countless countries, from Ethiopia to England, and judging by the many recent books on the subject, the animal is still high on popularity polls. The king of the animal



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— EMMETT R. BLAKE, *Curator of Birds, Chicago Natural History Museum*

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kingdom is not easily deposed, nor should he be. He is an animal of supreme beauty, dignity, and courage.

Mr. Carr's book is about lions, and he knows a lot about them. For fifteen years he was the warden of Kafue National Park in Northern Rhodesia, the largest in Africa, and during his tour of duty he acquired considerable knowledge, not only about lions, but about the confusing and always changing relationships between man, beast, and environment. He is an acute observer, a sound conservationist, and a very readable writer.

Yet there are parts of this book that somehow don't quite ring true. For instance, he tells of a well-known local lioness named "The Smiler," which the author and practically everyone else in the neighborhood knew was about to have cubs. Not only that; they knew from observation where she was going to have them. Then one of the wardens went to the spot, found the cubs, and correctly suspected that the mother must be near. Instead of withdrawing, he loaded his 14-bore shotgun and killed her when she appeared to defend her young.

Mr. Carr condones this killing as having been required in self-defense. Maybe so. In any event, the rest of the book is devoted to a description of his efforts to rear the orphans, and the end comes when he releases them to "return to the wild." What happens to them next—which really ought to be the end of the book—is not told.

There are dangers in a book of this sort. Young wildlife should be left alone, and any book that even vaguely suggests the pleasure of playing foster parent is not in the interests of man or any other animal. Mr. Carr repeatedly asserts that he never tried to make pets of his charges, but methinks he doth protest too much—the photographs that accompany the text indicate a very close association.

Nevertheless, during his baby-sitting job Mr. Carr came to know lions and he passes along a quantity of information in good style.

PIETER FOSBURGH
Author and Editor

BIRDS OF THE OCEAN, by W. B. Alexander. *G. P. Putnam's Sons, $4.95; 306 pp., illus.*

ALTHOUGH called a "1963 Edition," this is simply a reprinting of the 1954 revised edition of W. B. Alexander's handy volume, *Birds of the Ocean*, which has been out of print for some years. It is still the only book that provides means of field identification for the sea birds of the world. That this little work had already gone through two gen-
uine editions (the first in 1928) and
warranted reprinting today is the
evidence of its continued usefulness.
modern bird books, other than the P
son guides, have been in such g
demand as to warrant even a revised
tion in hard covers. Usually there
more up-to-date competing volume
the market.

For those not familiar with Ale
der's work it should be pointed out
the book is compact, convenient,
pocket-sized. Each sea bird family i
lotted a chapter, with the species
grouped according to pattern and co
for each species there is a short des
tion, statement of range, and a l
paragraph of miscellaneous notes;
dates are often mentioned. Sepa
chapters for each of the oceans and
birds likely to be found on them fa
tate the task of identification. The i
trations are the same eighty-eight l
tones that appeared in the first edit
they are chiefly photographs—ofte
birds at the nest—and diagramm
drawings showing flight patterns of a
trosses, petrels, gulls, jaegers, boo
and frigatebirds, and, on the wate
penguins and phalaropes. These dr
ings by the author, although not of
fessional quality, have long since pr
their value in the field. As this revi

lly dates from 1954, it does not re-
indings of recent explorations that
xtended known ranges and changed
iews of certain relationships. (In
cases, scientific nomenclature has
ged since 1954.) But these points
little or no importance to the aver-
ird watcher, who will need this
on any extended ocean voyage.

EUGENE EISENMANN
The American Museum

ETERNAL PRESENT, by Siegfried
on. *Pantheon Books, $12.50; 588*
llus.

OUGHOUT the approximately one-
lf million years that man has
d the world, his primary occupa-
as been to survive in hostile sur-
ings. Only in comparatively recent
has he changed to a slight extent;
estion today is not how man is to
ith the world, but how he is to live
himself. In this book, the great
cultural historian Siegfried Gie-
preads before us the first extensive
ce we possess of mankind—Paleo-
man—coming to grips with the
facts of human consciousness.
, he asks, were man's first positive
rs to the all-consuming problem
ntifying himself, of determining his
role in the pattern of existence? How did he come to terms with a world that threatened him on all sides? How did he reconcile himself to the fact that he was the most vulnerable, the least physically endowed of all animals? How did he arm himself against the natural and the supernatural powers, hold them at bay, and, indeed, induce them to act in his behalf? Today we are protected by many shields: society, religion, medicine, nations, and so on. Paleolithic man stood naked and alone; he had to wrest from the cosmos magical garments composed of potent symbols that, properly organized in the cultic rituals, would assure him abundance.

Thus, Giedion attempts to answer these questions by means of a depth analysis of Paleolithic symbols. He does so, not through a single approach, but rather by bringing to bear the combined forces of many disciplines: anthropology, psychology, ethnology, philosophy, and history. A cursory glance at this handsomely illustrated volume, drawn from a series of lectures given for the Mellon Foundation in 1957, may mislead the reader into thinking that it is a study of prehistoric art. It is that, but only insofar as the art works are a key to man's mental and spiritual life. Giedion, following the dictum of an earlier historian (Alois Riegl), sees the work of art as the physical expression of the inner life of man. And in cave art he finds a complicated, symbolic language that can still be read, if only haltingly and in part.

The ancient "cave dweller" did not, as is now known, live in those deep caves in which he painted and engraved on the rock walls. They were far too inhospitable for domestic life; rather, man chose the cheerier, sunlit mouths of caves and sheltered nooks under rock overhangs as his home. The pitch-black, dank, dangerous tunnels that wormed their way far underground were fraught with mystery and unknown terrors. These subterranean passages and halls were the sacred places through which the initiated inched their way to hold their magic rites. By the flickering light of animal grease lamps they invoked their demons and spirits, painted their life-bearing murals on the suggestive rock bosses and stalactites. Even today, despite the modern comforts of artfully concealed lights, concrete walks and steps, expert guides and factual guidebooks, the caves of southern France and northern Spain exercise a strong influence on the imagination of the casual visitor. Giedion takes us back more than a dozen millenniums, to when the caves were alive with magic and the hidden

caverns were covered with the symbols of the cult. Ancient man rarely represented himself because, Giedion suggests, he considered himself inferior, subordinate to the powerful beasts who gave their flesh to sustain him. Giedion formulates the meanings behind the representations of magnificent beasts, prints of mutilated hands, steatopygous females, and tectonic marks.

For Giedion, as for many other prehistorians, the guiding force behind all quaternary art is a basic anxiety: the fear of sterility, the cataclysmic loss of fertility. Hence, cave art served in the cult ritual to promote and insure productivity and abundance. The first half of the volume attempts to solve the symbolic puzzles on the cave walls within this framework of fertility symbolism. His demonstrations are fascinating; his accumulated evidence is compelling. His development of a symbolic language in Paleolithic times lacks the torturous windings of Freud, as well as the expansive gestures of Jung. He envisages a direct, forceful expression of sexual motifs by ancient man, motifs that were the concrete expressions of the dominant fertility cult. The importance of the concepts of fertility and abundance in the Stone Age cannot be overestimated. Man must have lived a barely marginal existence; long periods of semistarvation were infrequently interrupted by the few days of gorging that followed a successful hunt. The cycle of life ran much faster then; skeletal remains indicate that the average life span in the Paleolithic was about twenty years.

To understand the mentality of ancient man, to gain insight into his life-and-death struggle, we must, says Giedion, put to one side our modern tools of logic, of cause and effect, of materialism. We must enter into a world based on magical relationships, on the identification of the symbol with the thing symbolized, on the power of the ritual act to formulate the future. But can modern man retreat to this "primitive" stage of thinking and feeling? Giedion answers that he not only can but does. Beneath the shell of the rational are the deeper strata of the irrational and the alogical, which powerfully influence modern man. The potent symbols of cave art are still alive and vital today because we are still attempting to resolve the primary questions of human life that the cave man expressed in his subterranean caverns. We are no better prepared to solve them; we have found no better solutions than did our prehistoric ancestors. Cave dweller and apartment house dweller rub shoulders. It is from this context that title of the book, *The Eternal Pres* is drawn. The history of mankind is piece; the hours and millenniums by, but it is always the same tragic a who holds the center of the stage.

It is evident, then, that Giedion adh to a particular view of natural hist He completely abjures the older not of mankind growing, improving, ma ing over the years. Nor does he envis cultures rising and developing, as c Toynbee. Culture is an eternal dra whose plot and characters never cha

While the first half of the book is terpretative, the second half is desc tive, providing a comprehensive su of Paleolithic symbols, cave art, and cheology. The magnificent illustrati in color and black and white, speci prepared for this volume, are infe only to an actual visit to the caves. eerie feeling that one experiences d in the caves of Lascaux or Altamira, sense of detachment and isolation, never be transcribed. But Giedion s ceeds, as few cultural historians can making the past present, in dissolv the millenniums that separate anc from modern.

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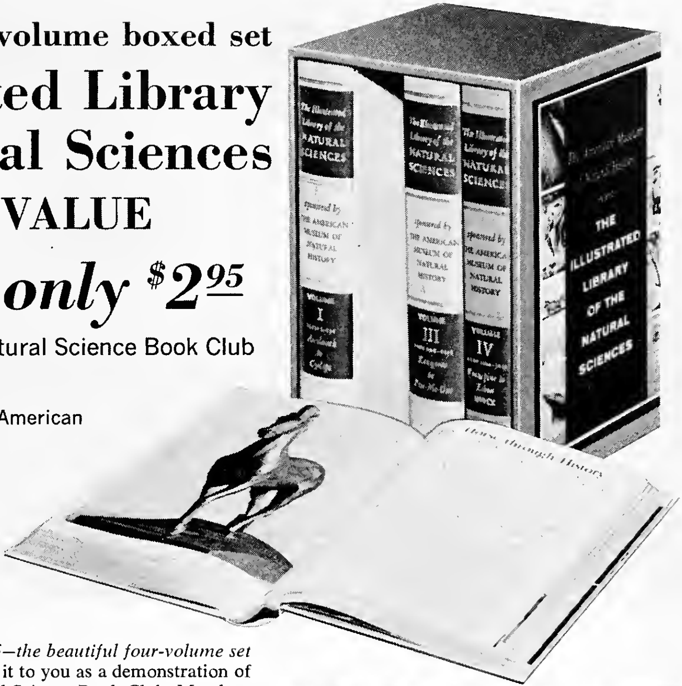

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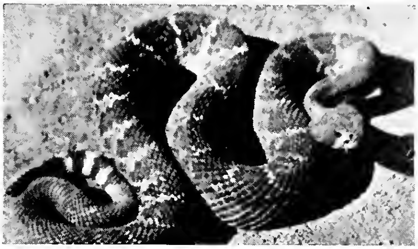

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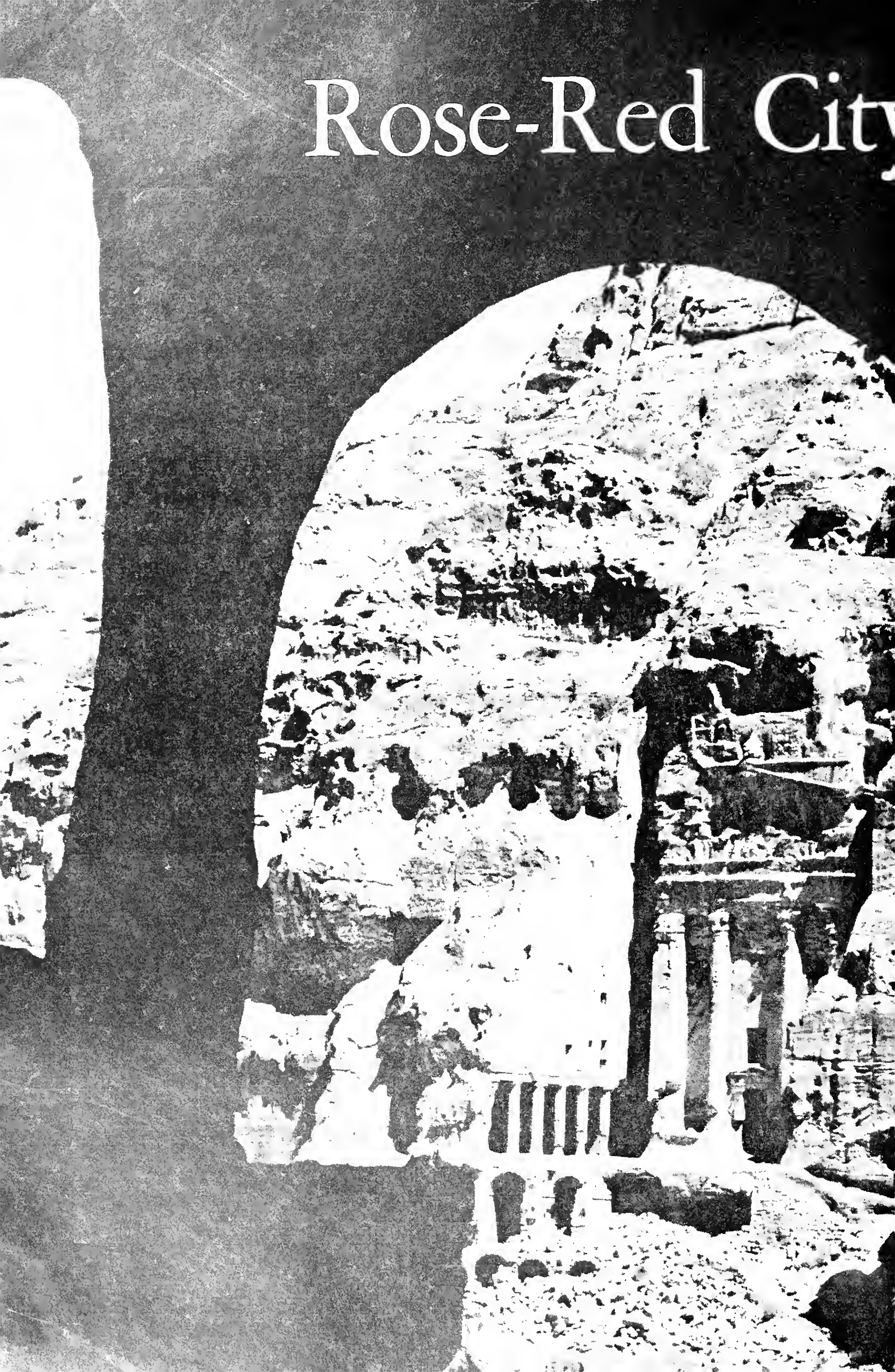
This African grasshopper pretends to be a withered leaf! (Learn all about him in these picture-filled pages.)

Rose-Red City



f Petra

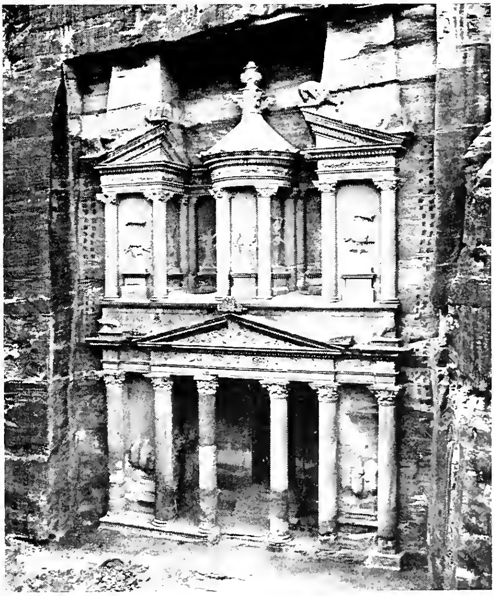
SEARED BY THE SCORCHING SUN by day and bathed by the light of stars by night, rock-girt and half-buried beneath the burning sands of the trans-Jordanic desert, lies Petra—"the rose-red city, half as old as time." A magnificent medley of multihued rock and the artistic skill of a bygone people, this ruined metropolis displays the colors of primeval dawn frozen into ripples of solid stone, and the lost hopes of pagan immortality chiseled in its heart.

Petra is situated some one hundred miles to the south of Jerusalem at Long. 35°26′ E. and Lat. 30°19′ N.—roughly the same latitude as Oklahoma City.

The ancient city-site lies between two parallel ridges of Nubian sandstone, which tower a thousand feet over the mile-wide desert floor between them. Nature thus sealed a pathway over whose sand and stone have moved more than thirty centuries of recorded travel. The site is usually approached via a narrow, twisting cleft, called the Siq, in the eastern mountain wall. Local folklore attributes this geologic fault to Moses, who, it is said, smote the rock with his wand to provide water for the wandering Israelites. By about the first century A.D., the Siq boasted a well-paved road, protected by a massive diversion dam. The torrential floods of two thousand years wrought havoc with both improvements, however, and the water-washed boulders that had begun to fill the Siq have only recently been replaced with gravel carefully laid for visitors.

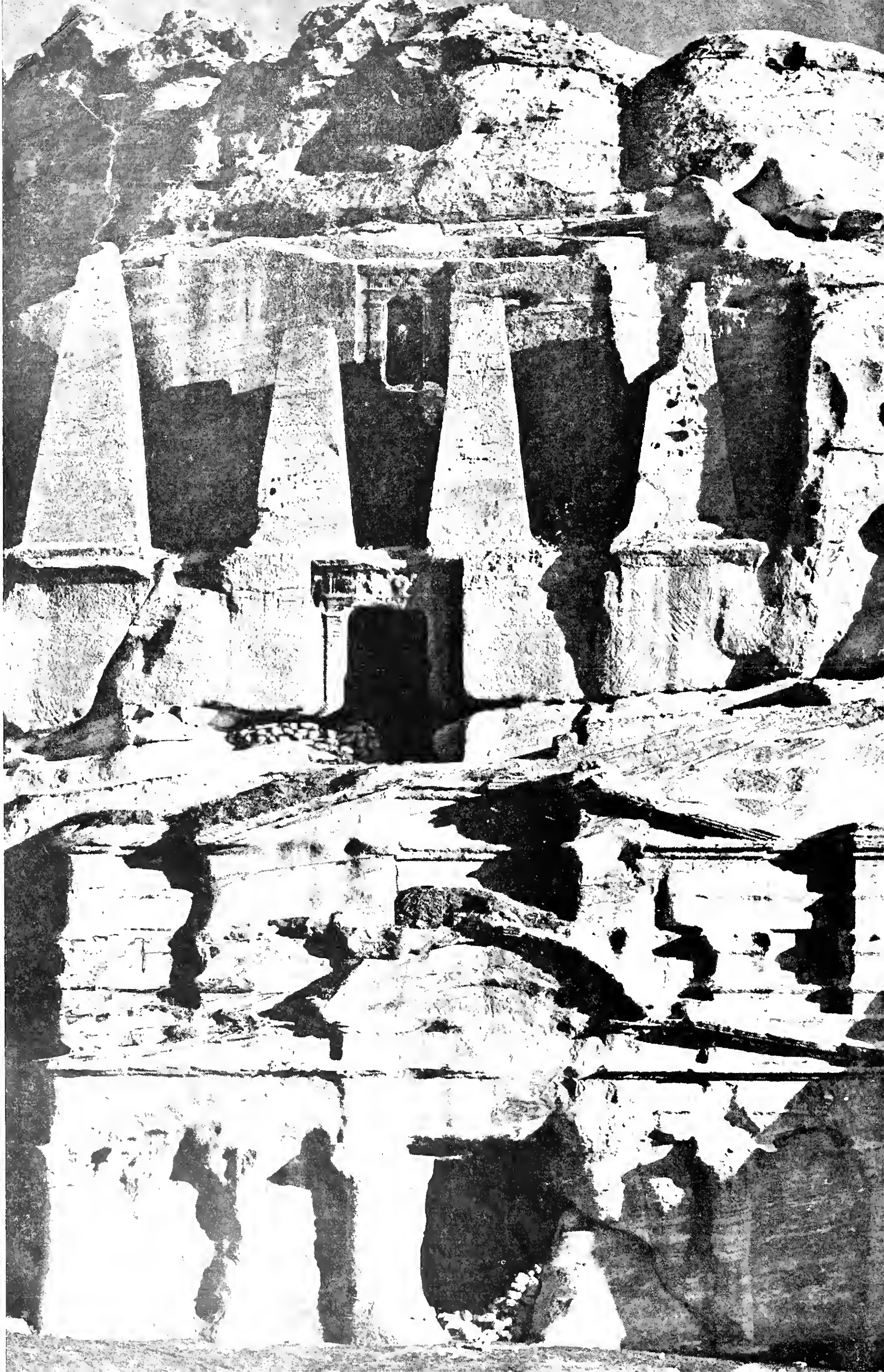
By PHILIP C. HAMMOND

Photographs by GEORGE HOLTON



Palace tomb was carved originally by Nabataeans and later reworked by Romans.

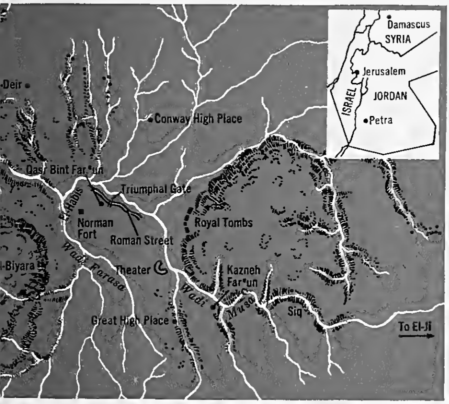
Third column from left at the Treasury of the Pharaoh has recently been reconstructed.



e ancient barrage is just now being restored. This will t the floodwaters of the rainy season away from the h of the Siq, sending them through the original rock-unnel at one side and around the city area to the nt spillways that once tamed the flow and made habita-afe in the valley. A tragic accident occurred in recent hs when a flash storm sent a sheet of rushing waters, five feet high, over the heads of a group of tourists ed in the Siq.

tering the Siq from the blinding light of the desert sun, s awe-struck. The shadows deepen, and the sky be-s a thin blue line above the towering cliffs that sepa-the traveler from the outside world. Echoing walls t only the clatter of hoofs on stone, the calls of wheel-irds, and the chatter of native boys. Civilization seems back in time. The road meanders between the cliffs suddenly the Siq falls away, and one stands before f the most perfectly preserved monuments of Naba-times, carved into the face of a rose-red mountain eflecting its hue into the dark passage of the Siq.

is is the Khazneh Far'un, the Treasury of the Pharaoh. oses fled from Egypt, so the locals declare, an angry ıoh pursued him, pausing only long enough to create



Site map of Petra in Jordan shows some of its major uildings, streets, and prominent topographical features.

posite tomb façade with obelisks is at the entrance Siq—a deep gorge that leads down into Petra's valley.

reasury by magic and store his gold in its vastness. ven if the origin of this monument, which is actually b, is made prosaic by reality, the architectural skill uman sweat that carved it from the cliff face must be wledged. Actually, the tomb's façade is an undying e, not to the nameless king for whom it was hewn, but to the eclectic art of the ancient Near East. Here is bly the best example of the desert culture that brought to her zenith and made her the queen of a thousand ercial holdings, ruling the trade routes that were ave-f culture from the fourth century B.C. to the end of the entury of the present era. At first glance just another copy of classical Hellenistic art, the deceptive architectural form of the Khazneh is the key to the Nabataean architecture. Linear perspective, coupled with stonecutting of exquisite skill, harmoniously joins the Western world with the Eastern. The columns are borrowed from the Greco-Roman canons, architraves, finials, moldings, and other architectural parts, but their assembly into a single carving is the work of the indigenous craftsmen who gave new spirit to an old style.

Unlike the Khazneh are the "classical" Nabataean tomb façades one sees as the open road winds around rock outcrops, mountains, and man-built walls into the heart of the ancient city-site. These are eclectic as well, but their synthesis is Near Eastern, not Hellenistic, and they are reminders of the caravanners who brought to Petra their recollections of Baghdad, Damascus, Teima, and Egypt. The early tombs are like the cultic carvings on the walls of the Siq and on other cliff faces—crude blocks representing the god of the desert days, Dushares, Lord of the Shara Mountains. Later curling tendrils of grape and set faces of gods adapted from other cultures marked the change from bedouin to townsman farmer and commercial baron.

Today, Petra's valley site might disappoint a traveler. New excavations and clearances have brought to light a paved Roman street lined with walls and dirt-filled doorways, a few columns point dejectedly toward the open sky, a once-triumphal gate straddles the road, but no city is to be seen. Yet, beneath the sands on every side are the ruins of noble dwellings, great markets, shops, storehouses, baths, and all the other remains of man's material existence. Only when the full moon rises from behind the ridge known as el-Kubtha can one's imagination reconstruct the ancient city. The Roman street gleams and seems once more to bear the weight of the Imperial Legions; the royal tombs gape darkly over their lost masters; the sound of the grazing camel and the light of bedouin fires arouse the ghosts of antiquity, and Petra reassumes her ancient glory.

During the day Petra becomes the archeologist's hunting ground. Paleolithic flint axes, Iron Age cisterns, Greco-Nabataean-Roman architectural devices, Byzantine crosses, Arabic pottery, and Crusader coins attest to the vast parade of cultures this site has known.

Defensibility, water, and agricultural promise were all the ancients desired, and under the simple name of "the Rock" Petra began her recorded history in the days of the Exodus, as the home of the biblical Edomites. Seemingly, only King Amaziah of Judah penetrated this refuge, and he boasted hyperbolically of 10,000 Edomite captives cast down from its heights in the eighth century B.C. Apparently the Edomite refuge can be identified with the mountain called Umm il-Biyara, for only there are the plastered Iron Age cisterns and typical crude Edomite pottery to be found in any abundance. This sheer-sided mountain was admirably suited for defense, and its single avenue of ascent and the protecting gate may still be seen. The first extra-biblical reference to the area is Diodorus Siculus' fourth-century B.C. description of an abortive raid on Petra, commanded by the Greek General Athenaeus, in 312 B.C.

By that date, a people called the Nabataeans were firmly inhabiting Petra. Sometime during the period when the army of Alexander the Great was hacking its way across the face of northern Coele-Syria, a unique bedouin tribe, the Nabataeans, came out of the desert. Untypically for

Semitic nomads, they were pirates until the Egyptian navy drove them from the Red Sea. Then they became land brigands until a more legal means of livelihood occurred to them and they became the "protectors" of the land.

The Nabataeans occupied Petra's valley, and gradually converted to an agricultural-commercial life. Their hydraulic engineering skill was astonishing, and their commercial acumen notorious. Probably by the first century B.C. the Nabataeans had already begun to dominate the great desert caravan routes and spread their outposts through all parts of the southern region, from Aqaba to the northern tip of the Dead Sea. Their interest in the bitumen resources of the latter area was apparently the major cause for their alienating the Hellenistic Greeks in the north, but a truce was eventually effected and Nabataean culture rose to keep pace with Nabataean commerce.

WESTERN contacts also grew, and the nature of the Nabataean culture became more complex, as a comparison of Diodorus' account of them with that of Strabo reveals. Commerce brought continued strife, as well, and relations with Idumaean and Jewish neighbors to the west and north were often strained. Caravans under Nabataean control moved northward laden with the goods of China, India, Qateban, Sheba, and Egypt to the ports of Gaza and the depots of Damascus, which were the gateways to the West. Pliny records a levy of 25 per cent laid on all caravans using the route—and Diodorus speaks of the luxurious living and cosmopolitan ways of Petra. By the end of the last century B.C., the Nabataean culture, in all its aspe had attained a height reached by only a few other na people in ancient Syro-Palestine. The pinnacle of that ture was achieved, at the turn of the Christian Era, un the leadership of Aretas IV (9 B.C.—A.D. 40).

With success came danger. Rome had entered the N East in 64 B.C. to "liberate" both captive and indepen peoples. Even by that time, the commercial fortune of Nabataeans was realized, and Pompey dispatched on his generals, Scaurus, to subjugate the Nabataeans. Roman expedition never reached Petra because of the renness of land and the diplomatic intervention of A pater of Idumaea. For more than a century and a hal relation of the Nabataean kingdom to the Roman Em was a loose one. Officially under Rome's control, the N ataeans, from their desert capital, ignored the issue— Roman authority. Had the Nabataeans paid the "assess taxes in 31 B.C., for example, Herod the Great would have been trying to collect them with his Jewish army might have turned the tide in favor of his allies, Anth and Cleopatra, against Octavius. But Imperial Rome persistent, and gradually the vast Nabataean commer empire was swallowed up piecemeal. Cultural dec followed commercial decline, and when the northern t routes supplanted the great southern ones, Nabata power was gone. Traditionally the fall of the Nabata is dated at A.D. 106, when the army of Trajan marc triumphantly through the Siq and planted the Ro eagle in Petra's streets. In fact, Nabatene was conqu

ng Byzantine period, from fourth century A.D. *to the*
g of Islam in the seventh, Ed-Deir, a Nabataean tomb,
worked and subsequently used as a monastery.

Theater, with seats cut from solid rock, was excavated in 1961-62 by the American Expedition to Petra, in co-operation with Jordanian Department of Antiquities.

far earlier, and her people continued to affect the course of Near Eastern history far later. But for all practical purposes, Petra, as a major force in the life of the ancient Near East, died at that time.

The Roman era of the city saw an external revival. Much new building, of which the street, markets, a temple called today the Qasr Bint Far'un, and other monuments still exist, was done to "glorify" the new rule. Honors, including the title of *colonia* were heaped on the empty shell. Native festivals continued as late as the third century, but the Nabataean spirit had been broken and the Romans controlled only what has been called by George L. Robinson "the sepulcher of an ancient civilization."

Under the Byzantines, from the early fourth century A.D. to the coming of Islam in the seventh century, Petra fared no better, and a few crosses, coins, and Greek inscriptions alone indicate their presence. It was during this period, however, that one of the more isolated royal tombs was reworked as a place of Christian worship and gained its present name, Ed-Deir, "the Monastery." Other tombs were also used for worship, and the sepulcher niches were recarved to form altar niches, while pious inscriptions were added to record the effect.

HISTORICAL obscurity then joined political and cultural darkness at Petra, and the site, its name, and the knowledge of its location dropped out of Western ken. Only in the Crusader period do we hear of it once more, this time as "The Valley of Moses," one of the Latin kingdom's major fiefs in Oultrejordain. Baldwin I entered the area in A.D. 1101, at the behest of the "monks of St. Aaron," who were local Greek Christians, and immediately recognized its strategic and commercial importance. The Crusader king needed both a defensive network to guard against the Moslems and funds to support his military establishment. A fortress, whose remains may still be seen, was built just outside the Siq, at El-Wu'eira, but with some embarrassment, no doubt, the Crusaders discovered that although they could see caravans on the route leading through ancient Petra they could not reach them in time to collect tolls! As a consequence, a minuscule Norman fort, complete with outer bailey, inner bailey, and k
was erected inside the city-site on top of a small pea
the western ridge called El-Habis. From its summi
patrol could sally forth, collect revenues and withd
safely under the watchful eye of the sentries at El-
'eira. By this means, "Le Château de la Vallée de Mo
rapidly rose to a position of major importance, both
tarily and financially, for the Latin king across the Jor
in Jerusalem. Isolated as it may have seemed to the me
arms residing there, the castle at Wadi Musa was lin
closely by its smoke signals and fire signals with the
of the great chain of forts stretching from the Holy
to Aqaba. Alas, the disastrous battle of the Horns
Hattin in 1187 changed all that, if, indeed, the tr
Jordanic fiefs had not fallen to Saladin's troops by 1182

Roman street, lined with columns, is in foreground. At rear are palace and urn tombs.

In the opposite direction the street leads to Qasr Bint Far'un and Umm il-Biyara.

Latin kingdom was forced to flee, and Wadi Musa n lost its strategic importance to Moslem forces, since nilitary and trade routes through the area were now r their control. Petra once more slipped into obscurity.

n August 22, 1812, a traveler made his way through a re in the Shara Mountains. This was Swiss-born nn Ludwig Burckhardt, disguised as a Moslem sheik. nsibly on his way to Nubia, Burckhardt had traveled ugh the Holy Land visiting ancient sites. When he ed into the trans-Jordanic area, he heard of a fabulous ent city of the dead, next to which was the traditional of Aaron, the brother of Moses. After some delay, khardt prevailed upon a local guide to conduct him aron's tomb as a pilgrim, and he noted in his journal: ppears probable that the ruins in Wady Mousa are those of ancient Petra . . . there is no other ruin between the extremities of the Dead Sea and the Red Sea, of sufficient importance to answer to that city."

When Burckhardt's *Travels* were published, Petra entered a new era. It was no longer a trade center pouring wealth into commercial centers, but rather a magnet that attracted visitors in ever increasing numbers. First came the geographers and "learned travelers," those intrepid men who braved the dangers of hostile government, poor roads, expensive accommodations, disease, and other natural hardships. Among the names on this list of early visitors to the newly found site, many distinguished ones may be found: Irby. Mangles. E. Robinson. Doughty. Forder, Musil. Dalman, LaGrange, Vincent. Brünnow, Domaszevski, Weigand, and others.

From their labors came the maps of the site still in use today. They recorded local place names and related them to known history; they examined and described ruins; they made quantities of drawings and photographs. Each visit brought startling new discoveries. One such was the discovery of the "Great High Place" by Professor George L. Robinson, just at the turn of the present century, which created a stir because of its unique parallel to biblical references to cultic places. These reports are still culled for scientifically valuable information.

By World War I, the inhabitants of the Wadi Musa district were becoming accustomed to foreign visitors, and Petra's ancient commercial value was translated into local wealth through guide fees and embryo tourism. This ceased during the war years, but Petra gained new fame as the locale of one of Lawrence's hard-fought victories against the Turks. Since that time, the touristic attraction of this "lost city" has gained steadily. Today visitors from all parts of the world make the trip to the little town of El-Ji, park their cars at the new resthouse, and make their way, on foot or horseback, to view the wonders of the site.

Meanwhile the reports of the learned travelers had reached the ears of another group of people—the archeologists—whose interest in Petra began to grow. It was not until 1929 that any serious scientific work could be undertaken on the site, however. In that year, George Horsfield, Chief Curator of Antiquities of Transjordan, began his pioneer excavations. With his positive attribution of characteristic pottery remains to Nabataean factories, the way was opened for a broad investigation of the culture. From that point on, the identification of other Nabataean sites spread through the southern area. Horsfield centered his activities in a vast, ancient dump on the northern slopes of Wadi Farasa. The major work was a cut made from surface to bedrock, on the basis of which the chronology of further work was established. Unhappily, in this period of Near Eastern archeology, Horsfield's methods led to a confusion of strata and resultant dating errors, which remain uncorrected. In any case, it is to the Horsfield days that we owe the present designation of one feature of the city known as the "Conway High Place," named in honor of Agnes Conway, later Mrs. Horsfield.

In 1934, Horsfield began another series of investigations, with the able assistance of Dr. W. F. Albright. The Conway High Place was cleared, as were certain of the more promising larger tombs—the Khazneh, the Urn Tomb, and the Tomb of the Roman Soldier. Two members of the British School of Archaeology in Egypt, Margaret Murray and J. D. Ellis, dug on the site in 1937, clearing cavesites at the north end of the city above Wadi Abu Olleqha.

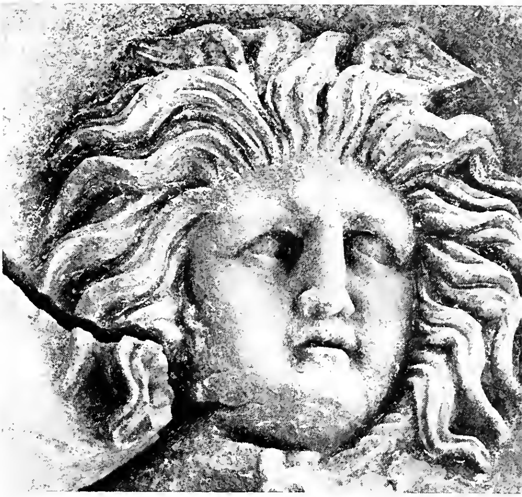
After the creation of the Hashemite Kingdom of Jordan, interest and technical personnel were joined for full-scale work at the site. In 1954, the Jordanian Department of Antiquities began a series of clearances and preservation activities that continues with increasing scope. In 1955, a party from the American School of Oriental Research in Jerusalem, with the author as a member, undertook specific, individual surface projects on the site. Later that same year, and again in 1956, the Department continued its clearance activities, concentrating on the Roman street, under the supervision of Miss Diana Kirkebride, who was later to excavate the first complete Neolithic village in the area, at El Baidha.

The British School of Archaeology in Jerusalem, w
Peter J. Parr as director, began limited excavation
the site in 1958 and continued through 1960. During t
period, attention was given to the supposed city-wall l
of Horsfield, the slopes of Katute, the Roman street,
wall line to the north, and certain other loci. The Brit
School was joined by an American party, under my di
tion, during the 1959 season. These excavations are the f
stratigraphic approach to the problem of Petra's c
archeological history, and the results, when publish
should be of exceptional value. Excavations on other N

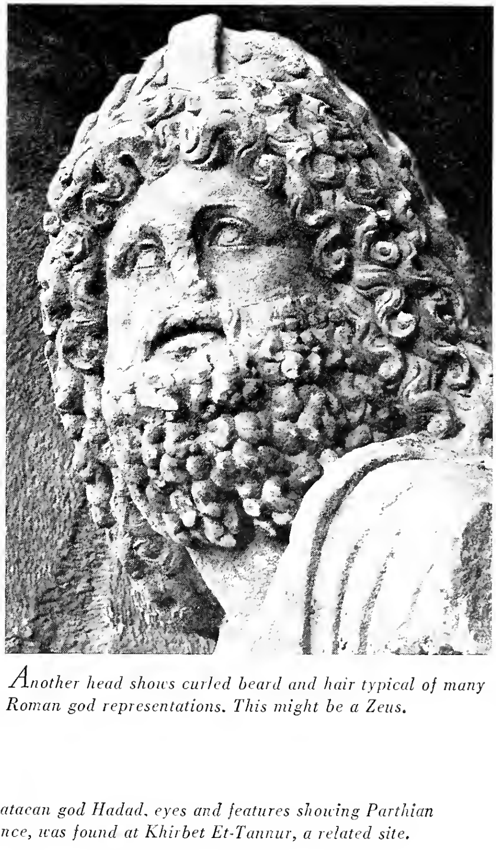
n sites, notably Khirbet Et-Tannur, Sbaita, and an, to name but a few, can then be related, and a picture of the specifics of Nabataean chronology history be gained.

e Treasury and the Triumphal Gate were partially red, for reasons of preservation, in 1960, by G. R. H. ht, working for the Department of Antiquities.

American Expedition to Petra, also under my direc- undertook stratigraphic excavation of the Main ter at the site in 1961 and 1962, in co-operation with epartment of Antiquities. The primary objective in



Roman-carved head of a woman, probably dating from second century A.D., *was excavated during the 1963 season.*



Another head shows curled beard and hair typical of many Roman god representations. This might be a Zeus.

Nabataean god Hadad, eyes and features showing Parthian influence, was found at Khirbet Et-Tannur, a related site.

1961 was to secure a complete picture of the stratigraphic history of the area. Four trenches were laid out, extending across the *orchestra* and stage to the *proscenium* (scenery) wall, across the front of the stage, and along the face of the *vomitorium sinistrum* (left entryway). Following the stratigraphic excavation, the *orchestra*-stage areas were cleared by the Department of Antiquities. In 1962, the expedition concentrated on detailed survey and planning, as well as on the completion of certain problems of the previous stratigraphic work. A long trench was opened, extending from the exit side of the *vomitorium sinistrum* through the *proscenium* and *postscenium* wall exits to the wadi outside the installation. At the same time, further excavation was carried out in the stage area to determine building phases there, relating specifically to the period of main use of the Theater. A total of 289 separate strata were isolated in the two seasons, and then interrelated and phased into eight periods that furnish a complete story of the use and decay of the Theater.

ARCHITECTURAL information was probably the most important "find" of the two seasons, and resulted in perhaps the most important comprehensive picture of a Roman period theater thus far achieved in the Near East. From this material has come much new knowledge concerning order, building practices, individual architectural devices, details of construction, and general knowledge of the specific theater, itself. The major find, in the usual sense, was the marble statue of Hercules, uncovered at the end of the 1961 season in the curtain slot of the stage. In addition, epigraphic material (especially Nabataean), coins, pottery, small finds, and similar items swell the list.

Out of the excavation has come, also, the strong possibility of another example of the engineering skill and eclectic art of the Nabataeans. Indications all seem to point to them as the original builders of the Theater, closely following Vitruvian canons but adding their own touches. If this tentative conclusion proves to be correct, the Theater at Petra will become one of the earliest provincial Roman-type theaters, and one of the few resulting from local enthusiasm for the arts rather than from the postoccupation desires of the Romans themselves.

Research through the years has produced a great deal of concrete evidence concerning the occupations and cultures of Petra, particularly of the Nabataeans. Since they are responsible for the first coinage in use there, most of the pottery remains, the majority of monuments, and all but a handful of the inscriptions on the site, a word should be said concerning some aspects of their culture that have been clarified by archeological research.

Pottery forms, especially the fine, thin, painted ware, have vague parallels to earlier Greek materials. From these and untraceable local prototypes, the Nabataeans rapidly developed what may be the finest indigenous wares of ancient Syro-Palestine. From one end of the kingdom to the other, the Nabataean factories produced masses of well-turned and perfectly fired bowls and cups superbly decorated with motifs of local flora, as well as masses of coarser wares. The latter gradually began to resemble contemporary Roman export wares, but by their side the characteristic thin ware continued. Of all the varieties of painted wares made, however, only a very few complete bowls have ever been found intact, although their sherds may be gathered by the basket on almost any Nabataean site. Unguentaria (small perfume-ointment jars), v bulbous bodies and slender necks are also ubiquito especially at Petra. These were apparently produced loc to provide vessels in which to transship the ointments perfumes that entered Nabatene from the rich southla

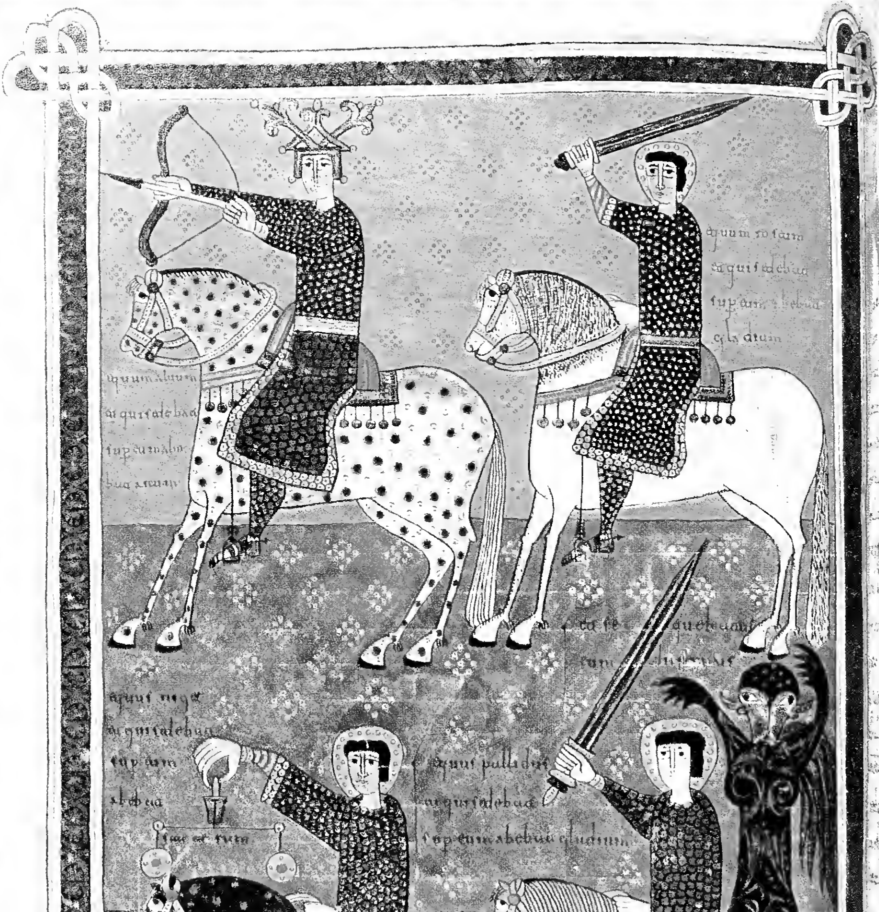
Petra's Nabataean monuments are almost numberl The tourist who enters Petra by the Siq sees the Khazn laboriously ascends to the Great High Place, moves p the Theater to the Royal Tombs, walks along the Ro street, and climbs again to Ed-Deir. Hundreds of to façades with crowsteps, gables, and other decorati crowd the mountainsides; cultic devices, ranging fr blocks dedicated to the god Dushares, set in little nic to adopted deities in human form, hide from the cas glance; graves are everywhere, as are the "high-plac that apparently delighted the pious Nabataean carv

Inscriptions, graffiti, and petroglyphs are in the m unlooked-for places, as well — behind rocks, in nar crevices, low along the footpaths, or across a tomb faça The Nabataeans adopted the Aramaic language of the of Coele-Syria and, as usual, contributed their own p sonal touch to epigraphy in a swirling, ligatured, se cursive script. The longest of the inscriptions is that on façade of the Turkmaniyah Tomb. Its imprecations aga defilers are still readable above the door of the ravis burial chambers. Another, shorter inscription lauds refurbishing of the Great High Place along the path le ing to its summit. Most of the other readable rema simply say "Peace" to the passing traveler. Pictures herdsmen, sheep, long-horned ibex, and camels, as v as a peacock and a gaming board on Umm il-Biyara, found on stones, tumbled blocks, or cliff faces.

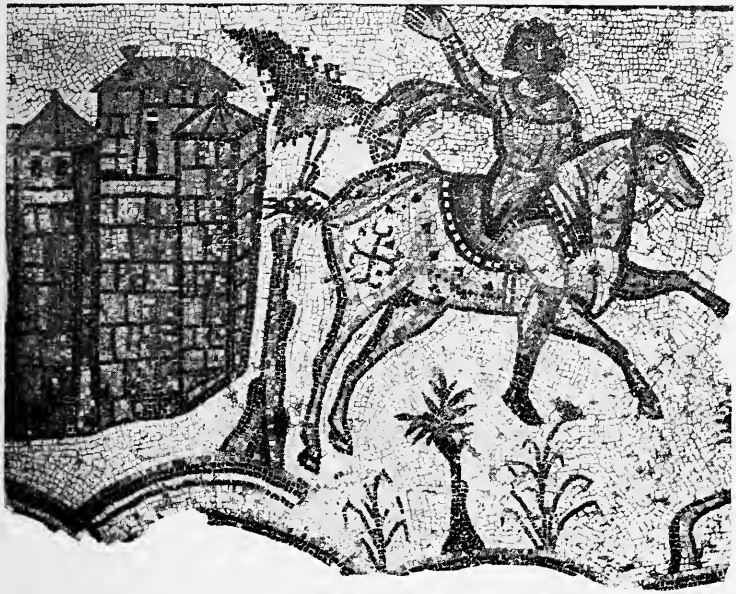
Archeologically and historically many problems re ing to Petra and to the Nabataeans remain unresol and await the spade and trowel of the excavator. W was the early history of the site? What was the act ancestral home of the strangely atypical Nabataea What happened to the genius of their culture after 106? What was their complete social structure? Wh are the dwelling places of all the generations of those v inhabited Petra? What are the dates of the greatest mo ments of Nabatene? What was the sequence of the N ataean kings? Where is their literature—or even th commercial accounts?

But Petra is recapturing her old glory in much the sa idiom as that of ancient times. The economic dema of tourism are seeking to exploit the past for present ne and Petra's location, natural beauty, and artistic contri tions make the site one of the most important sources revenue in Jordan. As a result, clearing and restorat operations on the site have begun on a scale never bef attempted. Soon the visitor will be able to see many of two-thousand-year-old ruins, either exposed or restor Communications, roads, and other facilities have b added to simplify travel to the site and its most import monuments. The bedouin still live in the valley in th black tents, but change has indeed come to that rose- city where once the Edomites roamed, where the Na taeans bartered, and where Roman legionaries march

Burial niches in this Nabataean tomb were somehow
from the incredibly patterned, multicolored, solid rock


equum album
et qui sedebat
sup eum habe
bat arcum
equum rosaum
et qui sedebat
sup eum habebat
gladium
sequebatur
eum
equus niger
et qui sedebat
sup eum
abebat
equus pallidus
et qui sedebat
sup eum abebat gladium

Mosaic from Carthage, ca. A.D. *520 is shown below. Rider of spotted horse is probably a Vandal conqueror.*



Ornamental Equines

SPOTTED HORSES SPAN AGES

Spotted horses have been portrayed by artists of ancient and recent civilizations of Asia, Europe, America, and Africa. In most cultures, painters are believed to have depicted the mottled animals, not because any traditional symbolism accrued to horses with such markings, but for decorative purposes. Spotting is derived from a genetic color determinant that is inherited by the horse in the same way as black or bay, and which can be bred into or out of any strain or type of horses. Falsely, the pattern had often been taken as indicative of undesirable hybridization or mixed ancestry. In recent times, spotting was excluded by horse breeders from the genetic line of recognized breeds; therefore, any spotted horse one may see today, however fine, will not be a pure breed. Still, there is no evidence that coloration is genetically associated either with good or with bad traits in a horse. (The photographs on these pages were first assembled in *Appaloosa, The Spotted Horse in Art and History*, published for the Amon Carter Museum of Western Art by The University of Texas Press.)

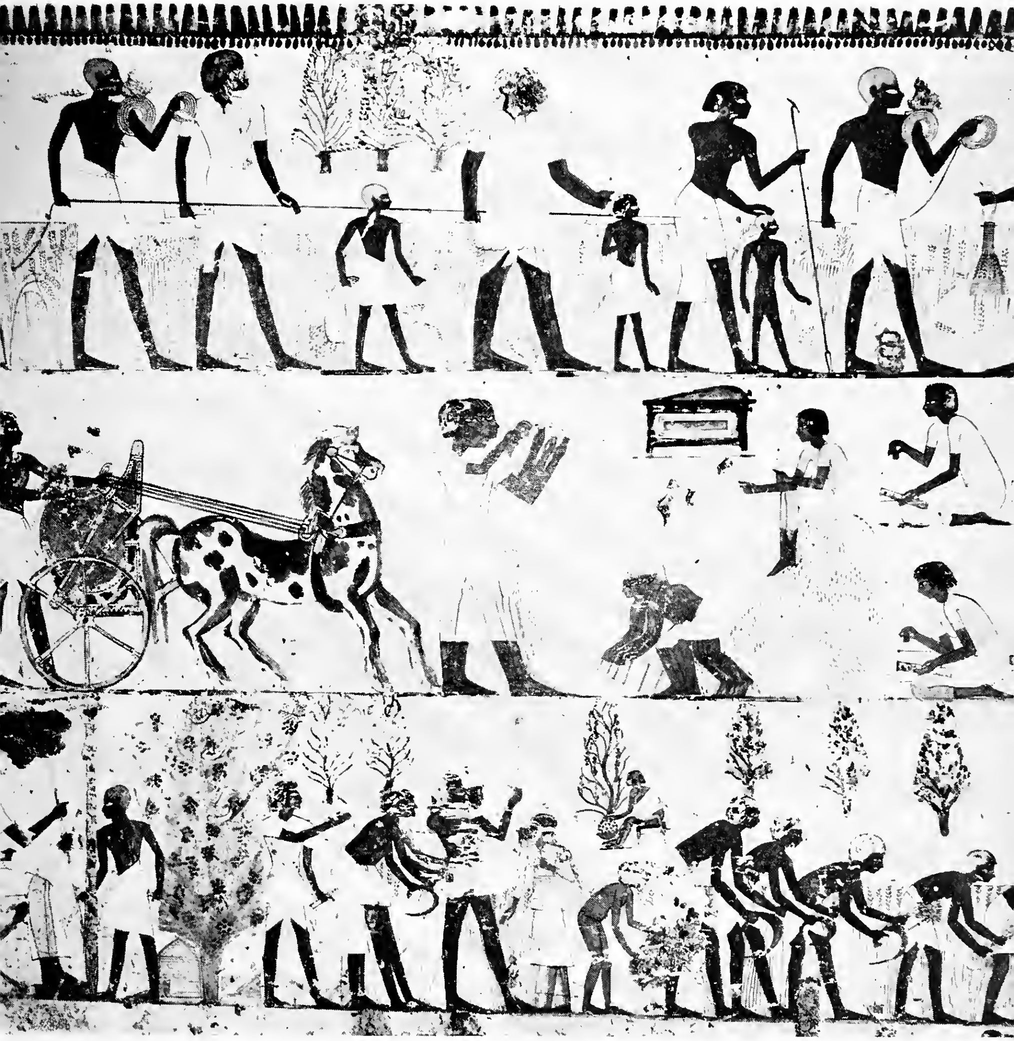
Spanish manuscript of the eighth ntury depicts the Four Horsemen of e Apocalypse on stylized mounts.

Early Man and the Horse

NEAR the village of Solutré, in east-central France, there is a large deposit of horse bones that was discovered to be the remains of the meals of Stone Age cave men. Many ancient sites besides Solutré offer evidence that to prehistoric man wild horses were a primary source of food. Portraits of horses are common in cave paintings made by prehistoric man, and the example reproduced on this page—spotted, pregnant mares on a cave wall at Pêche-Merle, near the town of Cabrerets, France—stresses the theme of fertility, for large horse populations meant a plentiful meat supply.

It is not known if men first attempted to domesticate herds of horses to assure a ready source of meat, but once horses had ceased to be merely food or pets, they exerted a profound influence on the fortunes of mankind, especially in the realm of warfare. The first definite historical records of domestication of horses come from opposite ends of Asia, in Mesopotamia and in China, not long before 2000 B.C. In both cases, the idea of domestication was introduced by barbarians who had used horses successfully in waging war. Only in relatively recent times has the development of military horses ceased to be the main concern of the world's breeders.

Horse-drawn war chariots helped the Hyksos to conquer Egypt, and it is in the charioteer's harness that the horse most frequently appears in the art of Egypt and the other old Near Eastern civilizations. Reproduced on the opposite page is a tomb fresco showing a team of strikingly marked animals (one barely discernible behind the other) that belonged to an official of the Egyptian Pharaoh Thutmose IV.



Fresco in Egyptian tomb of Late Kingdom, ca. *1415* B.C., *shows favored horse of a deceased official.*

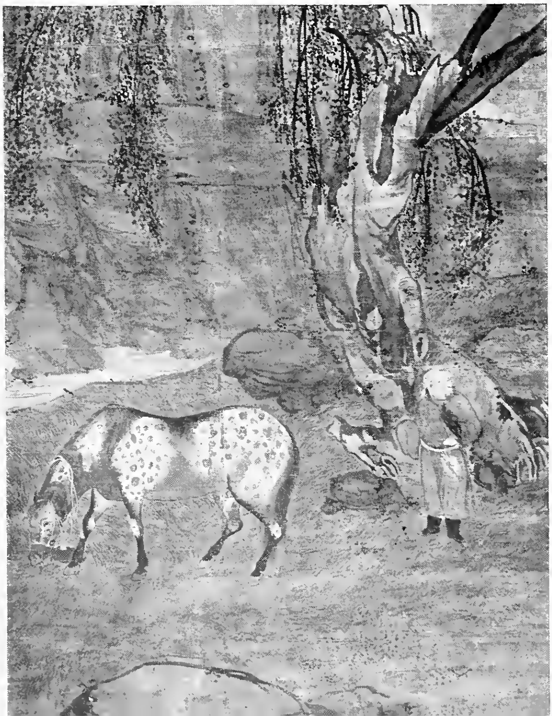
e near Cabrerets, France,
ns painting of pregnant mares.
ates from upper Paleolithic.

Asiatic Horsemen Roam the World

THE conquest of most of Asia and much of Europe by the Mongol horsemen of Genghis (or Chingis) Khan in the thirteenth century marks the zenith of the military effectiveness of the horse. The whole Mongolian horde was horse-borne, and its leaders developed irresistible cavalry tactics that have been studied ever since. The Mongols typified a people for whom the horse was the most essential feature of civilization. The horse was protector, food, drink, weapon, friend, and god. Mare's milk was the common drink, but soldiers traveling without rations sometimes cut open a horse's vein, drank the blood, closed the incision, and remounted. Horse skulls were worshiped, and shoulder blades of the animals were used to tell fortunes. Horse theft was punishable by death.

Horse cultures, including those of the North

Sixteenth-century woodcut reca the one hundred colts paid in trib to eighth-century Chinese empero

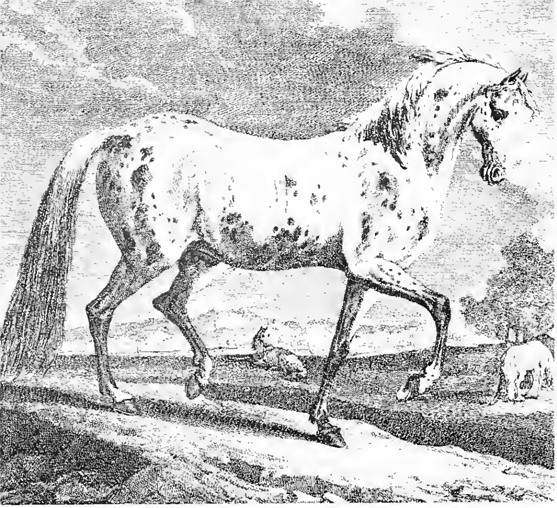


Wanderer and his mount is by fourteenth-century artist Chao Yung, one of a family of renowned Chinese painters.

American Plains Indians and, in lesser degree, of the western ranchers of the United States, depended on the availability of large numbers of horses and a pattern of life based on raiding, hunting, or herding. Where horses were few, horse ownership was restricted; traditionally, the man with the horse was either an aristocrat or a fighter. Even in northern Europe, horses were seldom ridden by commoners or used to work on farms until the last century or two before the coming of the automobile.

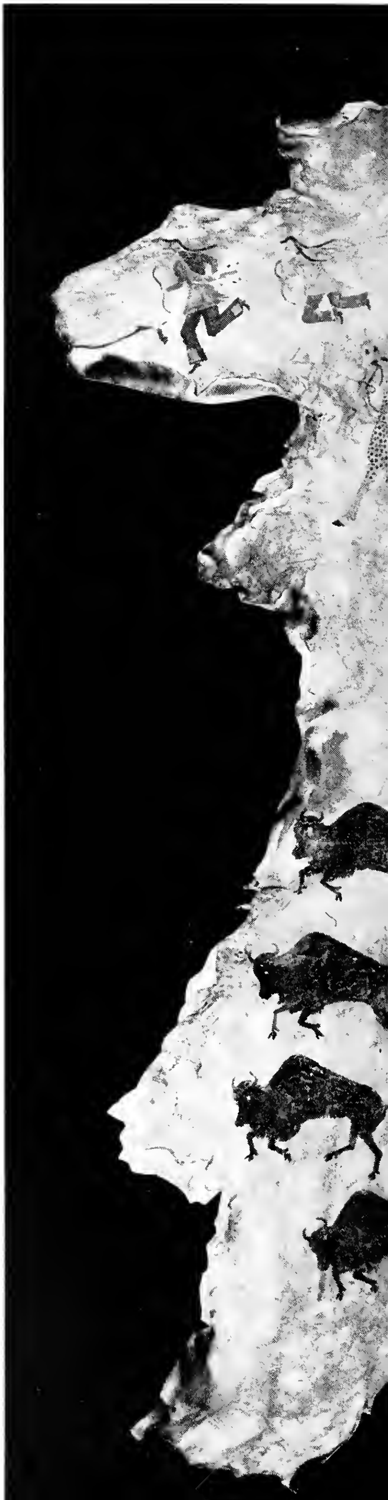
An attempt is now being made in this country to develop a recognized, separate breed of spotted horses from descendants of Indian range ponies. These are called Appaloosa horses. In previous paragraphs, a very brief history of man's use of horses was set forth; the spotted horse is part of this story, sometimes preferred for its beauty, at other times rejected because of misconceptions about its breeding, but always sharing in the events that have affected the long history of the species as a whole.

Riding his horse Rakush, Rustam,
he hero of Persian epic poem
hāhnāma, *lassoes the Chinese Great Khan.*



Vienna stables of Hapsburg Emperor harles VI included animal hown above. Engraving is dated 1740.

Horses in the West



Crow Indian elkskin, right, shows braves riding spotted ponies and cowboys on pintos during buffalo hunt.

In this detail of a Danish fresco, St. Martin shares his cloak with a beggar, seen at right.

Fishes and Climates

Fossil fish distribution indicates past environmental changes

Skeleton of a bullhead, ***Ictalurus*** **cf.** ***nebulosus,*** **is from a Pliocene deposit.**

By C. Lavett Smith

Everyone interested in fishing or fish culture realizes that different kinds of fishes have different habitat requirements. Trout and salmon demand cold, clear waters; pike and largemouth bass need weedy shallows; catfishes and plains minnows thrive in sluggish, muddy rivers. The existence of such differences offers a powerful scientific tool. If ichthyologists can establish what fishes were present during given geologic time periods, they can obtain significant indicators of climates in the past.

There are, of course, difficulties in using such a method. First of all, a specific fossil must be the same as, or closely related to, a living species; without such a relationship there is no basic criterion by which to judge the habits of the now-fossilized form. Because of close anatomical resemblance to living forms, there is justification for assuming that fishes that have lived since the end of Miocene times (about 13 million years ago) have had approximately the same life requirements as their relatives among present-day fishes. We cannot be as certain about the more ancient fishes; their fossil record has been difficult to construct, partly because of the extreme fragility and perishability of fish skeletons.

For truly significant indications of past climate it is essential to reconstruct a picture of a large sample of the aquatic fauna that lived in a region in any given geologic time, or, at least, to work with assemblages of several coexistent species. This large sampling is necessary because we cannot be certain that any one fish was typical of its contemporary relatives. But if we can work with five, ten, or more species, perhaps including some terrestrial animal fossils as well as fossil fishes, it becomes very unlikely that all of them were exceptional in their requirements for life. The larger the number of species in such assemblages, the more reliable are the conclusions that may be drawn about the environment in which they mutually thrived.

During the past three decades, fossil-collecting on the High Plains of North America has yielded a series of faunal assemblages that give valuable clues to the climatic history of that region. Many of these have been collected by field crews from the Universities of Kansas and Michigan under the direction of Dr. Claude W. Hibbard, Curator of Fossil Vertebrates of the University of Michigan Museum of Paleontology. Significant faunas are now known from Kansas, Nebraska,

IENTISTS view sedimentary deposits
posed in clearly perceptible strata.

klahoma, Texas, and other plains
ates. Mollusks and many vertebrates
amphibians, reptiles, birds, and mam-
als—have been studied in addition to
shes, and all have contributed to a
owing picture of this region's former
imatic conditions.

ERTAIN species are rare and some
are known only from single frag-
ents. Obviously, stout or dense bones
e more likely to be preserved than
e thin, delicate ones. Certain habi-
ts, too, are more likely to develop
e special conditions necessary for
ssilization. Most of the High Plains
ssils, for example, are formed of
ense mineral substances that over
any years have replaced the original
nes. These fossils are like the origi-
l bone in every way, and all of the
ne details are just as they appeared
hen the fish lived. Instances are
known in which even internal microscopic details have been preserved.

When a season's collecting is finished and the fossils are safely back at the museum or university, the task of identifying the material begins. First the fossils are sorted into major groups—fish, mollusks, mammals, and so on—and then specialists in these areas begin the exacting work of precise identification. Usually the final identifications are made, or at least confirmed, by direct comparison with comparable elements of living or other fossil species. Sometimes a single fragment is enough to permit an identification: at other times, a whole series of perfect bones may be unidentifiable simply because the bones possess no diagnostic features. Even when it appears that there is a perfect match between a preserved fossil and a living fish, there remains the possibility that the fossil species might have differed in some additional features that were not preserved or have not yet been discovered.

IN the past, some researchers have tended to assign to fossils names different from those of living species, solely on the grounds of the much greater age of the fossil form. Such a rechristening would normally imply that the fossil was genetically different from the living form, which, of course, cannot be demonstrated. If no evidence of genetic difference, such as may be shown by skeletal structure, can be found, the fossil is assigned to an appropriate living species. This serves to emphasize the close relationship and probable similarity of habits.

Fossil forms with no living counterparts are of special interest to the scientist who is concerned with cli-

IN OKLAHOMA PANHANDLE, erosion by the Cimarron River, *shown above,* has uncovered many ancient accumulations of important fresh-water fish fossils.

matic histories, because extinction of species might well have resulted from climatic shifts that made previous adaptations for life obsolete in a given region. But every precaution must be taken to insure that a case for an extinct fish has not been built up around an abnormal individual of a known species. Statistical procedures help in evaluation of observed differences. Indeed, such procedures are crucial in determining whether a strange fossil fish represents a newly discovered extinct species or is an odd individual of a well-known species with variations that are attributable to chance alone. If, however, two fossil forms differ between themselves as much, or in the same way, as do comparable living species, ichthyologists are inclined to regard each as distinct. Here the experience of the investigator who provides the data for statistical analysis plays a decisive role.

One of the first Pleistocene fish faunas from the High Plains to be studied with the above-described procedures was the Berends Local Fauna, named in honor of the Oklahoma ranch owner on whose land the fossils were quarried in 1953. This fauna, from the panhandle region, contains some twelve species, of which nine have been identified with reasonable certainty—yellow perch, gar, common sucker, black bullhead, channel catfish, muskellunge, green sunfish, and two kinds of minnow. These fossil fishes were found in beds dating from Illinoian times (the third glacial age), and all are close to, if not identical with, forms that live today on other parts of the continent. Only the black bullhead and the green sunfish still live in that part of the High Plains.

At present the climate of southwestern Kansas and the Oklahoma panhandle is semiarid, with a mean rainfall of less than twenty inches annually and with markedly wet and dry years. Streams, which are few and far between, may dry up completely in rainless years. Artesian springs feed some streams, but these harbor only a few species of small fish. There is no habitat suitable for gars, muskellunge, or channel catfish other than artificial ponds. The common sucker is also

USING A METHOD of gold prospectors, scientists search for fossils. The box has meshes to trap and retain fossils as running water carries off the silt.

sent from the region, possibly be- use of the lack of adequate gravel ttom spawning sites. The presence fossilized large river forms indi- tes that the climate of southern Kan- s and the Oklahoma panhandle must ve been much more humid during inoian times than it is today. Simply erpreted, this might lead us to hy- thesize a higher annual rainfall. But could also mean that sparse rain- l was then more effective than it is w, perhaps because evaporation ok place more slowly owing to the wer temperatures that prevailed dur- g periods of glaciations.

Today the muskellunge and the yel- v perch are northern fishes, the yel- v perch occurring no farther south an central Ohio. If we superimpose a map the distribution ranges of e living counterparts of the Berends cal Fauna, we find that there is erlap only in the region of the south- n Great Lakes *(map, page 38)*.

The conclusion we have drawn from e above evidence is that during the ne when the Berends fauna flour- ed in Oklahoma the climate must ve been much the same as it is today southern Wisconsin. Such a picture further supported by the presence fossilized spruce, fir, and pine pollen the same deposits that contain the ssil fish, and by the presence of fos- ized remains of such mammals as e meadow vole and northern shrew. llections made since 1953 from ds of comparable age at other loca- ns further substantiate conclusions sed on the Berends evidence.

Although the Berends locality is well south of the southern limit of the Illinoian ice sheet, a widespread cooling would have accompanied the advance of the glaciers and permitted the cold-water-dwelling perch and muskellunge to extend their former ranges southward. Conversely, as the ice sheets receded (it is generally conceded that there were four major glacial advances), the cool-climate forms would have been replaced by warm-water species from the south, such as alligator gar and buffalo fish (the latter are large suckers).

OUR studies of fossil fish have paralleled research efforts with molluscan, mammalian, and reptilian fossil records on the North American continent, and something about these projects should be noted here. As this region became warmer between glaciations it also became drier, and fishes have not been prominent in the fossil faunas recovered from interglacial deposits. The only significant fish fauna known from the area so far is Illinoian. However, Dr. Hibbard and his colleagues have already recovered a series of mammalian faunas that tell a story of warm and cool periods that are associated with all the major advances and retreats of the glaciers. Such mammals as zebras, camels, badgers, ground sloths, and certain other smaller forms have indicated warm climates, while mammoths, beavers, northern shrews, northern grasshopper mice, and others have been interpreted as evidence of cool climates.

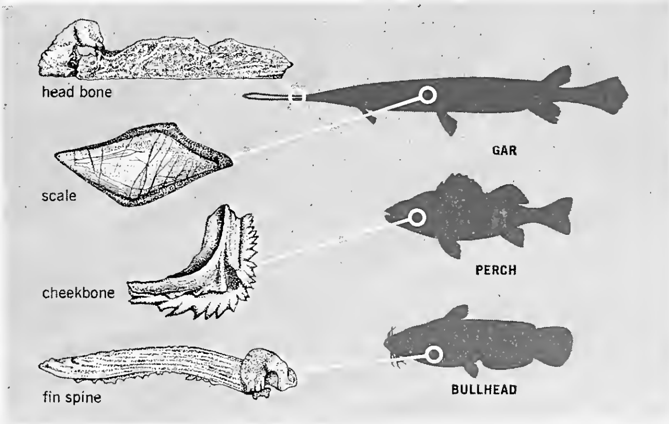
A vast amount of work has gone into these studies, which have presented several difficulties. For one thing, there is no single site at which all of the fossiliferous strata can be studied at once. Furthermore, the cardinal principle used in this work has been that the younger sediments are to be found on top of older layers. (Although certain types of sediments are associated with arid climates and others with wet, there is no direct way of knowing their age from such information alone.) Varied erosion and sedimentation patterns, plus collapses of the terrain that have followed subterranean erosion, have complicated the stratigraphy. As a result, it has been necessary for workers to piece together a picture little by little, determining in one area that bed A is younger than bed C, then at another location that bed B is younger than bed C, and, finally, at a third site, that bed B is older than bed A.

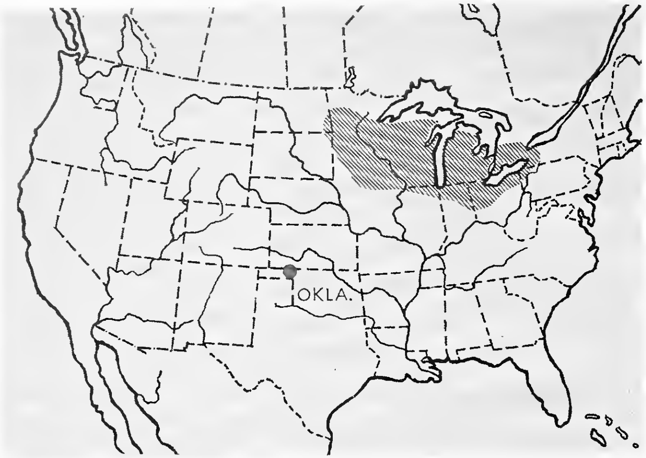
One godsend to stratigraphic studies on the Great Plains is Pearlette ash—a layer of volcanic ash that fell over a large section of the country near the end of the Kansan (second) glacial age. In some places this ash accumulated in depressions from which it is now quarried for use in the manufacture of scouring powder. This layer of ash serves as a reference point whenever it can be found in place. The whole project is like a jigsaw puzzle with many missing pieces. The Pearlette volcanic ash is like the reliable edge of the picture; beds found below the ash are older than late Kansan times and those above are younger.

Fossil fishes have also contributed to our knowledge of climate prior to the Pleistocene, or Ice Age. In the Pliocene, immediately preceding the

ATER SLUICES earth away and leaves sil fragments like ones seen below.

FOSSIL BONES have features that may permit the identification of a species.



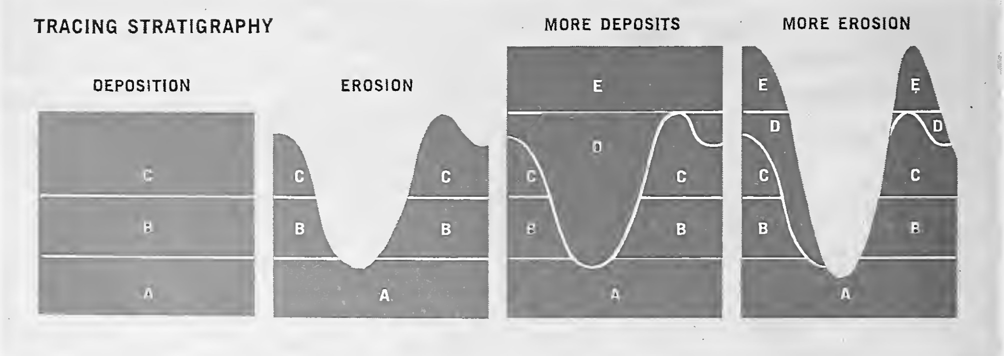


Berends fossil site is shown by dot. Range of same fishes today is shaded.

Ice Age, climate seems to have remained reasonably constant for about eleven million years, becoming somewhat dry only during the latter part of the epoch. In Early Pliocene deposits are remains of gars, bowfins, buffalo fish, and a species of large catfish. From Middle Pliocene beds we have minnows, black bullheads, crappies, and warmouth sunfish. From the nature of the sediments in which these last-mentioned were found we can tell that they lived in a large lake, and that other lakes presumably existed. Our fossils from the Upper Pliocene, later in time, are from small streams and include minnows, green sunfish, rock bass, and some small bullheads that appear to be related to the yellow bullheads. All of these except the bullheads, which still live in niches within the plains region, indicate the former existence of larger and more permanent waters than are now available to support aquatic life on the plains. Short-legged rhinoceroses and giant land tortoises have been found in comparable Pliocene deposits. In the Upper Pliocene, therefore, the climate must have been relatively mild.

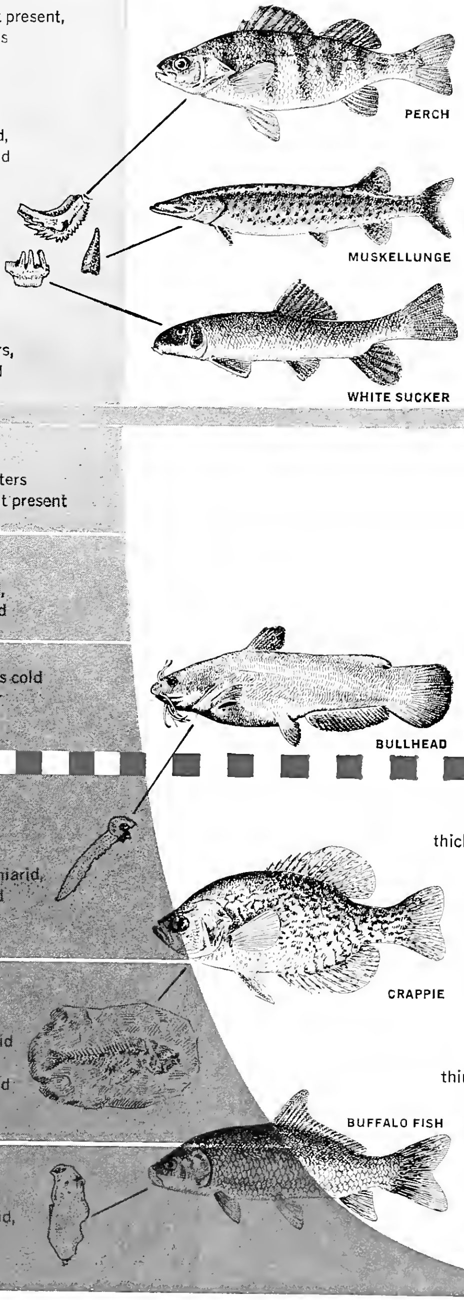
It might be expected that fossils will someday provide the ultimate evidence of the evolutionary course of North American fresh-water fishes. In the case of the yellow perch, for example, the North American and Eurasian forms are so much alike that ichthyologists have begun to doubt that they are distinct species. The fossil record supports the hypothesis that these American and Eurasian perch populations have not been separated for a very long time. While yellow perch are extremely abundant in the Berends collections, they do not appear in any collections taken from older deposits. The fish is a cold-water species and probably made its way to North America no later than the Illinoian glacial stage, but no earlier than the Upper Pliocene. Until such time, North American forms must have been part of the Eurasian population.

The scope of such detective work as that described in connection with the yellow perch has limits. Families and genera of fishes are older in origin than forms that are found in the Pliocene deposits, and so, unfortunately, there is scant hope of finding remote ancestors of present-day fishes there. In fact, there is strong evidence that many of our fresh-water genera were distinct by as early as the Eocene Epoch, some 58 million years ago. There is evidence, though, that two extinct bullheads from different levels in the Upper Pliocene may be direct ancestors of a modern catfish, the yellow bullhead. If further fossil material from the Early Pleistocene should corroborate the existence of this ancestral line, we may be able to use these particular catfishes as index fossils. That is, we might be able to determine the age of deposits by the kinds of catfishes present. If so, this will be one more valuable tool for the stratigrapher. Meanwhile, the search continues. Every rain exposes more fossils; each one is a piece in the puzzle of the changing climates of the past.



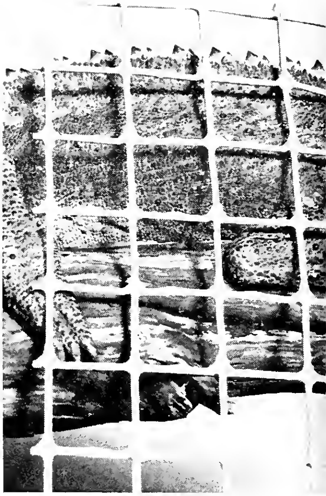
Deposition and erosion may disturb chronology of strata by causing some sediment to settle in unexpected positions relative to older or younger layers. Diagram shows how a late deposit (D, panels 3 and 4) reaches older level (A).

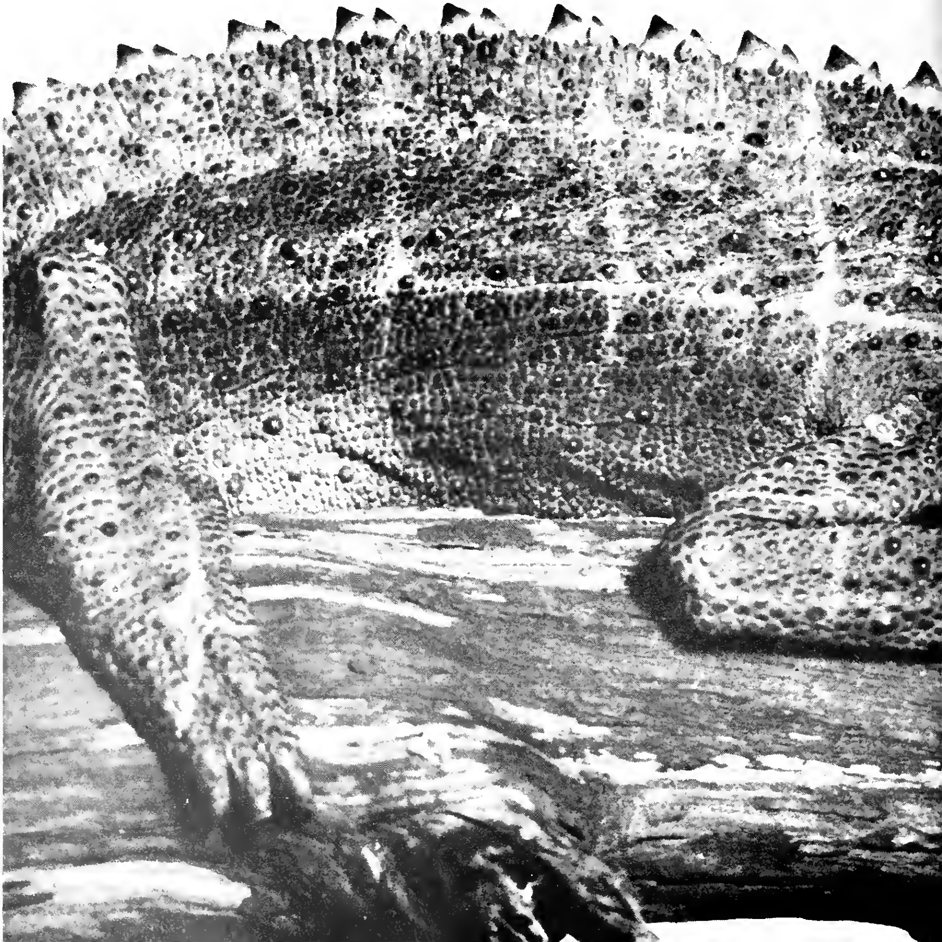
	GEOLOGIC TIME	CLIMATE	FOSSIL FISH	ANIMALS
	RECENT	19.4" rainfall 57.35°F mean temperature		bison jack rabbit
PLEISTOCENE	WISCONSIN GLACIAL	cooler than at present, more extremes		ground squirrel shrew badger skunk
	SANGAMON INTERGLACIAL	subtropical: becoming arid, then subhumid		muskrat tortoise mammoth extinct bison
	ILLINOIAN GLACIAL	cooler year round than at present		shrews voles
	YARMOUTH INTERGLACIAL	subtropical: warmer winters, becoming arid		pronghorn tortoise coyote jack rabbit
	PEARLETTE ASH			
	KANSAN GLACIAL	moist, cool summers; winters warmer than at present		mammoth mink weasel
	AFTONIAN INTERGLACIAL	subtropical: becoming arid, then subhumid		camel tortoise badger zebra
	NEBRASKAN GLACIAL	cool, but not as cold as during later glacial stages		shrews tiger salamander
PLIOCENE	UPPER	mild winters; subhumid becoming semiarid, then subhumid		thick-shelled giant tortoise mastodon cotton rat stegomastodon
	MIDDLE	subtropical: moist subhumid becoming semiarid to arid		short-legged rhino shovel tusk mastodon thin-shelled giant tortoise
	LOWER	subtropical: moist subhumid, cool summers		shovel tusk mastodon short-legged rhino giant tortoise



Color Change: Chameleon Camouflage

Nervous or hormonal controls affect hue





By Herndon G. Dowling

THE LIZARDS correctly called chameleons make up a distinctive family that is found in Africa and Madagascar. A single species (or perhaps a group of related species) ranges outside this region from Europe to India.

Generally slow-moving, chameleons are highly specialized for arboreal life and for feeding on insects. They lack the bony shields, protective armament, and defensive claws and dentition characteristic of most slow-moving animals, such as turtles and armadillos. Instead, they blend with their environment to escape the notice of possible predators.

Chameleons have accomplished this blending by using all the various techniques of camouflage. Their over-all coloration fits in with the browns, yellows, and greens of their environment. These colors are not uniform but occur in irregular spots, stripes, and blotches that draw attention away from the outline of the animal and away from that most distinctive animal feature, the eye. The body outline is so invested with fringes, flaps, and hornlike projections that it is hard to see against a "busy" background. In addition, the body is vertically compressed and casts a relatively small, unusually shaped shadow.

Perhaps the most interesting aspect of the chameleon's camouflage is countershading. This development of color-blending is especially characteristic of the slow-moving, arboreal

AFRICAN CHAMELEON's skin turns pale, *below*, where a wire screen, *left*, cast shadow on its body for a few minutes.

chameleons (a few members of the family have reverted to terrestrial life and are more active). If a sedentary arboreal chameleon is exposed to bright light and patches of shade, within three or four minutes the brightly lighted areas of the skin become darker while the shaded areas become lighter. By thus reducing the effect of contrasty shadows on its body, the chameleon appears to have the light pass *through* its body and the animal practically disappears amid its natural surroundings. However, if the chameleon moves suddenly or if the shading object is moved, a "print" of the shadow stays on the skin until it readjusts to new conditions.

CHAMELEONS are not the only lizards that display this reaction to light intensity, although they probably exhibit much more variety in their reactions than do other lizards. Many years ago I noticed the green print of a wire screen on my captive *Anolis* lizards in Alabama, after they had basked in the sun and turned brown except where the screen's shadow had touched them. Oddly, I have not seen this feature mentioned in descriptions of *Anolis* behavior, although the blanching effect of a shadow on African chameleons was noted more than a century ago by E. Brücke, a German scientist.

The mechanics of the color changes in the skin itself are relatively well understood. All of the color elements occur in the thick dermis that underlies the thin, transparent epidermis. The specialized cells that provide the different colors occur in four layers.

The outermost layer is made up of xanthophores, which contain yellow pigments. Scattered through the same layer are a few cells called erythrophores, which contain red pigments. Underlying this top layer of yellows and reds on most of the body is an irregularly distributed layer of cells that reflect blue light. Immediately below it is a more uniform layer that reflects white light. Neither the "blue layer" nor the "white layer" contains any actual pigment. The colors are produced in the cells by layered structures of crystals of a substance called guanine. The fourth, and innermost, color layer contains the main bodies of the melanophores—cells that contain melanin, a very dark brown pigment. The melanophores have long, tentacle-like arms that extend up toward the surface through the other three color layers.

The strata of blue- and white-reflecting cells are not involved in the chameleon's color changes. However, the layer of yellow xanthophores acts as a screen above these layers and the yellow or red cells can apparently contract or expand, giving stronger or weaker effects. Where the blue-reflecting layer occurs under the yellow, green is produced. In areas where the blue is absent, white light is reflected from the third layer through the xanthophores and erythrophores to give the true colors of yellow and red.

The main effectors of color changes are the melanophores. The cell walls of melanophores do not contract and expand, but the melanin they contain can be concentrated in the main cell body below the white-reflecting layer, or it may be dispersed into the cell arms that extend up through the other color layers, thus obscuring one or more of them.

The amount of melanin in the arms of the melanophores, then, is the principal determinant of the chameleon's color. Light greens and yellows are produced when the melanin is at maximum concentration below the white-reflecting layer. Melanin introduced into the white-reflecting area darkens the greens, and if dispersed completely over the yellow layer as well, obscures all the other colors and turns the chameleon dark brown—almost black.

Questions about the chameleon's change are not so much those of skin and cell structure, but rather of *control* of these structures. Even limited observation shows that the chameleon's color is determined by nervous or hormonal controls. The African chameleon turns dark when it is angry or greatly disturbed, when it is cool, or when it is in bright light although otherwise undisturbed. Conversely, it is pale when overheated or when it is undisturbed and in the dark.

The American *Anolis carolinensis* goes through a similar set of changes (although it is light when disturbed and dark when undisturbed), but they are not as complex as those in the African chameleons. According to present theory, however, the *Anolis* and the chameleons attain these similar results differently. Current literature suggests that color changes in *Anolis* lizards are accomplished by hormonal controls while color changes that take place in the African chameleon are under direct nerve controls.

Of course, the two kinds of lizards are not closely related and no doubt their color-control apparatus developed independently over a long period of time. However, I do wonder if perhaps some of the presumed differences are not due to the two different "schools" of research on animal coloration that are involved.

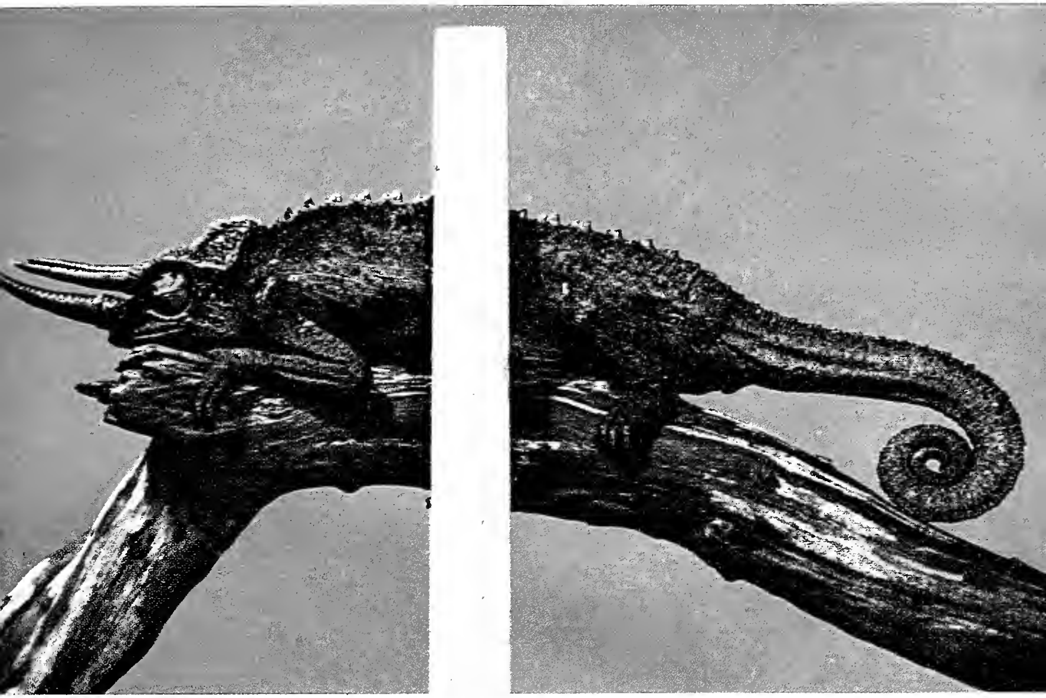
George H. Parker and his students in the United States, who studied *Anolis*, were advocates of the importance of neurohumors, or controlling hormones, in color changes. On the other hand, the work of Lancelot Hogben, his students, and other European biologists who studied chameleons tended to emphasize the importance of direct neural control, and it is the Europeans who have done most studies of African chameleons. Since the two groups have dealt with different animals and have approached their studies with different points of emphasis, it is no surprise that they have come to different conclusions.

Parker's opinion of the phenomenon is that the melanophores are affected directly by the light. Those cells affected by bright light disperse their pigment, causing the color of that area of the body to darken. The melanophores that are not so affected concentrate their pigment, which lightens the color in the area.

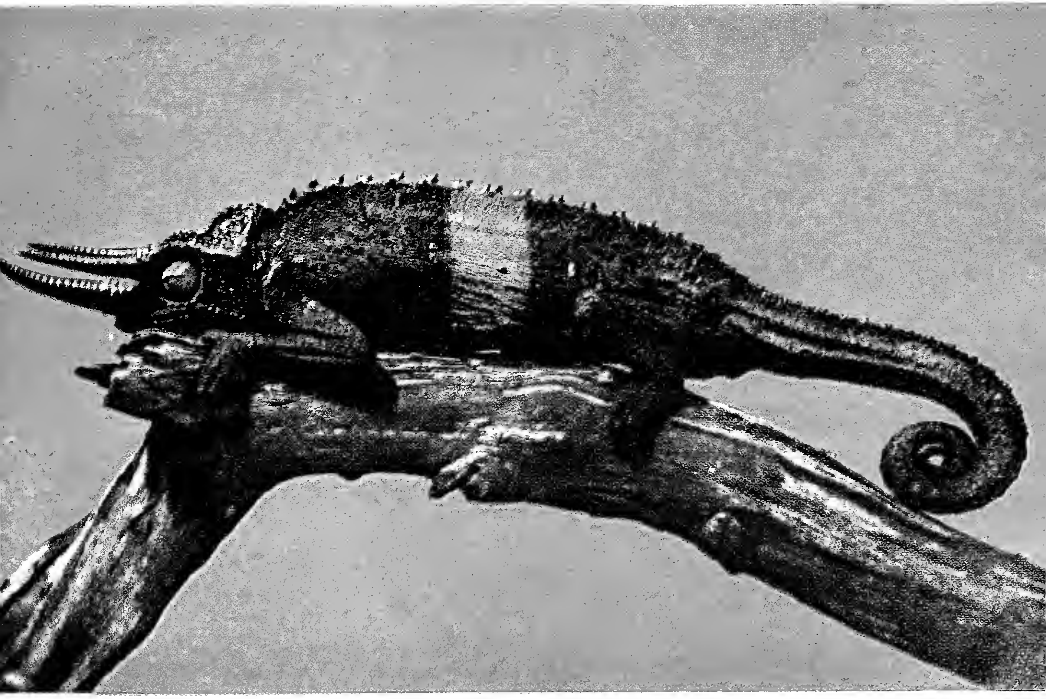
The theories of the European workers, who have actually carried out the experiments on the chameleons, postulate the existence of a very complex system of direct nervous control. According to these researchers there must be a series of dermal receptors in the chameleon that are affected by the light. Impulses from the receptors travel to the spinal cord, which then sends impulses to the melanophores, causing them to disperse or to concentrate their melanin.

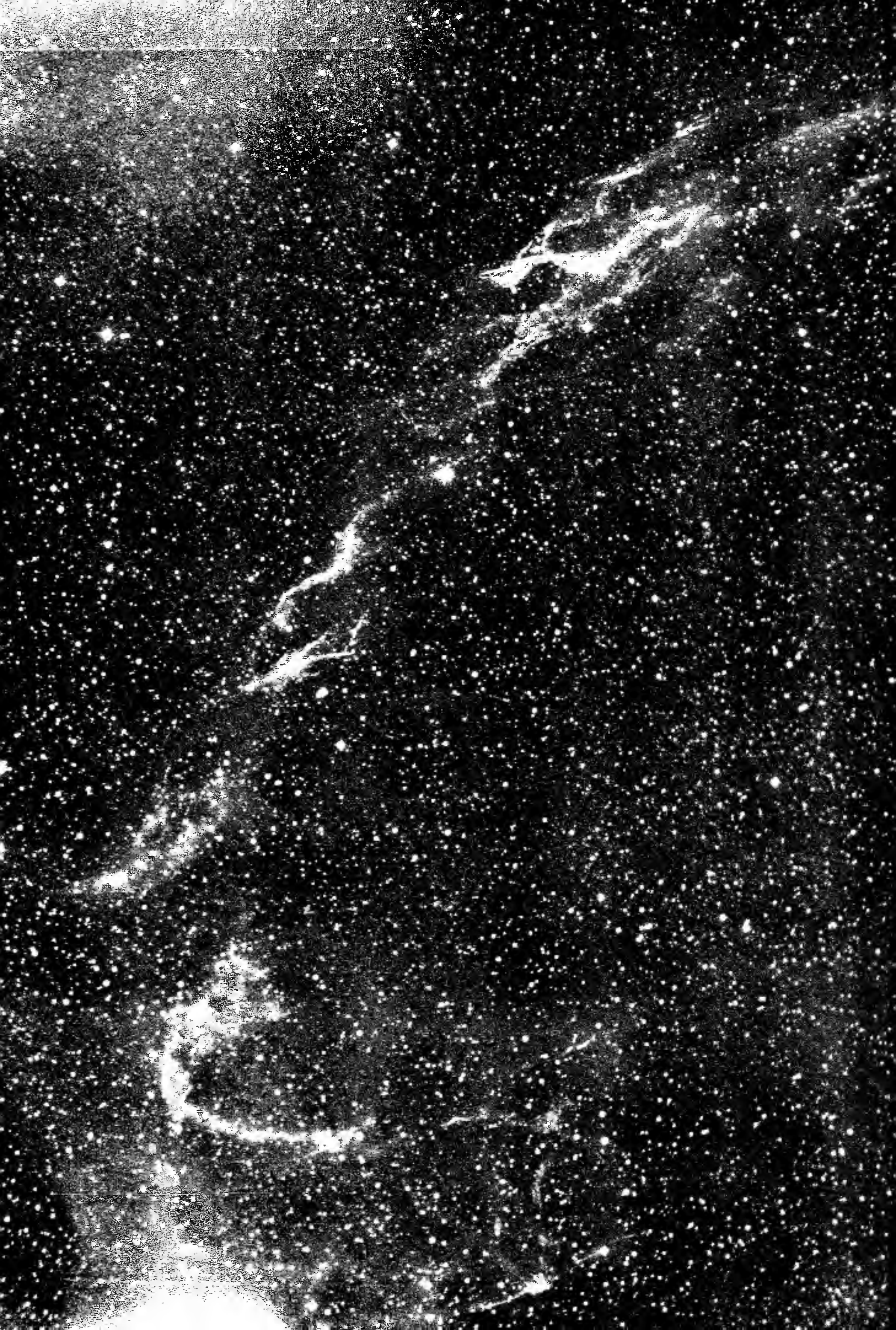
THE fundamental difference of opinion as to whether the color changes are mediated by a single neurohumor (without any nerves involved), or by as many as four nerve complexes, is still unsettled.

It is to be hoped that the necessary experiments and observations may be performed soon. Surely the Atlantic Ocean is no longer the barrier to international study of common scientific problems that it was to the distribution of the animals involved.



Wood slat shades part of chameleon's body, *above*. Pale band, *below*, remains where shadow fell. The "mechanics" of the lizard's changes of color are understood, but control of skin and cell structures involved still poses problem.





SKY REPORTER

hotometry yields clues to temperature and distance of stars

By Thomas D. Nicholson

ARLY ASTRONOMERS made the logical assumption that
the brightest stars were the nearest, which is true of
ny stars, but not all. In our winter sky, Sirius is the
ghtest visible star. It is also the nearest nighttime star
t can be seen with unaided eyes from most of the United
tes. Other bright winter stars, such as Pollux, Procyon,
d Capella, are also among the nearby stars.

Over the years astronomers have come to realize that
tance is not the only factor that governs the brightness
stars. Some, like Betelguese, Bellatrix, Rigel, and the
rs of Orion's Belt, appear very bright even though they
known to be very far away. If these stars were as close
Sirius or Procyon, they would appear as bright as the
on, although not so large.

Thus the apparent magnitude of a star—the way it ap-
rs from earth—may not indicate the true brightness.
t apparent magnitude is what we actually measure when
observe the brightness of a star in the sky.

In last month's "Sky Reporter" we compared the ob-
ved brightness of the sun (magnitude –26.7) with the
served brightness of Sirius (magnitude –1.42). The
ference in the magnitudes (about 25) indicated that the
n looks 10 billion times brighter than Sirius. The faint-
objects we can observe (with the 200-inch Hale tele-
pe at Mount Palomar) are about magnitude 23. This
oughly 25 magnitudes fainter than Sirius, which thus
ms about 10 billion times brighter than the faintest
servable stars.

Therefore, from the brightest object that we can observe
e sun) to the faintest, the range in brightness is approxi-
tely 50 magnitudes, or 100,000,000,000,000,000,000
es. The branch of astronomy with the task of measuring
urately the brightness of celestial bodies throughout this
rmous range is called photometry.

Before the nineteenth century, the brightness of stars
s estimated by visual comparisons among the stars
mselves. The most common method was to choose, near
star to be measured, comparison stars slightly brighter
l slightly fainter than the unknown star. The brightness
the star in question was then estimated by observing
ratio of its light to that of the comparison stars. Many
ateur astronomers still use this method for visual esti-
tes of the brightness of variable stars.

The first practical instrument for measuring stellar
ghtness—the photometer—was developed in 1836 by the
glish astronomer John Herschel. By optical means,
rschel reduced the image of the moon to a point of light,
n viewed it at various distances until it matched the
ghtness of the star being measured. The magnitude of
star was indicated by the distance at which the image
of the moon appeared to match the brightness of the star.

A much more precise visual photometer was developed in Germany in 1861 by J. C. F. Zöllner. In his instrument the star to be measured was viewed through two polarizing filters and compared to an artificial light of constant brightness. By rotating one of the two polarizing filters, the light of the star was dimmed until it matched the artificial "star." The star's magnitude was indicated by the angle through which the filter was turned.

Polarizing photometers were widely used in American and European observatories during the late nineteenth and early twentieth centuries. During these decades the first great photometric catalogues were prepared, notably at Potsdam, Germany, and at Harvard. At the Harvard Observatory, E. C. Pickering developed an improved instrument, known as the meridian photometer, in which the star Polaris was used as the comparison source rather than an artificial light. At Oxford, England, C. Pritchard devised the wedge photometer, in which a dark glass filter of increasing thickness—hence a wedge—was used to dim the appearance of the star that was being measured until it matched a comparison source.

During the twentieth century photographic and photoelectric methods replaced visual photometers. A photograph records the brightness of hundreds or thousands of stars at a time, as compared to star-by-star observations with the visual photometer, and it can record much fainter stars than the eye can see when using the same telescope.

THE magnitude of a star on a photographic plate is determined by the size and density of the image recorded by the emulsion. Magnitudes may be determined by visual inspection of the plate or with an instrument that measures the size and opacity of the negative images. Brighter stars are sometimes photographed out of focus, so that they produce circular images of equal area but varying density on the plate. The magnitude of the stars is then determined solely by image density.

Since photographic emulsions vary in the way they respond to light, the brightness of stars recorded on the plate must be calibrated against stars of known magnitude. Even so, magnitudes determined photographically may be different from magnitudes measured visually. The human eye is most sensitive to yellow light, whereas ordinary photographic emulsions are most sensitive to blue light. Thus red and orange stars are brighter to the eye than they appear on a photograph; and the blue stars are registered prominently on film.

The scale of photographic magnitudes is adjusted to match the visual magnitude for a white star with a surface temperature of about 18,000°F. Gamma Geminorum, a second-magnitude star in Gemini, is such a star. Its visual and photographic magnitudes are equal. A star with a visual magnitude greater than its photographic magnitude, such as Capella, in Auriga, is cooler and more yellow; a

**LOW AND ORANGE STARS are easily seen in color photo
part of Veil Nebula in Cygnus. These stars appear faint
en photographed with ordinary, blue-sensitive emulsions.**

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star with a visual magnitude less than its photographic magnitude, such as Bellatrix, in Orion, is hotter and blue.

The difference obtained by subtracting the visual from the photographic magnitude is a quantitative indication of a star's color and, therefore, of its surface temperature. The difference is called the color index. Since the visual and photographic magnitudes of Gamma Geminorum are equal, the color index of the star is zero. Stars with a color index close to zero are white stars.

The visual magnitude of Capella is approximately 0.05. Its photographic magnitude is fainter, about 0.85. The difference (0.85 minus 0.05) gives Capella a color index of +0.80, which signifies that it is a yellow star, slightly cooler and redder than the sun (color index +0.63). High positive color index is associated with cool, red stars.

The visual magnitude of Bellatrix is 1.64; its photographic magnitude is 1.41, which means it is brighter photographically. The color index of Bellatrix (1.41 minus 1.64) is –0.23, which indicates that it is blue, since negative color index is associated with hot, blue stars.

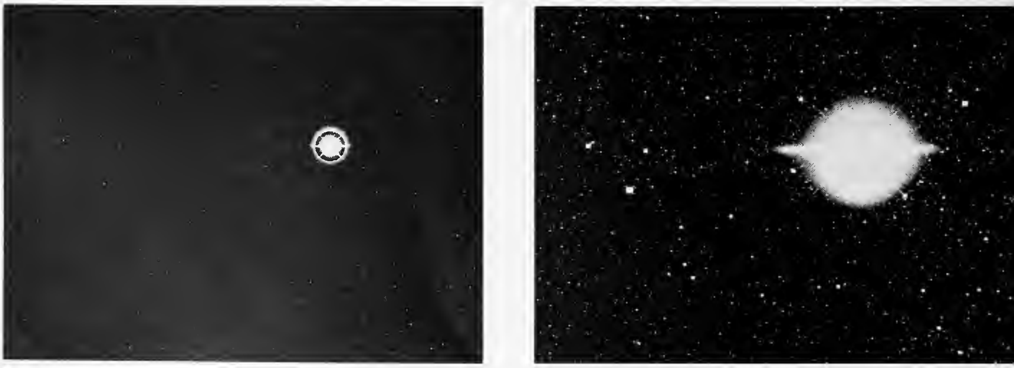
SPECIAL red-sensitive photographic emulsions have been developed that yield images approximating the visual brightness of stars. Stellar magnitudes obtained with red-sensitive plates are known as photovisual magnitudes, and they are equated with the visual magnitude scale. Color index, and therefore temperature, may be obtained for large numbers of stars by comparing their brightness on blue-sensitive and red-sensitive plates.

For very accurate photometric work today, astronomers use photoelectric instruments. The earliest of these, developed by J. Stebbins about 1910 at the University of Illinois, was based on the properties of selenium, which, in a particular crystalline form, varies its electrical conductivity according to the amount of light falling upon it. When small selenium cells are exposed in a telescope to the concentrated light from a star, the current across the cell depends upon the star's brightness, and therefore indicates the star's magnitude. Photoelectric cells were developed in Germany and eventually were adopted and further refined in the United States. The inside of a photoelectric cell is coated with a metal—such as sodium or potassium—tha gives off electrons when light falls on it. The electrons ar collected by a cathode in the cell and they generate a current that can be suitably amplified. Since the number o electrons emitted is proportional to the intensity of th light beam that strikes the cell, the output of a photoelectri cell indicates directly the illuminating star's magnitude.

Mounted at the eyepiece end of a large telescope, modern photoelectric photometers are so sensitive that they ca detect the light of a candle at a distance of 1,000 miles Since photoelectric cells can be sensitive over a wide rang of frequencies, these instruments can measure either visua magnitudes or photographic magnitudes when they ar equipped with appropriate filters. Photoelectric photometr is a rather slow process, however, because of the need fo careful preparation and calibration of instruments an because only one star can be observed at a time. Its use i generally limited to cases where extreme accuracy is required, or to establishing the brightness of reference star for calibrating photographic magnitudes.

Many years of carefully observing stellar magnitude bore fruit when astronomers began to accumulate measurements of stellar distances. If the distance to a star i known, its apparent magnitude can be adjusted to a scal that indicates the intrinsic brightness of the star. Whe the apparent magnitude is adjusted to a standard distanc of ten parsecs, the resulting measure of the star's brightness is known as absolute magnitude. A parsec is the distance at which the radius of the earth's orbit (93 millio miles) would form an angle of one second, or about 3. light-years. Absolute magnitude, therefore, is the brightness a star would have if it were located at a distance o 32 light-years from the earth.

When the absolute magnitude of a number of stars became known, astronomers found that the properties o certain stars were reliable indicators of their intrinsi luminosity. These properties included the spectral feature of some bright stars and the period of the light changes i some variable stars. From these properties, astronomer could estimate the absolute magnitude of the stars and, b comparing this with the apparent magnitude, could observ how greatly the stars had been dimmed by distance. Thu astronomers have discovered in the magnitude scales powerful implement for determining the distance t stars beyond the range of direct parallax measurements



PHOTOGRAPHIC MAGNITUDE of stars is determined by size and density of images. In different exposures of same sky area the brightest star is magnitude 7. Long exposure, a right, shows stars too faint to register in photo at lef

HE SKY
FEBRUARY

Quarter	February 5, 7:42 A.M., EST
Moon	February 13, 8:01 A.M., EST
Quarter	February 20, 8:24 A.M., EST
Moon	February 27, 7:39 A.M., EST

TIMETABLE

February 1	11:00 P.M.
February 15	10:00 P.M.
February 29	9:00 P.M.

(Local Standard Time)

February 15: Saturn and the sun are in conjunction, or arly in line as seen from earth. Saturn leaves the evening y and becomes a morning star, but it will not be readily ible until after mid-March.

February 16: Mars and the sun are in conjunction. Mars ters the morning sky, but it will not be seen easily as a rning star until late spring of this year.

February 15, 16, 17: Jupiter, Venus, and the moon are eresting to watch on these evenings. On the evening of 15th, the crescent moon appears lower than Venus, and piter is higher than Venus. Venus and the moon are in njunction about 8:00 A.M., EST, on the 16th, and by the ening of the 16th, the moon appears between Venus and piter. Then, about 4:00 A.M., EST, on the 17th, Jupiter and moon are in conjunction. In the evening sky of that date moon appears above Jupiter.

February 28: Venus and Jupiter are in conjunction about 0 A.M., EST, Venus passing within two degrees of Jupiter. the evening of the 27th, the two brilliant planets are quite se, and Venus, brighter of the two, is slightly below and to the right of Jupiter. By dark on the evening of the 28th, Venus has already passed Jupiter, but the two planets are still quite close to each other. However, this time Venus is slightly above Jupiter.

Mercury may be seen low in the east during the early dawn for several days during the first week of February, but only with difficulty. Although bright (magnitude zero), it rises only an hour and a half before the sun on February 1, and is soon lost in the brightening sky. Later in the month, it dims and moves closer to the sun.

Saturn and Mars, although they are morning stars, are much too close to the sun to be seen.

Jupiter and Venus appear each night during the month of February in the twilight sky to the west, shortly after sundown, long before any star can be seen. Venus, the brighter of the two, appears first, then Jupiter—above and to the left of Venus for most of the month. Jupiter, although receding from earth and growing fainter, is brighter (magnitude —1.8) than any star. During the month Venus brightens from magnitude —3.5 to —3.7, because it is getting closer to earth.

Extreme fatness is characteristic of the newly weaned monk seal pup.

The Hawaiian Monk Seal

Rare mammal survives in Leeward Island

By Dale W. Rice

In the middle of the North Pacific Ocean, the Leeward chain of islands extends like the tail of a comet for twelve hundred miles northwest of the main Hawaiian Islands. The islets nearest to Hawaii are jagged chunks of volcanic rock, the remnants of once higher islands. But at the far end of the chain, the volcanic peaks long ago sank beneath the sea; these islands have kept their heads above water only because their crowns of reef cor have grown upward to compensate f the sinking. All summer long, an en less succession of heavy ocean swel running before the steady northea trade winds, break over the fringi reefs into sheets of foam, slide over t blue-green shallows, and hurl the selves onto the glaring white co sand beaches. Those lonely beach and shallow lagoons are the home one of the world's rarest mammal the Hawaiian monk seal.

Monk seals are the only tropical and
tropical members of a predomi-
ntly cold-water family—the Pho-
ae, or earless seals, of which there
three species. The Mediterranean
nk seal *(Monachus monachus)*,
l known to the ancient Greeks, now
vives only in a few scattered col-
es in the Mediterranean and Black
s, Madeira and the Canary Islands,
l along the northwest coast of
rica. Columbus discovered the
ribbean monk seal *(Monachus trop-*
lis), which was formerly abundant
he Bahamas, the Florida Keys, the
ater Antilles, and along the east
st of Mexico. It probably has been
rminated. The Hawaiian species
onachus schauinslandi) is endemic
the Leeward Islands end of the
vaiian Islands chain.

Iow did the monk seals come to
e this relict, pantropical distribu-
1? Probably we shall never know
details of their history, but after
king a detailed study of their skull
tures, and taking into account what
eontologists have learned of the
fossil history of the phocid seals, I think the following hypothesis is the most plausible: the earliest phocids were descended from otter-like carnivores that lived in the fresh-water lakes of Asia during the Miocene Epoch—some twenty million years ago. As the extensive lakes slowly disappeared, the ancestral seals moved into the coastal seas. Some went north, into the Arctic Ocean; their descendants are the modern northern seals, such as the harbor and ringed seals. Others moved south to the vast Tethys Sea, precursor of the Mediterranean, which bordered the southern edge of Eurasia; from them the monk seals (and also the Antarctic seals and elephant seals) are descended.

Of all the earless seals, the monk seals have probably changed the least since Miocene times—they have not acquired the specializations that characterize the other branches of the family that invaded the cold polar regions. One species of monk seal has remained in the Mediterranean. From this birthplace, they pushed westward to the Caribbean, and eastward across Polynesia to the Hawaiian Islands. Since the extinction long ago of the intervening populations, the three groups of monk seals developed the distinctive traits that entitle them to recognition as separate species.

For many millenniums, the Hawaiian monk seals lived undisturbed on their remote islands. Apparently even the seafaring Polynesians never reached the western atolls of the Leeward chain, a fact that may account for the seals' survival here—and nowhere else—in the Pacific. In the early 1800's the intrepid whalers, sealers, feather-hunters, and guano-diggers, who in a few decades filled in the blank spaces on half the globe, discovered the Hawaiian monk seals' retreat. To them, the monk seal was only another source of oil and hides. Their slaughter of the animals on the Leeward Islands was characteristically thorough—almost complete, in

Churning water in her wake, a female repulses advances of a courting male.

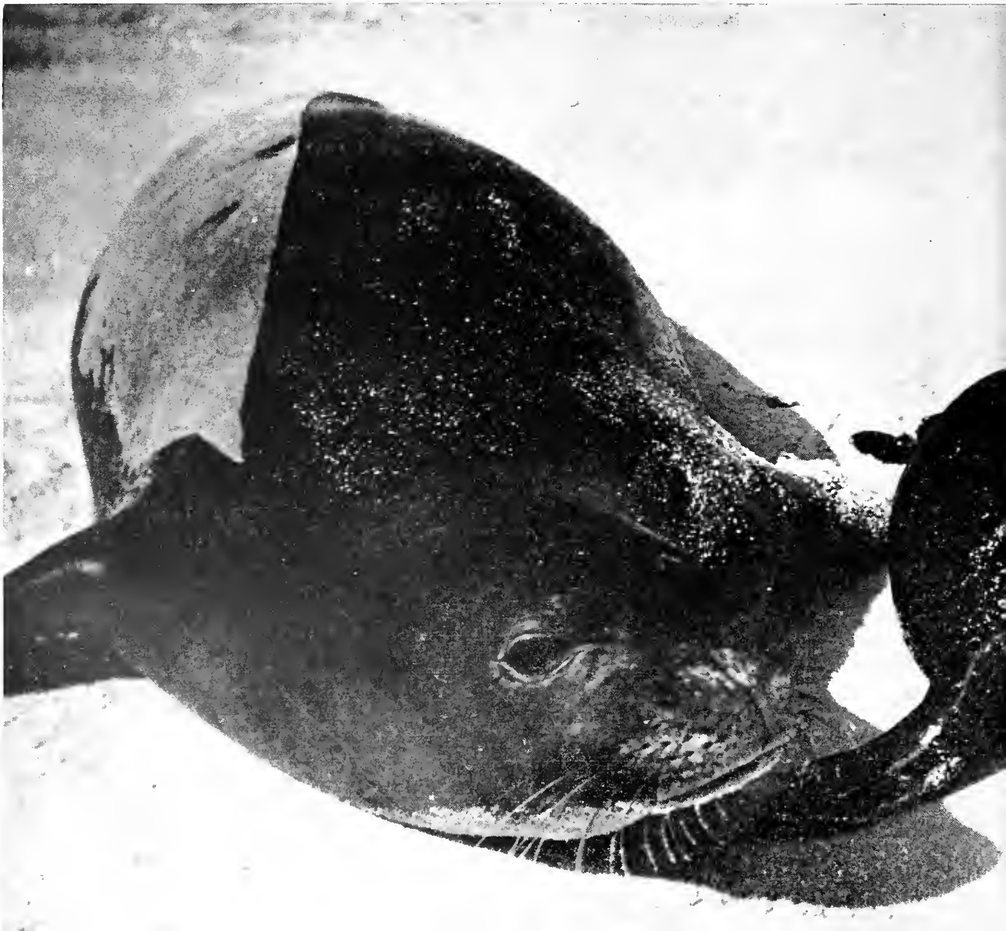
fact, by the year 1896, when Dr. H. H. Schauinsland, the German scientist after whom the species was named, visited Laysan Island. During his stay he saw no seals, but Max Schlemmer, who operated a guano works on the island, gave him the skull of a seal, one of only seven that had been seen during fifteen years. The Hawaiian monk seal thus barely escaped being exterminated without its existence ever being known to the scientific world.

With the coming of the twentieth century, petroleum reduced the need for whale and seal oil. The age of the sea hunters had ended. The few surviving monk seals and their sea bird neighbors once again were left to themselves. The Commercial Pacific Cable Company, Pan American Airways, and finally the U.S. Navy occupied Midway Islands, but they were too busy to bother, or even to notice, the seals. The other five atolls on which the seals lived remained uninhabited and very seldom visited.

When Karl Kenyon (Natural History, November, 1963) and I were assigned to Midway Islands in late 1956 to study the albatrosses, or "gooney birds," which nest by the thousands on the Leeward Islands, we were also determined to learn as much as possible about the monk seal—how many there were, and how they lived in an environment so different from that of their cold-water relatives.

The first seal I met was sleeping in the shade of the "scavvy" thickets *(Scaevola frutescens)* that rimmed the upper edge of the beach. I did not see him until he raised his head to look at me, and then lowered it and shut his eyes. A moment later he raised it again and took another look. With mouth closed he voiced a peculi "bgg-bgg-bgg-bgg-bgg," like wat bubbling from an upside-down ju He lumbered into the water, dived, ar surfaced a few yards off the beac from whence he continued to watch m a while before swimming off to find place where he could resume his na without being interrupted. This inna tameness, we found, is characterist of monk seals—it probably comes fro having lived so long on islands whe there are no land predators to atta them. Even seals on Midway, whic have contended with man for only ha a century, are no less tame than tho on other, rarely visited islands. Whe I went spear-fishing, I sometimes sa them watching me under water.

These behavioral traits were impo tant clues to the relationships of th monk seal. When I later imitated th bubbling voice for a biologist fro



ew Zealand, he said it sounded just ce the leopard seal *(Hydrurga lep- nyx)* and other Southern Hemis- iere species, which share the innate meness. I have since heard northern ephant seals *(Mirounga angustiros- s)* utter a similar sound.

As spring advanced, and cool, windy ys became less frequent, the first ps were born. We found that when e females were ready to give birth their pups they tended to congregate certain beaches and islets that were otected from wave action, either by substantial barrier reef, or because ey were on the lee side of the island. ey were also high enough so that e pup could crawl out of reach of gh spring tides. Although mother als tolerated each other's presence, ey vigorously repelled all other seals, rticularly courting males that at- npted to approach them. Unlike other species, such as the gray seal *(Halichoerus grypus)* and the elephant seal, there was no harem formation or other social ties between individual monk seals.

Black pelage of monk seal pups may protect them from tropical sun. They nurse frequently from their mothers' four functional teats and grow rapidly.

During first five weeks of life, the pup remains with its mother constantly.

Most of the pups at Midway were born on the small islets that could be visited only by special trips in a small boat. We placed numbered metal tags on the flippers of all these pups, but the weather and our work with the gooney birds prevented us from examining them at regular intervals. Finally one evening in late March a message arrived from Chief Green of the Communications Unit on Eastern Island (a restricted area)—two monk seals had just given birth to pups. This would enable us to make the regular detailed observations necessary to obtain sound biological data. The next morning we caught the early boat to Eastern Island. Chief Green led us to the two mother seals, who were lying on the beach beside their tiny, jet-black pups. The mothers were enormously fat. An average non-pregnant female, 7 feet 6 inches long, will weigh about 450 pounds, but a pregnant female may weigh 550 to 600 pounds. (Males are smaller; they average about 7 feet in length and 375 pounds in weight.) We were soon to learn the reason for the mother seals' obesity.

The mother seals showed no fear of us. They were not disturbed by our presence until we came too close; then they threatened us with open mouth and loud bellows. Karl Kenyon had to divert the mothers' attention while I leaped in and kidnapped their pups. We had to weigh, measure, and tag each pup quickly, before its angry mother could get to us. Reunited with their pups, the mothers sprawled on their sides, seemingly oblivious to our presence, and the pups began to nurse. We were surprised to find that the mother monk seal has two pairs of functional teats. All the other species

NUMBERED metal tags were placed on flippers of seals, which were measured and weighed at regular intervals.

LAYSAN and Lisianski Islands and Pearl and Hermes Reef are so remote that seals are undisturbed, *right*.

FEMALES gather in sheltered areas before parturition, and will attack courting males when pups are small.

earless seals, except the bearded l *(Erignathus barbatus)* of the tic, have only one pair. The possion of two pairs was probably the dition in the ancestral phocids.

E closely followed the development of these two young. At ut eighteen days of age, they began hed their velvety-black birth coat, ch is so different from the woolly, te or pale-gray birth coats of most l-water seals (NATURAL HISTORY, rch, 1962). Elephant seals are the y other phocids whose pups are n with black pelage. This dark hair bably protects the species from the nse sunlight of their near-tropical ne. The new pelage was short and rse, and was a dark, silvery-gray ve, shading to white below, like t of the adults. By the time they e four weeks old, their teeth had un to appear. This was their permanent set of teeth, for unlike most mmals, the milk teeth of earless ls are resorbed before birth.

At birth the pups weighed less than ty pounds, and were extremely nny. With frequent nursing periods, y now began to fill out. By the time y were four days old, they would m for brief periods in the shallow er. At first they swam weakly, and uld sometimes rest their forequarters on their mothers' backs. They soon became strong swimmers and spent more time in the water. The mothers' protective reactions were so strong that, even if they were swimming more than fifty yards offshore with their pups, they would come ashore to threaten us if we appeared on the beach. Since their young always followed them ashore, we could catch the pups for periodic weighings.

At Kure Atoll, while trying to distract a mother seal so we could examine her pup, I got too close. She grabbed my field notebook from my hands, shook it in her teeth, and flung it down into the sand!

Since the mothers remained with their pups continuously, they had no opportunity to feed, and the frequent nursing of the pups was a heavy drain on their blubber stores. We estimated one mother seal's weight at about 575 pounds when her pup was born. The weights of the pups increased at an unbelievable rate. One of them doubled his birth weight in fifteen days, tripled it in eleven more. By the time he was thirty-five days old, he weighed over 140 pounds, or four times his birth weight. His length had increased from 38 to 48 inches. He was so plump he could hardly move! His mother was now a gaunt creature, for she had lost almost two hundred pounds. For each two pounds the mother lost, her pup gained one. Eventually, when she no longer could nurse her pup she quietly slipped away and disappeared while he lay sleeping.

The other pup, whom we named "Little Herman," was deserted by his mother when he was but twenty days old, and weighed only 82 pounds. His mother was not as fat as the mother mentioned above, and evidently was unable to nurse him any longer.

THE months ahead were critical ones for the pups, for they had to learn to catch their own food. Their blubber stores helped to tide them through this period. At first they showed little inclination to leave their birthplace. We continued to weigh them at regular intervals. Sometimes we had to wade into hip-deep water to catch them; then we dragged them ashore, amid tremendous splashing.

Their weight steadily fell as they used up their blubber stores, but they were slowly learning the ways of adult seals. We sometimes saw them playing. They would dive, pick up a rock or some other object, bring it to the surface, drop it, and dive again. In this way they probably discovered what things were good to eat. They also began to wander farther from home. When the hot, still days of July arrived, we could no longer find them in their old haunts. They had probably moved to the outer reef, where many of the adults haul out during the summer months.

We next saw the pups when the windy days of autumn drove the seals back to the protected islets and sand bars near the main islands. Both their appearance and behavior were greatly changed. They weighed only about a hundred pounds, but they were longer —4 feet 3 inches, on the average—and had the streamlined shape of adult seals. No longer would they docilely let us weigh and measure them. It was a two-man job to wrap them up in a net to immobilize them and keep their strong jaws out of mischief.

Although most of the other tagged pups had survived, we never found Little Herman again. Apparently his scant blubber supply failed to last until he learned to find his own food.

This is probably how the food supply regulates the number of monk seals. When the seal population is high, supplies of readily available food would be somewhat depleted; the females would be unable to put on much blubber, and their pups' chances for survival would be correspondingly reduced. Our observations suggest that female monk seals do not give birth two years in succession. Only the females who do not have pups will accept the advances of the courting males. The physiological strain of rearing a pup probably prevents females from becoming pregnant again until they have regained their store of blubber during at least one entire year of uninterrupted feeding.

THE only sure way to determine an animal's food habits is to examine its stomach. Because the monk seal is one of the world's rarest mammals, we did not wish to collect many of them. In fact, we killed only two—both males. We also found the spewed stomach contents of two others. This revealed that they feed principally on octopuses *(Octopus* sp.*)* and moray eels *(Gymnothorax* sp.; *Echidna* sp.*)*, which live in the crannies among the coral formations, and on conger eels *(Ariosoma* sp.*)*, which burrow in the sandy bottoms of the shallow lagoons. They also take a few bottom fishes and reef fishes, such as flatfish, puffers, and goatfish. Octopuses and eels usually venture out of their hiding places only at night; this suggested that the monk seals feed mostly nocturnally. I had a chance to confirm this during a visit to Laysan Island, where we camped just above the beach. During the middle of the day, we sometimes counted more than three hundred monk seals basking in the sun on the beaches. But on several brightly moonlit nights I walked the beaches and found not a single seal, except mothers with pups.

In the summer, after the breeding season was over, we discovered another surprising fact about the monk seals. They began to molt their old pelage, now stained a yellowish brown. Instead of shedding each hair individually, like most mammals, they shed the epidermis in large, ragged patches. Shedding the epidermis in this manner is characteristic of reptiles, but of only one other mammal—the elephant seal. This, along with other features, such as the black coat of the pup, suggests that elephant seals and monk seals are very closely related.

At Midway, the regular boat run between Sand and Eastern Islands passed near the islets and sand bars that were the seals' favorite hauling grounds. We counted the animals on every trip—sometimes there were more than sixty. Low-altitude photoreconnaissance flights over the albatross colonies also gave us an excellent opportunity to make periodic counts of the monk seals on Kure Atoll, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoal. We also visited some of these islands by ship. The total population in the winter of 1957/58 was about twelve hundred—a gratifying increase from earlier years, yet a vulnerably low number for any animal species.

The reproductive rate of the monk seal is very low, even for a large marine mammal. Females apparently do not breed until they are at least three years old and then, as has been said, they probably do not give birth more often than once every two years. The bearded seal is the only other phocid known to have such a breeding cycle. In the spring of 1958, about one hundred seventy pups were born, a birth rate of only 14 per cent.

I saw one seal with a hind flipper missing, and others carried large scars on their sides, possibly the results of shark attacks. We encountered many sharks, including 12-foot tiger sharks *(Galeocerdo cuvieri)*, in the shallow lagoons, but they seemed to pay no attention to the seals, not even to pups. The seals have no other predators to fear in the shallow lagoons. Our counts indicated that the annual death rate must be very low—about 3 per cent. Like other marine mammals, they tend to live long. Annular layers in the cementum layer of the canine tooth of one adult male that we collected inc cated that he was twenty years old. present the seals seem to be increasi their numbers by approximately per cent each year.

EXCEPT for Midway, which is t site of the large U.S. Naval St tion, all of the islands on which t monk seals live are part of the Leewa Islands Bird Reservation, admin tered by the Fish and Wildlife Servic U.S. Department of the Interior. Th would seem to insure their surviv However, in recent years disturban by man has become an increasi threat. The U.S. Coast Guard has station on Tern Island in Fren Frigate Shoal, and has recently tak over Kure Atoll. Seals still occu Midway, in spite of its large huma population, but in '57 and '58, at lea seven of the eighteen pups born at Mi way failed to survive until weanin On the other islands, we found or one dead pup. The causes of the deat at Midway apparently were the in rect results of human activity—detor tion of explosives in the ship chann and perhaps persistent disturbance mothers with pups by photographe beachcombers, boating parties, a dogs. But on Laysan and Lisians Islands, and among the vast expans of Pearl and Hermes Reef, the mo seals still spend the quiet, dark nigh fishing in the warm, coral-studded goons, and bask undisturbed under t glaring tropical sun, as they have do for uncounted generations. Let us ho that they may continue to thrive a increase for many more.

Tameness of monk seals is remarkable. This may be a result of living so long on islands that are without land predators.

Male, in threat posture, is molting, when, unlike most mammals, the seals shed epidermis itself in large and ragged patches.

Huge upper jaws of a European stag beetle lend insect bizarre appearance.

If the pincers are larger than normal, they will hamper beetle in fighting.

TTING WOOD of old oak tree, *right*, stag beetle's natural environment.

An "Antlered" Grotesque

Stag beetle is named for its giant pincers

By Lars Holmberg

EUROPE'S LARGEST BEETLE and one of the largest insects found outside the tropics, the stag beetle is a truly impressive sight. Seen close-up it looks like a science-fiction creation, but it is really harmless.

The disproportionately large mandibles. which in the male may be as long as the body, resemble antlers, explaining the beetle's common name. In fact, the scientific name of the insect, *Lucanus cervus*, reflects the antler-like look of the upper jaws, because *cervus* is Latin for red deer. In the United States the Lucanidae are aptly called pinch bugs, since some can draw blood with the mandibles. Curiously, there seems to be an inverse relationship between the size of the mandibles and the beetle's fighting efficiency. The larger the pincers, the more unwieldy they are, and the less favorable is the leverage the insect can exert on them.

Male European stag beetles often attain a length of 2½ inches, but the females seldom exceed 1¾ inches. In any case, there is great variation in size among individuals of a given species. Of the 900 members of the lucanid family. the largest one by far is the East Indian *Odontolabis alces*, in which the males are frequently more than 4 inches long.

The stag beetle begins its life as an egg, which is usually deposited in a crevice in the bark of a decaying oak tree or, perhaps, in a pile of sawdust if the female lays the egg near human habitation. As the larva grows, it chews through the rotting wood or sawdust and soon becomes a fat, white grub with a brown head. The grub stage lasts for three or four years, sometimes as many as five. Eventually. on a warm day in May or June, the organism emerges. It is no longer an

unattractive grub, but a glistening, brownish-black stag beetle.

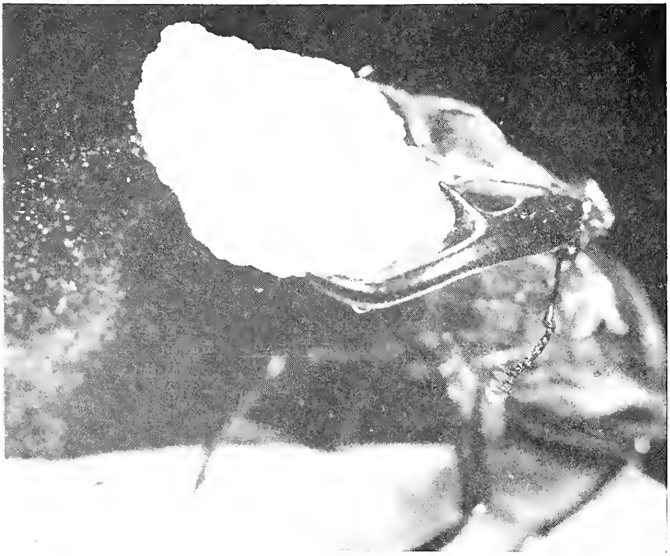
A stag beetle's life is short and ends with the summer. During these weeks, the insect engages in three principal activities: mating, eating oak sap and other nutritive liquids, and fighting with other stag beetles. Two of these pursuits involve the pincers, which are used to hold mates and fight enemies. Curiously, any sexual selection of the best fighting males would favor those with short, efficient jaws. But development of large jaws may be linked with other hereditary factors.

On light summer evenings in northern Europe, when nightingales and thrushes sing, stag beetles can be seen and heard, too, as they fly through oak forests in quest of mates.

The splendid male shown on these pages never saw a summer day because, oddly, he "overslept" as a grub. By the time he emerged from the sawdust heap in which he developed, it was already November, and all of the other stag beetles had died months before. He never saw another of his species, thus passing an atypical life.

Besides its remarkable form, the European stag beetle has yet another claim to fame. It is one of the few insects ever to have been depicted on a postage stamp — a Hungarian issue.

Length of mandibles is nearly that of body, *above*. The power of the jaws is evident, *below*, as the stag beetle crushes moist lump of sugar to powder.



RCE APPEARANCE of *L. cervus* does indicate its eating habits. It exists on a fluid diet that includes oak sap, which it licks with brushlike tongue.

Snow Eaters of Alberta

Cloud arch heralds quick chinook thaws

By Deryk Bodington

Canadians living in southwestern Alberta—the prairie province east of the Pacific coastal province of British Columbia—are merely amused when they hear a retelling of the old story about a settler driving his sled frantically across the snow in front of a swift chinook wind. The wind, says the tale, followed behind, melting the snow from beneath the rear half of the sled's runners, and threatened to speed up and leave the settler stuck on the bare ground. If this is a bit too Bunyanesque, the meteorological facts and economic consequences of the blows are only slightly less *outré.*

A chinook, sometimes called a "snow eater," is a warm, dry wind that was named for the Chinook Indian tribes of the West Coast, the direction from which early settlers knew this wind always blew. Usually it is heralded by a long, dramatic arch of clouds, like that seen in the above photo, which seems to reach from horizon to horizon. Like the Santa Ana wind of the mountainous area of southern California and the foehn of the Alps, the chinook gets its sta
when moist winds—that blow inlar
from the Pacific Ocean—rise and e
pand as they move across the mou
tains. As the air rises above tl
Canadian Rockies it is condense
and rain falls. It continues inland ar
over the mountains; then the air slid
down to the prairie on the eastern sid
It is compressed as it meets with tl
cold air mass of the prairie and in tl
process is further heated. The dr
matic chinook arch marks the conta
of warm and cold air masses.

Normally, the base of the clou
stays about two miles above t
ground. The formation resembles
arch when seen from below, becau
its ends are far apart and thus appe
to bend toward the horizon. Benea
this arch, the winds of the chino
stream eastward toward Calgary.

My photograph of the magnifice
chinook arch was taken from Sco
man Hill overlooking Calgary, whe
chinooks are common weather ph
nomena during the months of Nove
ber, December, and January. Althou
chinooks come in summer as wel
their dryness often contributes to
causes summer drought conditions
it is as winter phenomena that t
warm winds are welcomed by Albe

They provide interludes of relief
the normal sub-zero temperatures
e prairie, and can roll snow away
moothly (if more slowly) as a
er rolls up a rug. In this way thou-
ls of acres of winter pastures are
red for cattle grazing. Alberta's
r-beet industry, as well as her
s, depends on the chinook for a
tantial extension of the growing
on, and often the wind permits
ers to begin their field work in
ruary. The influence of the winter
omenon on the smaller vegetable-
ing business is also beneficent.
age is paid to the chinook locally
e form of business names—more
two dozen of Calgary's businesses
amesakes of the wind.

mid-January it is not uncommon
temperatures around Calgary to
as much as sixty degrees within
w hours after the arrival of the
ook. Usually, the winds move in
ng the early morning and may last
several hours or, occasionally, for
ng as a whole week. In January
963, a series of mild chinooks fol-
d one another into the Calgary
over a period of eight successive
, bringing unseasonably warm
eratures of from 40° to 55° F.
ing that time, a few lilacs began
to bud in southern Alberta. Then, just as suddenly as the winds appeared they vanished, and thermometers plummeted to 21°F. below zero.

THE meteorological bureau in Calgary has compiled comprehensive statistics on chinooks, some of which date back to 1893. On several occasions during the past seventy years there have been variations of as much as ninety-nine degrees between highs and lows in the month of January. In 1893, the highest January reading was 51°F., and the lowest reading was —48°F. In 1929, the high was 54°F., the low —45°F. These fluctuations took place in Calgary itself, where the average January temperature over the years has been calculated at 6°F. However, the meteorological record shows that in January, 1958, a month of almost constant chinook winds, the mean temperature was pulled up to a relatively balmy 28°F. The all-time January high for the city was recorded in 1942 at 61°F. In a recent December, a chinook raised the temperature by seventy degrees within a time span of five hours, and in February, 1908, another brought the temperature from —14° up to a springlike 76°F. before the snows again began to fall.

Sometimes the chinooks veer off course, or rise above the cold air mass of the prairie. I had an experience of an erratic chinook several years ago on a drive from Calgary to Banff. We left Calgary when it was 20°F. below zero, and drove onward through the bitter cold. About thirty miles from Calgary, we rounded a bend in the road and were amazed to find ourselves suddenly driving in pleasant, 45°F. weather. We arrived at Banff, and enjoyed a warm, sunny day. That evening, we drove back to Calgary. At exactly the same bend in the road, we re-entered the zone of sub-zero temperatures. In this instance, the chinook must have veered off course, flowed up the Kananaskis Valley and over the Highwood Pass to the south, circumventing Calgary entirely.

Many incidents have been reported of other misplaced or erratic chinooks. A pilot of a small plane once told of being raised seventy-five feet by an updraft as he flew near Calgary. In that seventy-five foot change in altitude his plane's thermometer jumped from —8° to 53°F. But usually chinooks are dependable. When, on a sub-zero winter morning, Albertans see a great cloud arch in the west they know that relief from the pervading cold is on the way.

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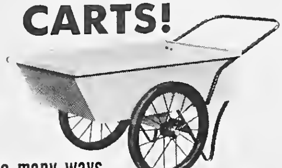

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About the Authors

Dr. Philip C. Hammond, the author of "Rose-Red City of Petra," is Assistant Professor in Old Testament at Princeton Theological Seminary. He brings to bear on his subject studies in Semitics at the Graduate School of Yale University (where he also prepared his doctorate in Near Eastern Archeology), and considerable field work. The latter includes work with the American School of Oriental Research, Jerusalem (Jordan), as a Fellow and, in 1961-62, the post of Director of the American Expedition to Petra. He is currently Director of the American Expedition to Hebron.

Fossil fishes are examined in "Fishes and Climates," by Dr. C. Lavett Smith, Assistant Curator of the Department of Ichthyology at The American Museum. Dr. Smith's interest in Cenozoic fishes began in 1952, when he participated in a University of Michigan field party that was led by Dr. Claude W. Hibbard. Dr. Smith is still actively studying Cenozoic fishes. He describes his major professional interests as the classification of fishes and the ecology of coral reef fishes, with particular emphasis on the reproductive mechanisms of the sea basses.

The color changes of the chameleon are discussed in "Color Change: Chameleon Camouflage," by Dr. Herndon G. Dowling, Curator of Reptiles at the New York Zoological Park (Bronx Zoo). Dr. Dowling, who characterizes himself as "a snake taxonomist by training and inclination," says that his zoo work has impelled him to view all reptilian attributes "with interest and appreciation." He has been especially concerned with taxonomic studies of colubrid snake genera and zoogeographic investigations of amphibians and reptiles. Dr. Dowling is also a Research Associate in the Department of Herpetology at The American Museum.

Mr. Dale W. Rice, author of "The Hawaiian Monk Seal," received an M.S. in biology from the University of Florida in 1955, and since then has been employed as a Wildlife Research Biologist with the Fish and Wildlife Service. For the past five years Mr. Rice has been the biologist in charge of whale research for the Bureau of Commercial Fisheries, and he is at the Bureau's Marine Mammal Biological Laboratory in Seattle.

"An 'Antlered' Grotesque" is Mr. Lars Holmberg's account of the large and bizarre-looking European stag beetle. Mr. Holmberg is a Swedish journalist who writes often on natural history.

Canadian free-lancer Deryk Bodington made the unusual panorama of the chinook cloud arch that appears in "Snow Eaters of Alberta." A citizen of Calgary, Alberta, he writes from years of experience with the chinook.

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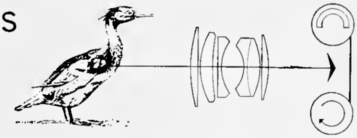


DAVID LINTON

LIND is an enclosure designed to conceal the photographer and his ratus. A trap, in nature photogra- is a device by which the subject its own picture. Of the two, blinds nuch more useful, and many of the pictures of wild animals have been from blinds. Although the develop- of long lenses and high-speed films shifted emphasis in recent years to res taken at long range, the blind ins a most useful accessory for the re photographer.

the early days of nature photog- y, elaborate attempts were made to ise blinds as natural objects. Now now that this is not necessary. since mals suspect a blind because of its rather than its appearance, and will become accustomed to any object—no matter what its shape— will eventually lose their fear of it if es not make threatening motions. rds are often accustomed to seeing nobiles, which, as a result, may as convenient blinds. Some of the er bird species, however, will toler- he presence of an auto only if it is ng, and will scatter if it stops. If is the case, the best compromise is ve a companion drive the car as y as possible without dispersing irds while you shoot pictures.

turally, a long-focal-length lens and ck eye are necessary to photograph a moving automobile. The camera d be held so that it does not touch part of the vehicle; in that way the grapher's body and muscles damp of the vibration. Most people will the slowest shutter speed that will reasonably sharp negatives under conditions to be about 1/250 sec., he lowest practical speed will de- on the length of the lens as well as e photographer's steadiness. Motion gnified to the same degree as is the e formed by the lens; a long lens— increases image size—must there- be held steadier than a short one, when the camera is in motion the lens will require a faster shutter than will a short lens.

Use Tripod in Car

few birds will accept the presence completely motionless car as long ople do not emerge from it. In such it is very helpful to have a camera ort in the car. A small tripod can be set up in many cars if two of the legs are extended to rest on the floor while the third is collapsed to rest on a seat. In many station wagons a tripod can be set up normally in the back. This is the best location, because the rear window gives a wider unobstructed sweep than any other. The window should, of course, be opened so as not to distort the photographic image.

The photographer should be seated comfortably while working, because holding an uncomfortable position for any length of time will make his hands shake. Even if the camera is on a tripod he may be unable to operate it smoothly.

A more permanent blind is better than an auto, of course, when a series of pictures is to be made over a period of time. It is a necessity for photographing shy creatures that may take days to become accustomed to its presence. Sometimes a blind is set up at a distance from the subjects and moved closer each day. In other cases a permanent blind may be left in place for weeks or years.

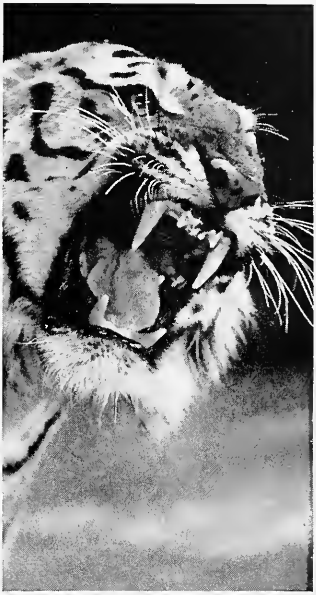
Characteristics of Blinds

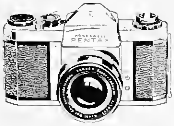
An ordinary demountable blind is similar to a small tent. Usually it is not waterproof, since it will not be used on rainy days, but the material must be sufficiently opaque so that subjects will not see the photographer moving about inside. Material of a neutral color that will blend with the surroundings is probably an advantage. Here, too, the photographer should be able to sit in comfort; otherwise he will not be able to stay mentally alert and physically relaxed.

In most places, a blind should protect the photographer from mosquitoes. It should also have adequate ventilation, as a blind exposed to the sun can become insufferably hot. Openings covered with nylon mosquito netting should admit air near the bottom of the blind, and other openings should vent it out near the top. The opening through which the lens projects can be provided with a drawstring or elastic ring to make a snug, mosquito-proof closure.

The best way to keep a blind cool is to erect it in a shady place. If there are no trees at hand, a separate "fly" (an extra cloth roof over the regular one, with an open air space between them) will make the enclosure more livable.

It is not too difficult to make—or to have made—a blind such as the one just





described, but it is easier to buy a small tent and convert it for use as a blind by adding camera ports and observation peepholes. There is a dome-shaped tent on the market called a "Pop Tent" that has a simple frame that fits into sleeves sewn into the tent. The inside space is not obstructed by poles, and there are no shiny metal gadgets outside that might frighten wildlife. Tents that have many loose hooks, springs, and lengths of metal tubing should be avoided. All tents should be staked down to prevent the wind from blowing them over, advertising to the contrary notwithstanding.

When Subjects Are Wary

The bolder birds, such as those that live along the seashore, will pay no attention to a photographer once he is settled in his blind. Some of the more wary species, however, will not relax until they feel that the blind is uninhabited. To deceive them, the photographer should walk to the blind with a companion who will leave a few seconds later. Most birds do not seem to note the difference between two humans entering the blind and only one leaving it.

For photographing high nests or arboreal animals, a blind can be built in a tree. It is best to construct a small platform at a place where several tree limbs join the trunk. The blind can then be erected with the platform as a floor, and the trunk and perhaps higher branches as supports. It is best to choose a large tree, to stay close to the central trunk, and to go no higher than necessary, because even a very large tree will move enough in the wind to blur a picture. It may also be necessary to brace or tie down the branch that is to be the scene of the picture.

Blinds for photographing mammals are usually placed at water holes or adjacent to trails the animals are known to frequent. Sometimes an artificial attraction is provided—food, salt, or water. The animals may avoid the blind at first, but will usually get used to it in time. The sense of smell that is so well developed in mammals is offset, to some extent, by their curiosity, and they will often come around to investigate an unfamiliar object.

Most animals are seldom seen in the middle of the day. Except for nocturnal species, early morning is the best time to look and late afternoon is second best. Most large mammals, such as deer, watch for danger at about their own level and rarely look for it above their heads. They often fail to see a tree blind.

Because a high camera viewpoint is seldom desirable for taking pictures of mammals, the elevated blind is most useful for remote control photography. The camera can be set up near the ground and the photographer can operate it from a vantage point some distance away. This arrangement is intermediate between shooting from a blind and using a trap
the photographer can see what he
photographing, even though he is n
actually at the camera.

Photographer takes picture at a distanc
by activating solenoid that trips shutte

Early works on nature photograph
describe how the camera shutter can
tripped with a thread strung out to whe
the photographer lies hidden, and ca
tion that the thread should be ru
through a screw eye at the bottom of o
tripod leg so that a tug on the threa
does not upset the camera. After ma
ing one exposure this way, the photo
rapher has to emerge from his blind
reload the camera and cock the shutt
for another try, by which time the su
ject is probably far away. The threa
stretches and causes a delay between t
time it is pulled and the time the shutt
opens, and it is difficult to gauge t
tension necessary to open the shutte

Fortunately, we now have a variety
devices to make the remote operation
cameras and lights as simple and
automatic as we choose. The least co
plicated gadget is an air release, a leng
of thin plastic tubing with a squeeze bu
at one end and a plunger at the othe
The plunger end screws into the ca
era's cable release socket and the ph
tographer simply squeezes the bulb
activate the shutter.

Slightly more sophisticated is t
electrically operated solenoid, which
basically an electromagnet with a mo
able core. In the early decades of t
flash bulb era, solenoids were used
synchronize camera shutters with fla
bulbs. Solenoids are still available, a
are now finding new uses in remote co
trol photography. The simplest type
solenoid screws into a standard ca
release socket, and can be operated fro
any reasonable distance by simply ad
ing more wire between it and the pow
source. The power applied must be su
cient to overcome the resistance of t
wire and to deliver enough energy at t
solenoid to operate it reliably. Two
three flashlight batteries are usually ad
quate for fairly short wires; for long
distances use a B/C ("Battery-Capa

flash gun, which delivers a quick e of energy from a capacitor that has charged by a 22.5-volt battery. At great distances higher voltages may necessary. The actual footage at h a given power source will con- ntly operate a given solenoid de- s on the size of the connecting s: large-diameter wire offers less re- nce than thin wire, so it may be over a greater distance. However, y wires are harder to conceal.

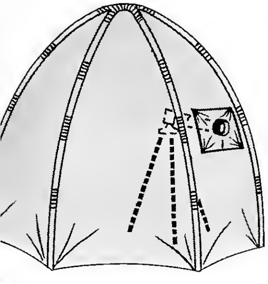
hen a camera that has flash connec- is remotely operated it can, in turn, lash bulbs or electronic flash units. batteries that power the lights ld be close to them to minimize loss ower in transmission. An electronic unit is advantageous in that it can ired repeatedly without replacing s. But the problem of advancing the automatically has to be solved, too.

Automatic Photography

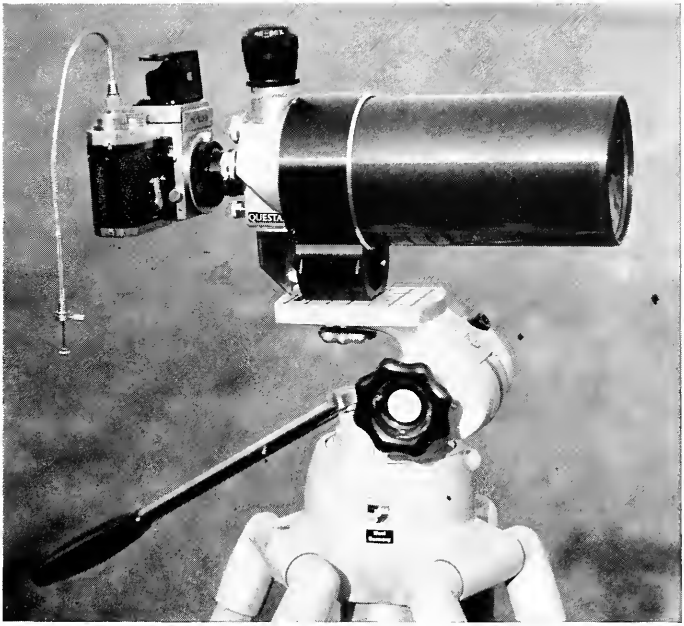
ECIALIZED equipment is needed for automatic camera operation. There everal cameras that advance the film wind the shutter automatically after exposure. Among them are the ot, the Tessina, and the discontinued n. There are also a number of cam- for which accessory motors (spring- ectric-powered) are available.

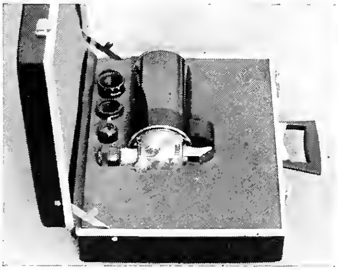
ost such cameras use 35 mm. film, some of the more expensive ones, gned for technical recording, use m. film. For situations that require er film capacity than the ordinary posure 35 mm. cartridge affords, are available for some cameras ssory backs that accept 50-foot rolls 5 mm. film, which provide several dred exposures.

e ultimate in remote control is eved with radio-operated tripping es, which may be fitted to several eras. This method eliminates string- wires from the camera to the photog- er's hide-out and makes it possible erate the camera from a distance of al miles. Presumably the photog- er could even hover overhead in a opter. Radio control units have not ed as efficiently as expected in



E-SHAPED TENT is suitable for use as to hide photographer and equipment.





places where there is a lot of electrical interference, but out in the open they ought to function well.

Pictures at Night

The problem that usually comes to mind first in regard to night photography is how the photographer can see what he is doing. Ideally, he should set up all his equipment while it is still light, and he should be sufficiently familiar with it to operate in the dark (otherwise he should not be using it in a blind, anyway). As for seeing when the subject arrives in front of the camera, it is rarely so dark outdoors that a human cannot see after his eyes adapt.

At permanent or long-term blind sites it may be possible to leave a small light on every night until the subjects get used to it. Many nocturnal mammals show surprisingly little fear of lights at night and will enter a pool of brightness if they have sufficient motivation. Even more surprising, many will return to an attractive spot after having had flash bulbs fired at them, and despite the scent of man.

If the light used to make the picture is too disturbing to the subjects, it is possible to use infrared rays instead. The camera is loaded with infrared-sensitive film, and special red flash bulbs or red filters over the flash reflectors are used. This technique has one disadvantage—most creatures present a rather strange appearance in infrared pictures because the coloring of skin, eyes, and hair looks appreciably different from that to which we are accustomed.

The noise the camera makes may be a problem, particularly if the camera has an automatic winding mechanism. The sound can be muffled somewhat by swathing the machinery in batting or enclosing it in a box lined with sound-absorbing material. Although the lights must generally be fairly near the subject, it is well to remember that the camera does not have to be near either. For example, lights could be set up around a salt lick and connected to a camera equipped with a long lens, which could be located some distance from the scene. The photographer could, if convenient, operate both lights and camera from yet a third position.

Knowing where to look for birds and other animals is a subject in itself. A good knowledge of the subject's habits will help, but experience in the field is the most important factor. Information given in field guides about habitat, food, and nesting sites is useful.

The camera trap is an arrangement by which the subject itself will operate the camera, and usually any lights that are required. It is easy to find published instructions for making a variety of traps, but it is hard to find a good picture that was taken using one. Working with a camera trap is a form of photographic roulette; one never knows what will tur up on the film.

The big trick with camera traps is t photograph the species one wants an not something else, and traps have othe drawbacks, too. When a variety of subjects is wanted, a camera set at the righ height and distance to photograph moose will not take a good picture of mouse, even if a mouse triggers it. An most traps can be set off by a fallin acorn or merely a strong wind. If the desired subject does activate the trap, th picture may show only the tip of the tai

A higher photographic yield—in quantity if not in quality—can be expecte from an automatic camera. Equipment i arranged much as it would be for a remote control setup except that a trippin device is added. This can be any gadge that will complete an electrical circu when the subject is in the right plac For example, some microswitches ar sensitive enough to be activated by a bir landing on a branch. There are also ele tronic relays that will respond to almo any stimulus one could name. Th familiar "electric eye" operates when beam of light is interrupted. A simila cell can be used with an invisible bean A relay can also be made to respond t a sound or even to the change in capac tance caused by an object passing near concealed metal plate.

All such devices share the same di advantage: they are too easily triggere by a host of unforeseeable occurrence The few controls the photographer ha over the content of his picture are h skill in aiming the camera appropriat ly, and in placing and adjusting the tri ping devices so that, hopefully, only th desired subject will operate them. Eve the most elaborate equipment gives th photographer no control over exposu at the moment the shutter is tripped. is imperative that automatic camer used in such setups have a switch clutch to turn off or disengage the dri mechanism when the end of the film reached. Judging by the results that ha been published, photographers are in danger of being made obsolete by trap

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AN "ANTLERED" GROTESQUE

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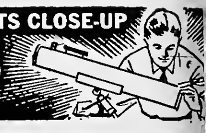

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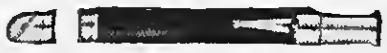

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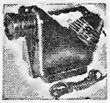

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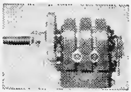

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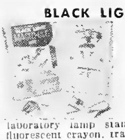

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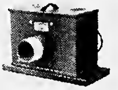

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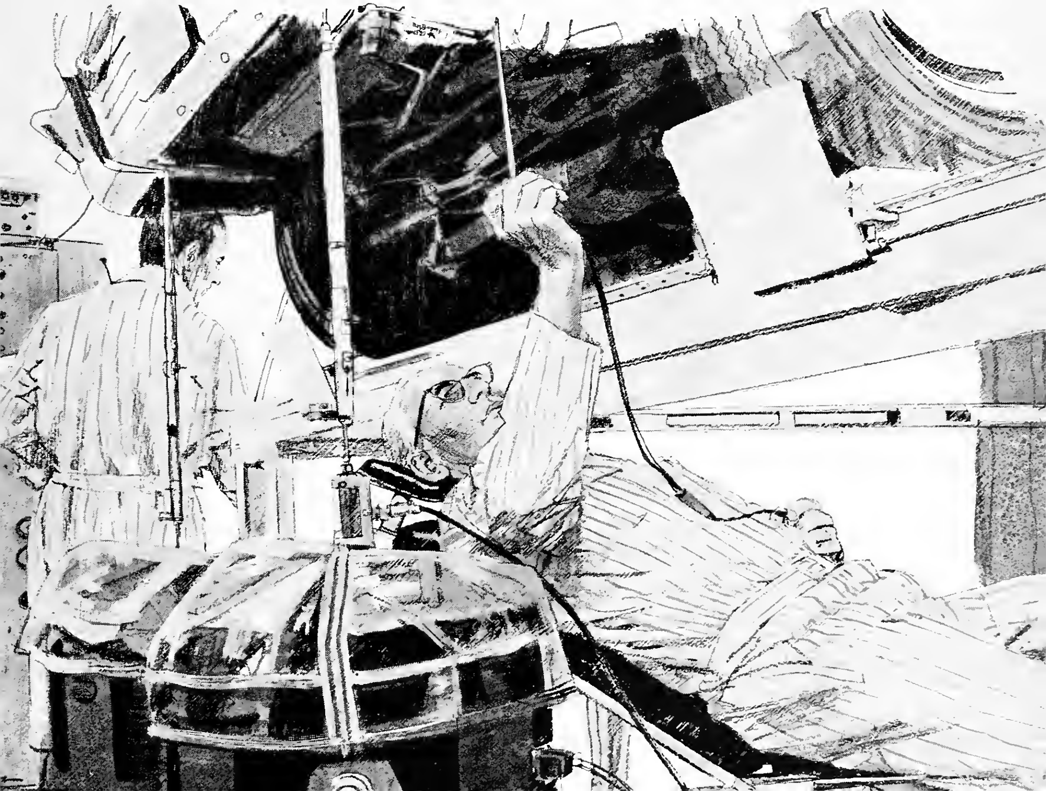

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Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTOR

Vol. LXXIII MARCH 1964 No.

ARTICLES

DEPARTMENTS

COVER: *Drosera rotundifolia*, the common sundew of northeastern Unite States, is one of a group of plants sometimes called "carnivorous." Each roun sundew leaf is covered with tiny hairs, on the tips of which are very sweetl scented. mucilaginous drops. The odor attracts an insect: it is snared in th viscous hairs, and plant enzymes break down its soft parts. After several days, th chitinous portion of the body blows away. In this picture, taken by H. J. Jorda insect remains are visible as a dark shadow at the bottom. For more informatio about these and the other insectivorous plant species, please turn to page 2

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Museum Memo

Report from the President

T has always been the purpose of The American Museum of Natural History to make known to the greatest possible number of people the full meaning of our program, l to set forth our educational objectives.

Because NATURAL HISTORY has always been the official rnal of the Museum, it is logical that I should use it as neans of reaching the Museum's far-flung audience of nbers and subscribers—in fact, all readers and friends of Museum—for it is my wish to thank you for your interest l to report to you on our many plans for progress.

It has been said that an organization of any kind is as ng as the people who, in one way or another, contribute t. In the case of a public-supported institution like ours, s an uncontrovertible fact. I believe the strength of the seum is growing in many ways, and I would like to tell briefly of some of them.

A most encouraging growth area is in attendance. During last fiscal year 2,442,977 people visited the Museum, and ,771 visited The American Museum-Hayden Planetarium. s total of 3,061,748 is an increase of more than 150.000 r the previous fiscal year. We believe this increase repre- s a worldwide pattern of growing interest in the natural nces. (This may represent a new and basic philosophy. ause man has become aware that his world can be de- yed, he is looking at it today with new and wondering eyes.)

Another area of growth is in exhibition plans, a number vhich are being geared to culminate five years from now— ghly significant date in Museum history. On April 6, 1869 e year the Suez Canal opened) a group of prominent ens signed the Act of Incorporation of The American seum of Natural History. Thus, in 1969 the Museum will h the end of its first century of service. By that time, we e to have completed new halls devoted to ocean life, the ogy of invertebrates, the primates, the birds of North erica, earth history and geology, and the cultures of ern Woodlands and Plains Indians, Eskimos, the peoples frica, and the peoples of the Pacific. Each will demon- te exciting techniques whereby science can be translated terms everyone can understand, made possible by close peration among scientists, architects, and artists.

All of the halls will contain the latest scientific dis- ries, and herein lies our third and unquestionably our t vital area of growth. No exhibit would be possible with- years of scientific research—the very foundation of the eum as a vital educational force here and throughout the d. There are always some of our scientists studying, col- ng, or experimenting in such places as New Guinea, ca, Antarctica, the Amazon. This is fairly common knowl- . But our newer members (and even, perhaps, some of standing) may not be acquainted with several of our spectacular and, hence, less well-known, activities. For nce, the Museum maintains four research stations at h our own scientists and those from other countries can ue their own lines of investigation. These range from ial behavior and astronomy to biophysics, entomology, hology, and so on through the biological alphabet.

No research activities of any kind are possible without ries. Our main library is one of the best repositories of ral history publications in the world. In addition, there the Osborn Library of Vertebrate Paleontology, the etarium library on astronomy and allied subjects, and the photographic library, including a slide lending library.

Perhaps we should also include here mention of Museum publications. There is, of course, NATURAL HISTORY. There are, in addition, *Curator*, a magazine of museology, and the widely distributed scientific papers—the *Bulletin*, *Novitates*, *Anthropological Papers*, and *Contributions of the American Museum-Hayden Planetarium*. There is also a new publishing venture, undertaken jointly with Doubleday and Co., under the name of Natural History Press, which issues *Nature and Science*, a magazine for elementary school children, as well as books on natural history for adults.

While we are on the subject of little-known facts regarding the Museum, I think we should discuss grants. Now, the Museum is a non-profit institution, and as such must seek support. However, it also distributes funds that have been given for specific purposes by individuals, foundations, and federal agencies. These enable research training to be provided for students from high school age through those working for their doctoral degrees.

It goes without saying that research is never finished. Every answer has as its concomitant another question. As a result, the end of our first century is really only a beginning. The more we plan and accomplish, the more we must continue to plan and accomplish. Our increasing responsibilities in research, education, and exhibition are a reflection of that growing interest in science I mentioned earlier—an interest that could never have been envisioned by even such far-sighted men as the founding fathers.

The responsibility affects us all equally, whether we are scientists, non-scientific Museum employees, one of the Board of Trustees, or Museum members, because we demonstrate our deep interest in the work done here by being associated with it in the first place. The association is not parochial. As a research center in the biological and earth sciences and as an educational medium, The American Museum is international in scope. It goes far beyond the country's boundaries and into the minds of men who are concerned with knowledge of the world of which they are a part. We are constantly turned to for guidance, assistance, and, most important, for leadership in the scientific disciplines we represent. Unless we continue to expand and to make the future always more important than the past, we will be relinquishing our rights of leadership. The status quo only maintains a reputation; to be meaningful, a reputation must be enhanced.

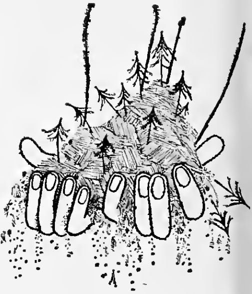
You who are members have helped the Museum immeasurably over the year by heightening public interest in the meaning of natural history through the simple expedient of being enthusiastic. An even larger membership could undoubtedly create even more excitement in learning. This is the only way an institution like ours can survive. It must continue to generate interest and enthusiasm by virtue of its solid scientific accomplishments, for it is only such accomplishments that permit the Museum to speak with a voice of authority. The results of scientific discovery will, in turn, be given back to its supporters in the form of broader research and education programs and more comprehensive exhibits. In other words, a continually growing membership will, as it has in the past, enable us to meet the constant and many-faceted challenge of scientific progress and interpretation in the context of a rapidly changing world.

Alexander M. White

Reviews

Man and nature joined in quiet crisis

By William Vogt



The Quiet Crisis, by Stewart L. Udall. *Holt, Rinehart and Winston, Inc., $5.00; 209 pp., illus.* Man and Nature in America, by Arthur A. Ekirch, Jr. *Columbia University Press, $4.50; 231 pp., illus.*

The interrelationships of the human nervous system with the human environment have not been widely recognized as part of human ecology but they are, essentially, the theme of these books. Ever since European man arrived on this continent he has been driven and guided —or misguided—by ideas, ideals, notions, values, desires, and motivations that were his own and that were often destructive of the complex of physical factors making up his surroundings. A sense of responsibility toward the land and its non-human creatures emerged early only among such oddballs as Thoreau and the Bartrams, and a few others including perhaps the most sapient of our presidents, Thomas Jefferson.

There was little doubt, especially among those who were guided to the New World by religious zeal, that the continent was here for them to subdue, and they were the most inner-directed of men. They followed the desires of their own often flinty hearts, and if water flowed down hill and took soil with it, well, so much the worse for soil. These were the adventurers, the exploiters, the killers, the entrepreneurs, and the developers, and whether their god was Jehovah or Free Enterprise they had few of the kindly thoughts for fellow creatures that are enjoined by the Buddha. Their ignorance of nature's laws was, on the whole, colossal, and their lack of a sense of responsibility was constructed on the same scale.

Fear and threat of destitution arising from land abuse and population pressures have, like cirrhosis of the drunkard's liver, begun to stimulate thoughts of reform, although one does not have to jet far to see soil erosion, rugged individualists among the stockmen who still maintain their right to wreck the ranges, and the dripping faucet that continues to be a symbol of national wastefulness.

These two books are essentially the story of the relationships of man's attitude with the land. Mr. Ekirch's book, *Man and Nature in America,* is chiefly concerned with the product of nervous systems—economics, sociology, history, bureaucracy, verbalizations of one sort or another—and its first paragraph exposes an ignorance and resulting confusion concerning natural sciences that probably has few recent equals, certainly in books published by university presses. Incredibly, he does not even mention the American who has most advanced modern thinking about man and nature, Ald Leopold. Nevertheless, for anyone interested in the story of human attitudes toward nature in America, although little of the book is devoted to nature itself, it is a good summary. While i neglects Leopold, it does include the influence of the Hudson River school o painters, which the next book ignores.

The Quiet Crisis—which, in this worl of jets, superhighways, jackhammers, bulldozers, and thin-walled apartment inhabited (it appears) chiefly by TV's seems strangely named—is a happy com bination of critical evaluation of huma thinking-feeling about the totality o land, and the empathic history of th land itself. Written (with the acknowl edged help of his staff) by a man famou for enjoying the land as much throug the soles of his feet as through his mind such a book could almost certainly no have been produced by any former Secretary of the Interior.

Unlike most who have thought an written about conservation, Secretar Udall recognizes that man is intrinsi cally a part of nature, and that notion are a part of man. In one of his man trenchant sentences he writes approv ingly: "Henry Thoreau would scoff a the notion that the Gross National Prod uct should be the chief index to the stat of the nation. . . ." His concern extend far beyond the responsibilities of the De partment of the Interior and he almos —but not quite—comes to grips with th inevitable necessity of putting a ceilin on population. This is hard to unde stand in a Secretary who has only re cently approved an outstanding repor on the need to limit certain animal popu lations in national parks.

Why a beaver dam is more "natural than a mill dam has never been sati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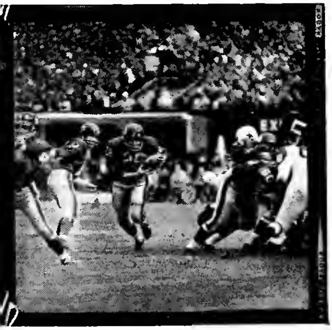


factorily explained by "nature lovers, and Mr. Udall, in accepting man as part of nature, has many wise things t say about cities and the density-depen ent problems created by the human sp cies. "As the area of conflict and overla increases we must constantly improv our decision-making techniques," h warns. "Nor must we be afraid to decid the toughest of issues; practices tha defer necessary decisions can also be threat to the national welfare."

It is probably inevitable that a boo by a member of the Cabinet should b political, and it is in this area that th book's slip occasionally shows. The C vilian Conservation Corps is inordinatel praised with no recognition of their destruction of large areas of wildlife hab tat through drainage and other activities The failure of his own Department (before he became its chief) to protect th Alaskan salmon is not mentioned, an while the Secretary points out the "magnificent opportunity" to respect Alaskan wilderness and wildlife, of the Rampar Dam deponent sayeth nothing. Franklin D. Roosevelt is lauded as a conservationist; there is no mention of the way Ja Darling had to outwit him to get fund for waterfowl habitat restoration. Th Secretary's staff should get lumps fo depriving the Audubon Society of Corkscrew Swamp and for not updating him on the violation of Olmsted's vision o Central Park by Robert Moses and Newbold Morris. But these defects are slight mere freckles.

This is an outstanding, absorbing, inspiring book that should be read by every conservationist. It weaves conservation an increasingly urgent human activity into the tight, living web that makes up our exploding interrelated world. Yet it reminds us that we can all play our part and, indeed, have a responsibility to do so. Writing about the Yellowstone, Secretary Udall says: "The concern of a few people for the rights of future generations made the difference, and this factor of foresight would mean the success of most future park Proposals." The need for both the concern and the foresight grows in importance every year.

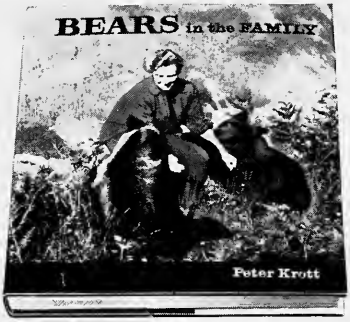
The illustrations, both black and white and colored, are superb, and are quite worthy of the book itself.

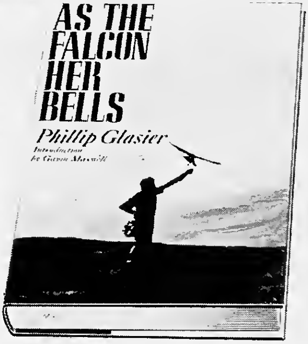
Dr. Vogt, internationally known, award-winning scientist, specializes in both the behavior and the ecology of birds, and in human ecology and conservation.

COPPER TOWN, by Hortense Powdermaker. *Harper & Row, $7.95; 391 pp., illus.*

DR. POWDERMAKER has, over the years, demonstrated her ability to dance a lively gavotte, dropping curtsies with equal grace to the disciplines of anthro-

logy, sociology. psychology. and his-
y in such diverse ballrooms as Mela-
sia, Mississippi, and Hollywood. Now
e enters the African scene with a fan-
ngo that is at times somewhat wild,
t always exciting and provocative.
Copper Town is no ordinary book about
e problem of social change in an Afri-
n mining community. For one thing, it
eminently readable; while it is schol-
y, it is at the same time a book that
yone can read with enjoyment. Dr.
wdermaker's success is due in large
rt to the thoroughness with which she
viously prepared both her project and
: written account of it.
We must be particularly grateful to
: for explaining, in the Introduction,
actly how she set about tackling her
d work, and why. This is sound aca-
nic practice, by no means always fol-
ved, and it adds immeasurably to the
ue and interest of the book for the
neral reader.
The basic problem is one of change,
l throughout we are reminded that in
pper Town the process of change af-
ts not only the Africans but also the
ropeans. So that we can understand
process more fully, Dr. Powdermaker
es us a background to both communi-
s. This necessarily involves her in gen-
lizations, and with some of these I
ght quibble, but the validity of her
in argument is in no way affected.
n showing how tribal values and cus-
ns persist, even after the tribe had dis-
egrated as a localized political unit,
Powdermaker uses transcripts of con-
sations and interviews, and the reader
ible to sense the tremendous depth of
ling that runs below a not always un-
fled surface. And it is a powerful
hnique, as Dr. Powdermaker allows
ropeans as well as Africans to speak
themselves in this way.
She selects her quotations to good ef-
t. She cites an African union member
o approved of calling medical workers
on strike even though a number of
ldren in the hospital died as a result.
nen asked if he still approved in the
ht of the deaths, he said, "Even if they
, they are not my relatives." Dr. Pow-
maker makes use of such examples to
strate the strength of traditional val-
; — in this case, kinship — that persist
n among the most apparently "de-
balized" Africans.
The Africans of Copper Town see
mselves as members of the new eco-
nic order, but some of them feel that
y still belong, at least partly, to the old
bal order, and they are still subject to
ch of its powerful tradition. A differ-
iation is drawn between these "in-
nsigents" and the "moderns" who
n the gulf with more ease and success
n many Europeans care to acknowl-
ge. While the horizons, or "range of
ntity," of the former remain limited,





the horizons of the latter are constantly expanding. Dr. Powdermaker gives a dramatic picture of the extent and nature of this expansion, while pointing out that at the same time the same process is at work among the Europeans.

I personally query Dr. Powdermaker's interpretation of witchcraft, and her generalization that it normally involves revenge and "black magic" rather than "white magic." It seems that there is a confusion here between magic, witchcraft, and sorcery, which to the Central Africans are quite distinct processes involving totally different mental attitudes.

This does not mean, however, that the author's deductions are necessarily at fault in this area; it merely means that I wish she had been allowed enough space to go into greater detail and tell us still more. And that is surely the mark of any first-rate book. I recommend it wholeheartedly to anyone interested in human beings and human problems—a "must" for those interested in Africa.

COLIN M. TURNBULL
The American Museum

JOHN CLAYTON: PIONEER OF AMERICAN BOTANY, by Edmund Berkeley and Dorothy Smith Berkeley. *University of North Carolina, $6.00; 236 pp., illus.*

THE dainty, starlike Spring Beauty, *Claytonia virginica* L., one of the earliest blooming of all eastern American wildflowers, is familiar to many, but few know much about John Clayton (1686-1773), the American botanist in whose honor Linnaeus named this delightful harbinger of spring.

Clayton, a contemporary of John Bartram, Mark Catesby, Peter Collinson, and Benjamin Franklin, collected plants and also described them for the first important flora of British North America, *Flora Virginica.* This work was compiled by John Frederick Gronovius and was published at Leiden in two parts, in 1739 and 1743. A second edition, revised and enlarged, was published in 1762.

Strange as it may seem, little information has ever been gathered together concerning the life of this important American botanist. In a letter of January 4, 1751, to Cadwallader Colden, the botanist Peter Kalm wrote: "There is nothing we want so much as a Biographica Botanicorum; the old were very negligent in that: there are many of which we hardly know any other thing but the name; nay, if we seek yet to the history of their life, we are obliged to pick up here and there a word in the writings of their contemporary's; . . . I have already got the history of Mr. Bartram's life; of Clayton I hope D. Gronovius will give out his vitae historiam."

Dr. and Mrs. Berkeley, some two hundred years later, fulfilled Kalm's hope for a life of Clayton. They searched diligently both American and European archives for authentic correspondence and official documents, and have reconstructed the life, interests, and contributions of this early American. Their scholarly work is extremely well documented, most readable, and presents a wealth of heretofore unpublished material on eighteenth-century botany and botanists.

ELIZABETH C. HALL
N.Y. Botanical Garden

HEREDITY AND HUMAN LIFE, by Hampton L. Carson. *Columbia University Press, $5.00; 218 pp., illus.*

OUR concept of man and the mechanisms that have led to his differentiation from other primates has been profoundly modified in recent years by a number of events. There have been since the mid-1920's a series of fundamental discoveries of fossils relating to this story. The nature of the gene and its behavior has been magnificently clarified in a series of brilliant laboratory studies. And the way genes interact within aggregates of individuals has been illuminated in a whole new branch of genetics that is concerned with the breeding population as the unit of evolution.

Much of this new knowledge is either inaccessible to the lay reader or is available only in specialized language. Professor Carson has attempted here to present this new view in a strictly nontechnical style, and, on the whole, he has succeeded admirably—if one overlooks the inevitable omissions that the vested interests will be quick to point out.

In effect, Carson has written an evolution of man and race by beginning with the gene, analyzing the individual as a product of both heredity and environment, and applying both genetic and evolutionary principles to the specific story of the differentiation of man and his diversification into races.

Unfortunately, Carson has oversimplified in several cases in which the facts are still obscure. The antiquity of *Homo sapiens*, for example, is hardly known as precisely as he would allow. And it is still far from certain that the modern races of man had their beginnings only 40,000 years ago. There is also a polemic touch to the book that—although on the side of the angels—is bolstered by faulty logic. It does not do the case for antiracism much good to say that the genetic factor in intelligence cannot be isolated and identified because intelligence itself cannot be measured precisely with our current techniques, and later to ascribe group differences in this attribute to cultural environment as though we had the means for doing so. It may be true, but this is not the way to resolve the issue. Nor does it help to minimize the adaptive nature of pigmentation, for example, by invoking genetic drift. If this were so, one might expect far more variation to

ve been preserved in the small isolates at have survived to our day. Conti-ntal uniformity speaks for more than random effect.

Despite these caveats, *Heredity and uman Life* has much to offer any read- who likes to keep informed of the ogress of science.

Harry L. Shapiro
The American Museum

IE GREEN TURTLE AND MAN, by James Parsons. *University of Florida Press, .00; 126 pp., illus.*

HIS account of *Chelonia mydas*, the . green turtle, is an invaluable con-bution to our knowledge of the bio-gical distribution of a highly exploited eature. Dr. Parsons has traced the his-ry of the relationship of man and the een turtle from *Chelonia*'s use as a otein-yielding necessity, through its port as a luxury food item, to the pres-t methods for its conservation. The tensive bibliography ranges from the rliest explorers, and includes Francis rake and Captain Cook, plus modern thorities such as William Beebe, James . Oliver, and Archie Carr—who wrote e foreword to the book.

This is an account of existing and his-ric attitudes among various populations regarding this reptile. It should aid modern conservationists toward an effective program to insure the continuation of the species—an important source of protein, in the form of eggs as well as meat, for many tropical peoples. The photographs throughout are of unusual quality and of outstanding reportorial content. Among them is a sequence dealing with the project undertaken by the Caribbean Conservation Corporation—Dr. Carr is the technical director—which is seeking to restore *Chelonia mydas* to its former numbers. The author, primarily a geographer, has done an outstanding job in making available to scientists and interested observers this compendium of information on the history and distribution of the green turtle.

Georg Zappler
The American Museum

ANIMAL WORLDS, by Marston Bates. *Random House, $15.00; 316 pp., illus.*
THE WONDERS OF WILDLIFE, by Franz A. Roedelberger and Vera I. Groschoff. *Viking Press, $8.50; 232 pp., illus.*

BOTH of these superficially similar books are large, "conversation piece" picture books, replete with beautiful, revealing, and sometimes dramatic photographs. On this ground both will appeal to many interested in natural history.

Here, however, the resemblance ends. In *Animal Worlds*, Professor Bates has accomplished the sort of tour de force we have come to expect of him; he has condensed an enormous number of facts and ideas while writing simply, interestingly, and authoritatively. Even without the illustrations (horrible thought) the text would stand alone as a lucid, thorough description and analysis of the major environments and habitats of the world and of the animals that inhabit them. Without seeming pedantic to the casual reader. it could serve as a text of the fundamentals of animal ecology.

Animal Worlds begins with a chapter on the general conditions of animal life, and then describes and discusses specific animal environments in the major parts of the seas, the wetlands, and the fresh waters. The chief environmental divisions of the land are similarly discussed and range from tundra, grasslands. and deserts, to forests, mountains, and islands. A most timely series of concluding chapters traces something of the natural history of evolving man, the effect of modern man in the areas where he is changing the environments with terrifying acceleration, and the ways in which some animals have fitted into the conditions of even our greatest supercities. Throughout the book the reader is led into a genuine understanding of the manner in which animals of each major type of habitat have evolved their many types of interrelationships, and of how closely tied to the physical forces of their environment they are.

I am sorry to note that the author has ignored the dangerous effects of man's pollution of much of the world with chemicals such as insecticides and detergents. This is a major factor that alters many animals' lives. Perhaps the manuscript antedated *Silent Spring*.

The illustrations and their reproduction are extremely good. In a few instances there is an unfortunate repetition of "cute" species, such as the raccoon and the white-footed mouse. Those all-important Arctic lemmings are not shown, and the snowshoe "rabbit" is erroneously illustrated among tundra animals. However, the special virtue of the photographs is the way in which many of them, while effectively portraying the animals, also most revealingly show the natural environments. Very few of the photographs look like posed pictures of zoo animals.

In contrast, *The Wonders of Wildlife* was obviously written to go between a series of photographs of European animals. The sequence is confusing and the text, although informative and interesting enough, lacks plan or continuity. A number of fundamental errors, such as calling first the pterodactyls and then the lizards "ancestors" of the birds, leads one to suspect the depth of the authors' knowledge. Most of the photographs are excellent, and some are superb; but others are patently posed, and some look retouched. Although there are some very timely and valuable words about the great need for conservation, I can see little use for the book in this country when equally attractive ones dealing with our own plants and animals are so readily available.

Alexander B. Klots
The American Museum

Sea Birds, by Charles Vaucher. *Dufour Editions, $16.50; 254 pp., illus.*

This book, despite its comprehensive title, concerns only twenty-odd sea birds and gulls, a couple of ducks, and a few shore birds—all photographed on the islands and coasts of the British Isles and the Baltic Sea. A short text accompanies the photographs, and a section is included that gives descriptions of the birds concerned, with notes on their breeding and an outline of their distribution. This section is brief, and the text, although well written, is sketchy.

The great majority of photographs are outstanding and many are excellent, especially those of the birds taken in flight. The latter certainly include some of the most remarkable ever taken. The series on the gannet is superb and probably unmatched, and some of the birds photographed on land, such as the fulmar and shag, are equally remarkable. There are 255 photographs, fifteen in color (and, I may add, not up to the standard of the black and white). The author has wisely added some very beautiful seascapes evoking different moods, and some striking scenes of the coast of Brittany.

This book is not comprehensive or "scientific," but it does not pretend to be. It is really aimed at those who are thrilled by the sea and its incomparable birds, and in this it is perfectly successful. A conscientious reviewer should note, however, that the present edition, prepared in England, is not quite up to the standard of the original edition, published in Switzerland in 1958. The format of the latter was a little bigger, the paper was of superior quality, and the reproduction of most of the photographs was better, but the quality of this present edition is still very high.

Charles Vaurie
The American Museum

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Animals, symbolic of the Egyptian tribes, hack at forts. Slate dates *ca.* 3000 B.C.

By
ALAN R.
SCHULMAN

Siege Warfare in Pharaonic Egypt

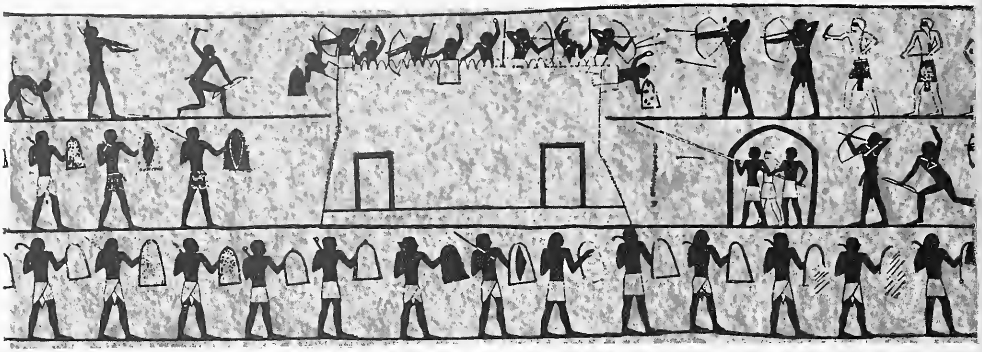
ALLUSIONS TO SIEGE WARFARE in the written and pictorial records of Pharaonic Egypt are compara- ely rare, and yet siege operations must have been rried on extensively during the approximately three ousand years that the rule of the Pharaohs flourished the land of the Nile. Siege warfare, which entailed chniques and tactics of attack against, and defense of, ed fortifications, was radically different from the mode fighting employed by troops campaigning against her troops in the open field. In the latter case, the o opposing forces met head on in battle, and the out- me hinged on many factors, such as superior numbers, aining, discipline, tactics, physical stamina, courage, occasionally, the introduction of some new weapon perhaps a new mode of warfare.

In an attack against a fortified area, however, the de- nding force had a decided initial advantage. The wide- read custom, in antiquity, of situating strongholds on e highest ground available compelled an attacking emy force to fight continuously uphill. Thus the at- ckers were exposed to the deadly missile fire of the fenders, who were protected from retaliation in kind walls and ramparts. Well-constructed and well-pro- sioned fortifications—garrisoned by determined, dis- plined, and brave soldiers—were, in the millenniums fore the invention of explosives, virtually impregnable to ordinary methods of attack. Consequently, new military doctrines and new weapons of war had to be devised for their reduction. It was probably for this reason that siege warfare and military engineering were born.

An operation against a fortified area, whether a single small fortress or a large, walled city, made use of two seemingly opposed tactics: on the one hand, the swift, direct assault; on the other, the slow, more formal siege that isolated the defending garrison until it was ultimately starved into submission. Although either tactic could be used independently, it was customary to combine them during a protracted siege.

EVIDENCE of this mode of warfare in Egypt prior to the start of the New Kingdom (*ca.* 1585 B.C.) consists, for all practical purposes, only of pictures showing the direct assault. The earliest of these is preserved on a ceremonial slate palette of the Archaic Period (*ca.* 3000 B.C.), now in the Egyptian Museum in Cairo. On it the king is depicted in a highly symbolic manner as Horus, the falcon-god, hacking away with a mattock at the bastion of a walled city that is seen from above in plan view. This motif is repeated six more times on the palette, each time with the figure of the falcon replaced by a different heraldic emblem. These emblems may be different personifications of the king or of his tribal allies. As each of the walled fortifications shown on the ceremonial slate palette encloses signs that are apparently the names of the towns, we may consider this scene to be the recorded summary of the actual con-

cene from Khaemhesy's tomb, *ca.* 2500 B.C., first-known depiction of the siege ladder.



Ram's crew, middle right, is protected by a shed, a Middle Kingdom tactical innovation.

quests of an unknown early dynastic ruler of Egypt.

At Sakkara, in the tomb of Khaemhesy, a royal carpenter and overseer of building in the palace who lived during the Fifth Dynasty (*ca.* 2560—2425 B.C.), a painting vividly portrays the assault of a walled fortification. At the top of the scene, an Egyptian soldier uses a mattock to attack a wall in a manner similar to that of the mattock wielders depicted on the Archaic palette of some five hundred years earlier. When I remember the ease with which workmen, using only this simple agricultural implement, tore down the walls of a mudbrick structure during the 1962 Pennsylvania-Yale excavation at Arminna in Egyptian Nubia, I can easily understand how effective the mattock must have been as a primitive siege weapon. The mudbrick with which the ancients built their fortifications would have presented no obstacle to a number of determined and energetic men so armed. However, to assault a wall in this manner would have left the attackers highly vulnerable to the defenders' fire, and undoubtedly would have resulted in heavy casualties. During the Metropolita
Museum of Art's excavations at Thebes in the fir
quarter of this century, a number of mummified bodie
of soldiers of one of the Eleventh Dynasty king
Nebhepetre-Mentuhotep (*ca.* 2060—2010 B.C), wer
discovered. These all bore arrow wounds, the angles
which showed that the arrows had entered from abov
this suggests that the arrows had been fired from a wa
at men attacking on the ground below. Obviously, le
costly assault tactics had to be developed.

THERE are three ways to penetrate hostile walls: b
going through them (breaching); by going ove
them (scaling); by going under them (tunneling,
sapping). The Khaemhesy painting shows the secor
of these tactics in use: a scaling ladder with whee
affixed to its lower end to facilitate movement has bee
placed against the wall; a file of soldiers armed wit
copper or bronze battle-axes are shown swarming u
brandishing weapons against the defenders as they reac
the top of the wall. At the base of the ladder are tw
more soldiers armed with long picks. They may b
digging at the base of the wall, but some scholars inte
pret the picks as supports that are held before and behin
the base of the ladder to prevent it from shifting whi
it is being climbed.

The siege ladder also figures prominently in a secon
painting from the Old Kingdom, made about a centur
later for the tomb of Iny at Deshasheh. Here the ladde
is shown without wheels, and a soldier holds it at i
base as if to steady it for his fellows who have alread
ascended or as if he himself is about to climb up. A
another part of the wall an officer, leaning on a staff an
with a battle-ax tucked in his girdle, supervises tw
soldiers who seem to be using two pointed crowbars t
weaken a wall, or perhaps a gateway. It is also possib
that this scene illustrates a form of sapping, the thir
method of penetrating a wall. Since so much of the scer
is unpreserved, it is impossible to determine if, as i
the Khaemhesy painting, a soldier was depicted else
where in the composition using a mattock to hack dow
the wall. It is likely that this was the case, as the tact
is alluded to in a passage of the tomb-biography of
contemporary noble, Uni, who was buried at Abydos

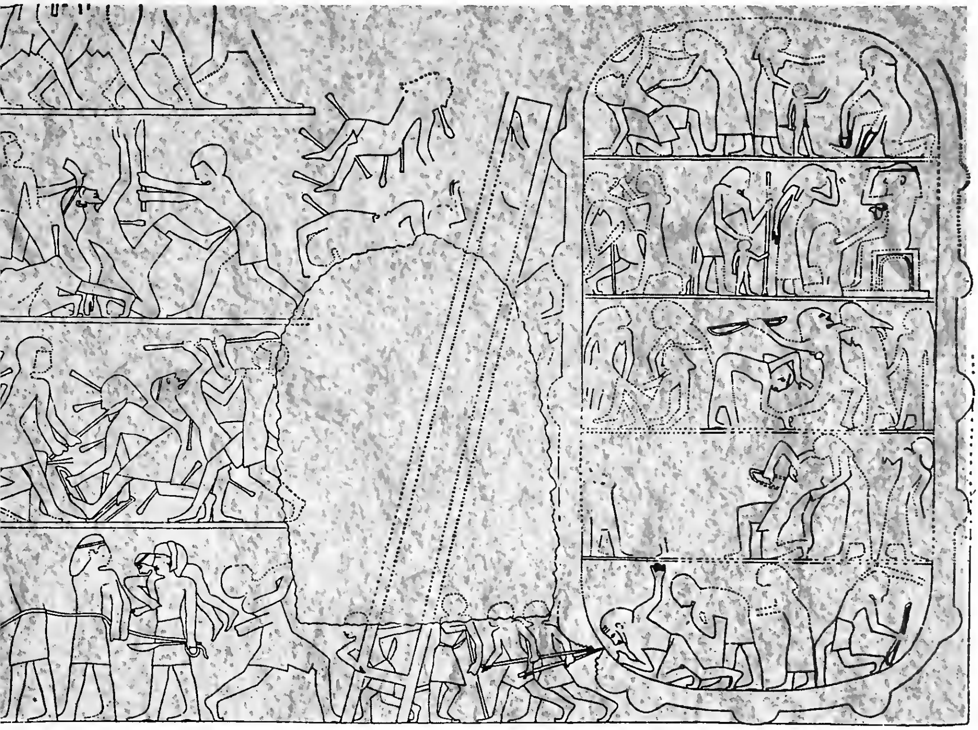
"This army returned in safety, after it had hacked up the land of the Sand-Dwellers . . . after it had destroyed the land of the Sand-Dwellers . . . after it had demolished its fortresses . . . after it had chopped down its orchards and vineyards."

If we are to credit certain texts literally, siege assault tics were described in literature from the onset of the w Kingdom (after 1585 B.C.). I will move on to this terial after discussing some pictorial evidence from Middle Kingdom.

The tombs of some of the nobles of the Middle King- n (*ca.* 2130—1785 B.C.) at Beni Hasan in Upper ypt provided the only records of siege warfare that preserved from the Middle Kingdom. These are five resentations of assaults on fortresses, but all are ies of a single, conventional scene; they differ only the most trivial details, so that a description of one uld suffice. In this example, for the first time the tress under attack is shown in a side view. It domi- es the center of the composition. At one corner of the tress is a gate, on each side of which is a clearly ineated, sloping glacis. A series of crenelated bastions turrets line the summit of the wall. These are occupied the defending archers. The attackers are shown in registers on each side of the stronghold. Those sest to the wall are archers who keep up a barrage of ow fire against the defenders. Behind the archers nd other soldiers armed with shields, axes, and thrusting-spears, as well as reserve supplies of arrows. Near the gate several soldiers, sheltered by a mantelet (a covered shed), manipulate a long pole—obviously a battering-ram—against the gate (NATURAL HISTORY, August-September, 1963). It is also possible that they were working it against the weakest portion of the wall, where the wall forms an angle with the glacis. Standing or kneeling archers are always shown before or behind the ram, where they undoubtedly were stationed to give the ram and its crew covering fire. Neither scaling ladders nor individual sappers appear at the base of the wall, perhaps because the artist who composed the scene wished to emphasize the new weapon, the mantelet-covered battering-ram.

NOT until the beginning of the New Kingdom do we begin, finally, to find verbal descriptions of siege warfare. The first references to formal investments of cities are noted in the tomb-biography of an Egyptian soldier who participated in the campaigns. He was a native of El-Kab, in Upper Egypt, named Ahmose, the son of Ebana, and he served in the army of King Neb-pehty-Re Ahmose I, the founder of the Eighteenth Dynasty (*ca.* 1585—1308 B.C.). It was Ahmose I who continued the war of liberation against Egypt's Asiatic overlords, the Hyksos, and brought the struggle to a

In painting in tomb of Iny, soldiers, under ladder, sap a wall by using crowbars.



victorious conclusion when he took the enemy capital of Avaris in the delta, then reduced Sharuhen, the principal Hyksos stronghold and advance base in northern Sinai. Of the siege and fall of Avaris, the tomb-biography of Ahmose, the son of Ebana, records:

> "I followed the sovereign on my feet when he advanced on his chariot. When the city of Avaris was besieged, then I was valorous on foot in the presence of his majesty and was transferred to the ship 'Manifest in Memphis.' Then there was fighting in the Padjeku-canal of Avaris. . . . Then fighting was renewed in this place. . . . Then there was fighting in the Egypt south of this city . . . . Then this city was taken."

Ahmose's account of the siege and capture of Sharuhen is even more matter of fact:

> "Then Sharuhen was besieged for three years. Then his majesty took it."

THERE are no further detailed records of sieges until the middle of the Eighteenth Dynasty, during the reign of the great warrior-king, Menkheperre-Thutmose III, who made no fewer than seventeen expeditions into west Asia after he took the throne of Egypt. It was during his first invasion of Palestine (*ca.* 1470 B.C.) that he smashed a powerful Syro-Palestinian coalition in open battle on the Plain of Esdralon. The survivors fled into nearby Megiddo, the biblical Armageddon, and took refuge there, but the immediate capture of the city was prevented by the eagerness of the Egyptian army to plunder the deserted enemy camp that lay between it and Megiddo. This lost opportunity infuriated the king, who was well aware that:

> ". . . every chief of every northern country which had revolted was within it, so that the capture of Megiddo was the capture of a thousand cities . . . ."

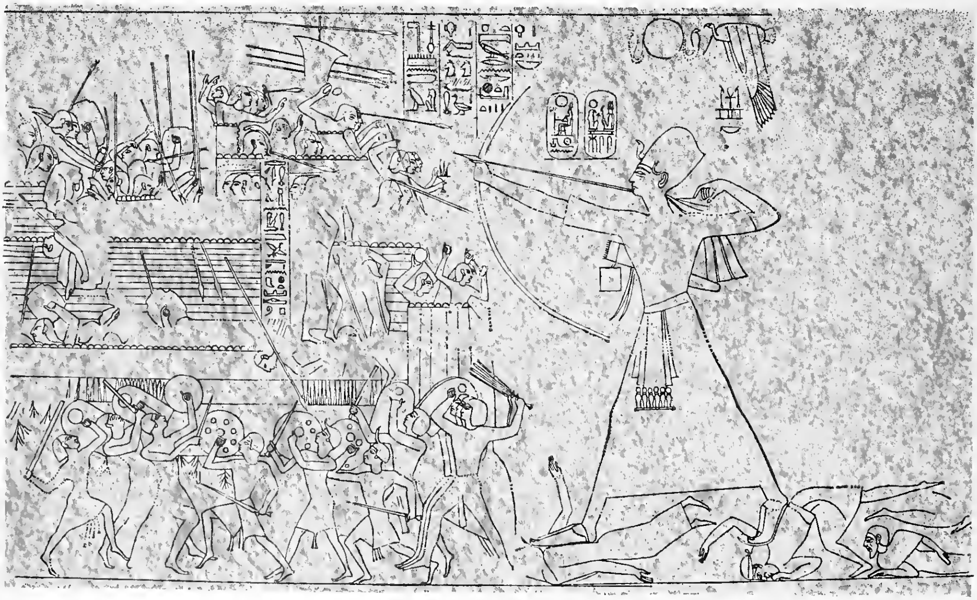
Restoring the discipline of his army, the king lai siege to the city. The importance of this operation i emphasized by the fact that six separate accounts of it all of them highly fragmentary today, are preserved. Th fullest is that given in the annals of the king that ar carved on a wall in the great temple of Amun—th paramount god of Egypt in the New Kingdom—a Karnak in Thebes. It is, unhappily, rather badly mutilated, but enough remains to give a very lucid picture o the earliest fully documented siege attested in a Egyptian record. The beginning of the text is now lost but it certainly must have contained a description of th king's instructions to his army on how to begin the siege Picking up with the siege in progress, the preserved narrative reads:

> "[The officers of] the infantry [were instructed] to command [their soldiers, and to assign] every [man] his place. They invested [this] city, surrounding it with a ditch and enclosing it with the fresh timbers of all their pleasant trees, while his majesty himself was upon a fortification east of this city, watching [over it by night as well as by day]."

A long lacuna in the text follows, ending with a reference to either the city or a siegework:

> ". . . it was enclosed with a thick wall . . . with its thick wall, and it was named 'Menkheperre, the Surrounder of Asiatics.' People were stationed to

In Luxor temple relief, Ramesses II is idealized as vanquisher of the city of Dapur.



watch over [this] enclosure of his majesty, and were instructed 'Be steady of heart! Be [very] watchful!' Then his majesty. . . . [Here a lengthy portion of the text is lost and what follows is too fragmentary for translation here.]"

The length and inevitable outcome of the siege are ted on a stela that Thutmose erected at the temple of mun at Gebel Barkal in the Sudan:

> "My majesty imprisoned them [the enemy princes] for a period of seven months before they came out into the open, pleading to my majesty and saying 'Grant us thy breath, O our lord! [i.e., show mercy to us].' "

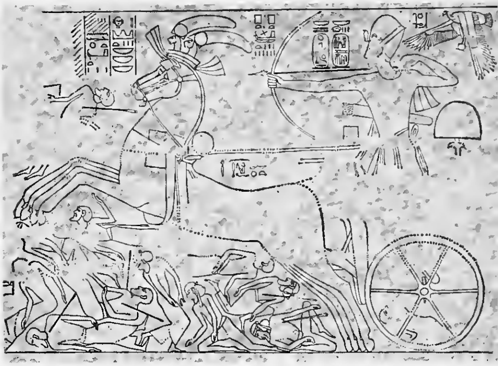
The siege operations that Thutmose carried on gainst another enemy city, Kadesh, are briefly noted the annals at Karnak and again in the Theban tombography of one of the veterans of the campaigns, a rtain Amenemheb.

KADESH was attacked twice, the Karnak annals reveal, in the course of seventeen invasions that the ng made into Palestine-Syria. During the sixth Palesian expedition Thutmose is said, in the annals, to have rrived at Kadesh, attacked it, chopped down its groves, d ripped up its grain." During the seventeenth and final mpaign he is said to have "arrived at the region of adesh and taken three cities there." Amenemheb's ography also contains two terse references to this:

> "Again I saw his [the king's] bravery while I was in his entourage: when he took [the city of] Kadesh, I was not absent from the place where he was. . . . Then his majesty sent every valiant man of his army forth to breach the new wall which had been made for Kadesh. I am the one who breached it, being the foremost of every valiant man."

The policy of the Egyptians — chopping down the emy's orchards and ripping out their planted grain—entioned in connection with the fall of Kadesh, was common feature of their doctrine of siege warfare, nd is noted in a number of texts and pictures. The obious reason for such plunder is that it permitted the ttacking Egyptians to live off the land they were inading and to utilize the wood of the enemy's forests nd orchards for their own construction, including the aking of siege equipment. By this same destructive ction, the enemy was denied the use of these resources. is possible that the strategy was even more far-reachg. The Egyptians themselves may not have had any tention of permanently garrisoning the cities once they ere captured. Instead they may have hoped to make em untenable for reoccupation by the enemy when ventually the conquering forces withdrew.

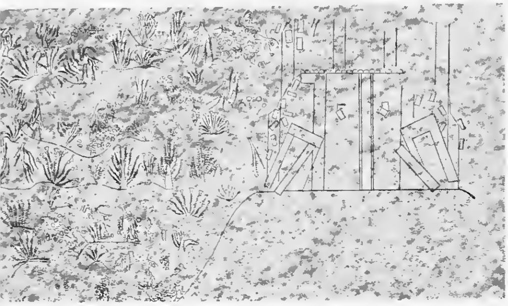
The only other possible allusion to a siege in the ighteenth Dynasty sources known to me forms the ackground of the literary narrative of the taking of ppa by Djehuty, a general of Thutmose III. The town ll to a proto-"Trojan Horse" stratagem, whereby an gyptian commando force was sent into the city, conealed in large wicker hampers, which ostensibly conined gifts for the Joppan prince. Since no details of e actual siege are otherwise given, the taking of the city of Joppa will be excluded from further discussion.



Conventional view of king, awesome, the sole author of victory, is from temple of Luxor.

There are no real written accounts of sieges per se stemming from the Ramesside period (*ca.* 1308—1090 B.C.), but the conquest of hostile cities frequently forms the motif of the magnificent battle reliefs that are preserved on the walls of the Ramesside temples at Thebes and elsewhere. The conquest theme is usually treated in a highly stereotyped manner designed to magnify and emphasize the king's prowess as a conquering god; although his infantry and chariotry sometimes trail behind him to watch the attack, they offer no assistance. Indeed, none is necessary, for the king's mere presence is presumed sufficient to cause the gateways of the beleaguered fortresses to crumble and to terrify the craven enemy into surrender. There are occasional departures, however, from idealized representations, and these are highly instructive.

The fall of a "city which his majesty carried in the land of Hatti, Dapur," is pictured in a relief of Ramesses II (*ca.* 1290—1224 B.C.) in the temple of Luxor on the east bank of the Nile at Thebes. It shows the king on foot "fighting the city of the enemy of Hatti, in front of his infantry and his chariotry." The king is accompanied by Egyptian soldiers and foreign auxiliaries, but the impression conveyed is that it is he, and he alone, who is responsible for the Hittite city's fall. But a different version of this same incident appears in a relief found in the king's mortuary temple on the west bank of the river at Thebes—the Ramesseum. There, the same types of siege equipment that are shown in the Sakkara, Deshasheh, and Beni Hasan tomb paintings of the Old and Middle Kingdoms have been brought into action against Dapur. The Hittite city is a large, well-defended stronghold, enclosed by a complex of girdle-walls and situated high on a sloping glacis. At the base of this glacis, half-obscured by the figures of four princes, are four mantelets of a shape that differs slightly from those of the Eleventh Dynasty. Beneath the protection of the mantelets, battering-rams are being worked against the wall. A covering party of infantrymen shields this operation from a possible Hittite attack, while assault troops have mounted a wheelless scaling ladder and have climbed to the top of the wall. In the text accompanying this



Syrian city, pictured in Luxor temple, is reduced to desolation by Egyptian armies.

scene, Ramesses is described as "one who hurls down their possessions, who makes all of their places into desolate mounds."

At Karnak, still another relief of this king depicts the fall of "a wretched city which his majesty carried, for it was evil, Askalon." Here, too, the use of siege equipment is shown: at one side of the fortification a scaling ladder has been raised up to the wall and an assaulting foot soldier has mounted it; at the opposite side of the fort another soldier, armed with a battle-ax, chops at the left gate of the stronghold's two portals; at the base of the glacis an attacking force defiantly brandishes weapons against the embattled town.

To portray an attack against a gate by an ax-wielding soldier might have been the intent of the creator of the relief of Ramesses II in the Nubian temple of Beit el-Wali. The scene is dominated by the conventional view of the king, on foot, charging against the fortified city, but beside and slightly in front of him is the figure of a prince, waving an ax and charging toward the fort. The fall of the city of "Mutir which the mighty sword of his majesty took," pictured in reliefs of Ramesses II at the Luxor temple and at the Karnak temple, show that the city was taken after the gate had been breached. In the Luxor scene, the king charges the city from his chariot. The panic-stricken enemy flee before him, driving their flocks into the shelter of the town. No siege equipment at all is visible, and yet Egyptian soldiers have gained the walls, for one stands on the battlements, brandishing a bow and stabbing an enemy, while a second drags a struggling foe through a window. The Karnak scene shows that the gates of the town have been battered in.

EGYPTIAN soldiers are also pictured in a relief of Ramesses III (1192—1160 B.C.) from his mortuary temple at Medinet Habu, on the west bank of Thebes. Without the visible presence of any siege weapons, the soldiers have gained the wall of a Hittite town. One of the gateways of the fort has been smashed open, so that we may assume that the Egyptians effected their penetration into the city by breaching the gate. This is not the case with the last of the pictorial accounts of the fall of a city, also from a relief of Ramesses III at Medinet Habu. Here the Syrian town of Tunip has been assaulted by the Egyptians. Scaling ladders have been placed at each side of the gate and have been mounted by Egyptian assault troops. Other Egyptians have already gained the wall and are systematically clearing it of defenders. An Egyptian trumpeter stands on a battlement and gives a signal while another soldier stands behind him and holds a standard aloft. Meanwhile, a squad of soldiers is smashing the gate below with battle-axes. Outside of the fortress, to the right, more Egyptians destroy the surrounding countryside. One chops down a tree while another seems to be casting fire into a hayrick.

On the written side of the picture there is a passage in *Papyrus Anastasi I,* a literary text from the time of Ramesses II. This text is usually considered an outstanding example of literary satire by means of which its author, the scribe Hori, pokes fun at and rebuffs the pretensions to knowledge of a brash young colleague of his, a certain Amenemope. While this is so, the essential military nature of the text is usually overlooked. Time and again Hori refers both to himself and to Amenemope as soldiers, and the latter half of the papyrus, which is concerned with Amenemope's ignorance of Syria and Palestine, stresses his need for knowledge of matters that would be of the highest interest to a soldier: terrain and topography, locations of various Asiatic towns, the march distances between them and, significantly, the nature and condition of their fortifications, as well as the locations of river-crossings and mountain passes.

AMENEMOPE is frequently confronted with elaborate descriptions of the living conditions encountered when on active service in the field, and then chided for his inexperience of them. In an earlier portion of the text Amenemope is given a series of problems to solve. These deal with the provisioning of a military expedition to Syria, with the transport of an obelisk and the erection of a colossus, with the digging of a moat, or ditch, and with the building of a rather large ramp. That the army was involved in supplying the man power necessary for such projects is not only implied in the passages cited, but is also expressly stated in other documents of the period. A portion of particular interest in connection with siege warfare is that dealing with the difficulties incurred in the making of the ramp and the moat:

> "What has been given to you is a ditch to be dug, and you have come to me to ask about the giving of rations to the military people. . . . Now you are the clever scribe who is at the head of soldiers! [Well], a ramp is to be made, 730 cubits [long], with a width of 55 cubits, [containing] 120 compartments filled with reeds and beams. [It shall be] 60 cubits in height at its top, 30 cubits [at] its middle. Its batter [shall be] 15 cubits, and its base 5 cubits. The amount of bricks needed for it must be asked from the military officers, [but] all the scribes together lack the knowledge among themselves, and they each confide in you, saying 'You're a clever scribe, my friend! Decide for us quickly, and see, your name will emerge. Let someone be found here to magnify the other thirty [scribes]. Don't let it be said about you that there exists [even] some small matter about which you're ignorant! Tell us the required number of bricks!' See, its measurements are 30 cubits [by] 7 cubits wide."

If the inherent military substratum of *Papyrus Anastasi I* is kept in mind, then the probable purpose for a ramp of such large dimensions seems clear: Amenemope was not being tested merely on his ability to solve a difficult mathematical problem; he was confronted with the military engineering problem of constructing a siege ramp, a piece of equipment mentioned perhaps for the first time in connection with the siege of Megiddo by Thutmose III. To anticipate, such a ramp was certainly used when the Nubian conqueror Piankhy laid siege to Memphis some five hundred years after *Papyrus Anastasi I* was written. Similarly, the ditch to be dug in Amenemope's problem could very well have been meant to refer to a ditch like that with which Thutmose III encircled Megiddo.

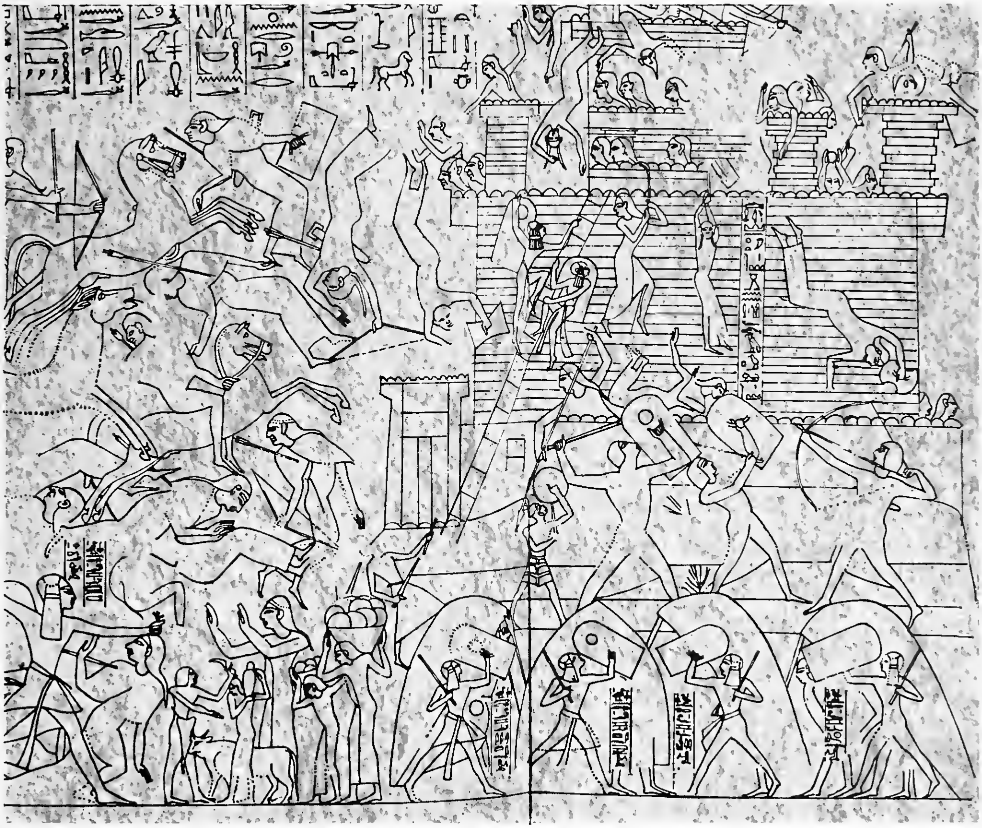
Direct references to siege warfare are not found in Egyptian documents covering the period from the end of the Empire until the foundation of the Twenty-third Dynasty (*ca.* 1085—720 B.C.), but this means only that the Egyptian records containing such references either have not survived or have not yet been found. That such operations undoubtedly took place is implied by the contemporary non-Egyptian documents—for example, the biblical account in I Kings 14: 25-26 of the Egyptian invasion and the plundering of Palestine in about 918 B.C.

More than compensating for this gap in our knowledge is the great stela of Piankhy, the energetic, puritanical, cavalier king of the Twenty-third Dynasty. Piankhy set up the stela in the temple of Amun of Napata at Gebel Barkal in the Sudan to commemorate his conquest of Egypt in 720 B.C. The stela is a veritable textbook of Egyptian military strategy and tactics in the post-Empire period, and its descriptions of sieges are the fullest that are preserved in any written Egyptian sources. Of the several sieges described, the first may be considered as the immediate *causus belli:* Tefnakht, prince of Sais, had invaded the Upper Egypt in an attempt to enlarge his dominion. Meeting stubborn resistance at Herakleopolis, he laid siege to it. The graphic description of what happened was related to Piankhy at his capital in Napata:

> "Behold, [he] is [now] assaulting Herakleopolis. He has completely ringed it around, allowing neither reinforcements [literally: enterers] to enter nor refugees [literally: departers] to depart, but [rather] fights daily. He has invested it in its entire circumference. Every leader knows [his own sector of the] rampart, that he may cause every man among the leaders and tribal sheikhs to lay siege from his own sector."

Piankhy was quick to act, and dispatched a relief army at once. At its approach Tefnakht abandoned the siege

Unlike earlier Ramesside art, this relief shows assault techniques of army with weapons.



and retreated northward. The pursuit by Piankhy's troops was delayed by the necessity of reducing the cities of Tefnakht's allies that barred the way, the most important of which was Hermopolis, which proved a tough nut.

The siege did not proceed to Piankhy's satisfaction and he personally came to Egypt to take matters in hand:

> "Then his majesty wrote to the leaders and the military commanders who were in Egypt. . . . 'Hasten into battle array and join battle. Surround Hermopolis. Capture its people, its herds, its ships which are on the river. Don't let the field hands go into the field and don't let the plowmen plow. Assault the frontier of Hermopolis and fight against it daily!' Then they did the like. . . . They surrounded Hermopolis on its four sides, without letting reinforcements enter and without letting refugees depart. . . . [Piankhy takes personal charge.] He set a command post up for himself at the southwest of Hermopolis, assaulting it daily. A protective wall was made to cover the wall and a 'wooden-servant' [some kind of siege engine] was raised up high against it. Archers shot arrows and catapults hurled stones, slaughtering people among them [the besieged] every day. Days passed and Hermopolis gave forth a foul stench to the nose. . . . Then Hermopolis prostrated itself."

Just before Piankhy's arrival at Hermopolis, part of his army attacked and reduced a neighboring stronghold, Tatehen:

> "Then they fought against the fortified region of Tatehen [named] 'Great of Strength.' They found it filled with soldiers and with all the valiant men of the Deltaland. Then a battering-ram was made and used against it. Its walls were demolished, and a great slaughter was made among them."

WITH the surrounding countryside reduced and with Hermopolis fallen, Piankhy was free to advance against the Nile Delta. Town after town on his route opened its gates at the approach of his army, and finally the ultimate object, Memphis, the capital of the delta, was reached:

> "Very early the next morning his majesty arrived at the White Wall. He anchored to the north of it. He discovered that the water [of the river] had risen up to the wall tops and that ships [could be] moored at [the top of the wall] of Memphis. Then his majesty saw that it was [otherwise] a stronghold, the rampart having been heightened with a new wall, and the bastions equipped with [such] strength that no toe hold for fighting against it might be found. Thereupon every man among the soldiers of his majesty spoke his mind with respect to every doctrine of fighting. Some men said 'Come, let us assault [it, attacking it every day]. See, its garrison is numerous.' Others said 'Let a ramp be made against it. Let us raise the earth against its ramparts. Let us tie a "wooden-servant" together. Let us erect towers. Let us make hangings on the sides against it. Let us divide it in this [way] on all of its sides with a counterwall and a . . . at its north [end], [that] we may find a path for our feet.' Then he caused his soldiers to cross [the river] and to fight at the harbor of Memphis. They carried away for him every ferry, every yacht, every barge, and every transport which had been anchored at the harbor of Memphis, their prow ropes being tied at its buildings. . . . Then his majesty personally crossed over to draw up all the ships. His majesty commanded his soldiers 'Advance against it. Mount the wall tops. Enter the houses overlooking the river. If one of you gains the rampart, let no one stand in its vicinity. Don't let [hostile] gangs oppose you. . . .' Then Memphis was taken."

With this text, then, the purely Egyptian documenta tion comes to an end. Mention of siege tactics carrie on by and against the Egyptians occurs occasionally i Assyrian, biblical, and Greek sources, but these fall ou side the realm of this paper. Egyptian tactical doctrin for the reduction of enemy strongholds, and its gradu development may be summed up as follows:

The earliest form of attack was a direct assault b soldiers armed with a very primitive weapon, the ma tock, with which they literally hacked down the opposin walls. As this tactic undoubtedly proved to be wastef of life, other modes of attacking enemy walls were sough By the end of the Old Kingdom, assaults on towns i cluded the chopping method plus the use of scaling la ders and sapping at the foundations of walls and gate.

The Middle Kingdom saw the introduction of batte ing-rams, which were protected by mantelets to give cov to their crews. Although they are not pictured in a preserved scenes from the Middle Kingdom, we ma assume that the earlier weapons, equipment, and tacti continued in use.

In the New Kingdom, we see the first full-scale sie operations. The beleaguered city was cut off by a counte wall and ditch. It was continually harassed by attacks which all the previously mentioned techniques and in plements were used; at the same time, the city was b sieged until it fell to an assault or finally was starved in submission. The training of full-fledged military eng neers probably took place at this time, and may ha begun earlier. Certainly the ramp mentioned in *Papyr Anastasi I* points to this, as well as to the fact that t siegeworks and equipment had already become elaborat

By the Twenty-third Dynasty, this prior agglomer tion of different tactics developed into a highly technic doctrine. The city was invested. Various types of sie weapons—including battering-rams, siege ramps, sie towers, catapults, and wooden servants, whose exa nature is still unknown—all were employed against The effectiveness of this ultimate combination of Egy tian siege weapons is best illustrated by a relief of Ra essess II in the temple of Luxor. An unnamed Syri city is shown after the Egyptian army has passed. T gateways are battered in, the walls broken. Bricks f crumbling to the ground. In the nearby countryside, t trees and bushes are hacked and chopped. It is a sce of desolation calling to mind the Latin proverb: "Th make a solitude and call it peace."

Karnak temple relief details the demi of Askalon—"a wretched city . . . it was evi

Arctic grizzlies, this one a
ll-grown adult, range across
the continent's far north
rom Hudson Bay into Alaska.

Grizzlies are squirrel-sized at birth, and are born in winter. Cubs, below, are in the early months of life.

Grizzly Territory

xact range of Arctic bears is obscured by old rumors

y A.W.F. Banfield

THE ARCTIC, or barren-ground, grizzly bear is one of the largest and ost powerful predators on the North nerican continent. Yet, formidable these animals are, their exact distri- ition across North America is still ly incompletely known. As this paper ll show, hearsay accounts of grizzlies ve misled scientists more often than t, perhaps most in the case of the mored presence of the bears in the ngava peninsula of northern Quebec d Labrador, which I will discuss later the light of present-day surveys.

In recent years, most American mammalogists have accepted the proposal that the North American grizzlies are New World representatives of the Old World brown bears, *Ursus arctos.* The earliest scientific name applied to the barren-ground, or Arctic, grizzlies was Swainson's *richardsoni* in 1838. This may be considered the appropriate scientific name of the Arctic grizzly population if it is a distinct subspecies, as scientists believe is likely.

In their natural environments, grizzlies breed every other year in June or July. As is the case with many carnivores, delayed implantation of the fertilized ovum is involved, and the embryos do not commence their development until autumn. The cubs, which are usually twins but may number from one to four, are born between January and March while their mother is in winter dormancy. They are squirrel-sized at birth—only nine to ten inches long. In spite of their small birth size, the cubs may grow to weigh one thousand pounds at maturity. Except during the brief breeding period, the bears are solitary. They spend the severest months—November to March—sleeping in caves or other shelters.

WHEN Europeans arrived in the New World, the grizzly's domain had spread from the snowy, Arctic mountains of Alaska to the arid plateau of Mexico, and from the salmon-filled rivers of the Pacific coast across the Great Plains to the fringe of the eastern hardwood forests. The Boreal forest that spreads its broad evergreen band across the continent from Maine to Alaska probably was not penetrated by grizzlies in significant numbers. Only in mountainous, northwestern America have these bears occupied the coniferous forest. They seem to prefer to make their homes in open country—plains, alpine tundra, or the Arctic tundra—beyond treeline on the roof of the continent. Occasionally, grizzlies stray short distances into the taiga, the swampy "land of little sticks" that lies on the southern border of the tundra.

In the early days, most observations were made along canoe routes, at portages, and on spring sled journeys. Today, the use of aircraft in the north may be responsible for greatly increased numbers of observations of bears on the tundra. Recent geological, geographical, and wildlife surveys have also produced many sightings. Comparison of these contemporary reports with early explorers' accounts gives me the impression that the bears have been increasing, and that their distribution has been expanding. But is this the result of changes affecting the observed or merely the observers?

TO help answer this question, I made a search of the literature concerning early exploration of the Canadian north, where grizzlies might be expected to occur. Most of the reports, I found, were straightforward, often substantiated by the taking of a specimen bear. But there are more than a few doubtful secondhand accounts. Except for two of these questionable reports, which will be mentioned later, all grizzly records before 1899 were limited to the western continental tundra, from Aklavik to Bathurst Inlet, and inland to the source of Coppermine River.

Samuel Hearne, an English fur trader with Hudson's Bay Company and, in 1771, the first European to reach the Arctic Ocean by overland route, observed the Arctic grizzlies more than 25 years before Lewis and Clarke met the bears on the upper Missouri River. On July 8, 1771, Hearne found a grizzly den in a mound of earth, possibly a frost-heaved "pingo," a small hill of mud pushed up by continual frost action. This site was about 125 miles southeast of the Coppermine River, an area in the present-day Northwest Territories. He also noted troughs dug by the bears in search of Arctic ground squirrels *(Citellus undulatus)*, and named the prominence "Grizzled Bear Hill."

The two questionable secondhand reports mentioned are those of a Captain Lyon, in 1824, and of the popular

Mature Arctic grizzly may weigh as much as 1,000 pounds.

Grizzly roams open country—the alpine or Arctic tundra.

Male is solitary except in the summer breeding period.

author Frederick Schwatka, in 1885. Captain Lyon wintered at Igloolik at the northwest corner of Fox Basin in 1821-22, and interviewed an Eskimo from Wager Bay, which is on the west coast of Hudson Bay. The Eskimo told him that both black and white bears were numerous in his region. His "black bears" were probably grizzlies, but it is also likely the Eskimo was reporting in very general terms. Eskimos are great travelers, and many have visted distant parts of the Arctic coast. His reference might have been based on observations made far to the west. Since the Eskimos rely upon game reources for their sustenance, they are amiliar with the Arctic and subarctic auna well beyond their immediate hunting grounds. For instance, Eskimo hunters of the Ungava, east of Hudson Bay, are familiar with the musk ox, "omingmuk," even though its range does not extend far enough eastward to occur in their country. They can quite as easily describe "aklak," the barren-ground grizzly, to a European inquirer.

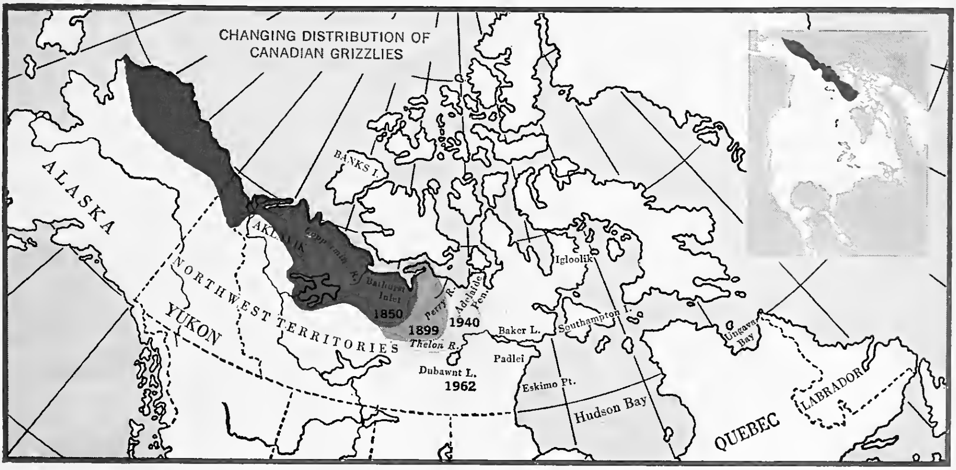
FREDERICK SCHWATKA, who gave the second of the two nineteenth-century reports on Arctic grizzlies, travled overland with W.H. Gilder from Marble Island, Hudson Bay, to Chanrey Inlet on the Arctic Ocean in 1879-80, looking for relics of the ill-fated Franklin expedition. (Sir John Frankin's Second Expedition to find the Northwest Passage, 1845, was lost without survivors. The great search hat followed delineated most of the orth coast of the continent.)

From Gilder's report we know that they made no direct observations, but Schwatka's popular account, *Nimrod of the North*, contains two secondhand references to grizzly bears. The Eskimos of Adelaide Peninsula reported that on rare occasions they met grizzly-like animals during summer caribou hunts; the Chesterfield Inlet Eskimos reportedly had killed a few bears. We know that the summer caribou hunts for skins often took the Eskimos far inland, so these reports might well have been based on localities miles away from the camps mentioned. Schwatka supposed that all American grizzlies wandered north to the Arctic Ocean during the summer, then retreated southward to treeline in the autumn. With such a broad but erroneous impression, it is doubtful that he would be critical of distribution reports.

On the other hand, we have the accounts of many competent nineteenth-century observers such as Sir George Back, George Simpson, James Anderson, Warburton Pike, J.B. Tyrrell, Caspar Whitney, and "Buffalo" Jones, all of whom traversed the eastern barren lands during the same period as Schwatka without finding grizzlies.

During the first forty years of the twentieth century, grizzly bears increased markedly in the upper Thelon River Valley, and to a lesser extent along the Arctic coast, including the Perry River region. Although a few naturalists visited Keewatin District during this period, they failed to meet any bears. At the same time, a dubious reference to grizzly bears in Keewatin District came from the Danish explorer Peter Freuchen, on the Fifth Thule Expedition of 1921-24. He reported black bears ("akdla," in Eskimo) occurred south of Baker Lake and Eskimo Point, but without substantiation by observation or specimen. Here again we note the possibility of confusion of black with grizzly bears. The known occurrences of black bears *(Ursus americanus)* near timberline at Padlei and Nueltin Lake makes it even more difficult to appraise this reference. Our confidence in the report is hardly encouraged when Freuchen continues to say that the bears suck their forepaws during "hibernation" until they are pink and tender!

WHEN a Royal Canadian Mounted Police patrol from Baker Lake observed a grizzly on the lower Thelon River, east of Schultz Lake on July 23, 1940, the patrol was witnessing the start of a grizzly dispersal to the southeastward that has continued to the present day. An eastward wanderer was killed near Padlei in April or May, 1943; Dr. G.M. Wright, a geologist of the Geological Survey of Canada, saw two grizzlies near Wholdaia Lake on July 29, 1956; A.G. Loughrey, a biologist of the Canadian Wildlife Service, saw one at MacQuoyd Lake, southeast of Baker Lake, on May 7, 1958, and obtained a skull of a specimen taken at Nicholson Lake (on the Dubawnt River) the same season. According to Eskimos who had lived at Garry Lake on the Back River, grizzly bears were encountered there with increasing frequency in the late 1940's and 1950's. (Many of these later records were gathered by Harington, Macpherson,



and Kelsall, field officers of the Canadian Wildlife Service, for their article in the December, 1962 issue of *Arctic.*)

There are even indications that grizzlies have invaded the offshore Arctic islands. A bear was shot on Banks Island during the winter of 1951-52; two others were observed on the ice off Southampton Island by Eskimos, one in the autumn of 1948, the other in 1950. These were reported by an Eskimo in an interview with Richard Harington in 1962. George Sutton spent a year, 1929-30, on that island without hearing of grizzlies.

From this summary of observations it is evident that grizzlies were relatively rare in the experience of men on the Arctic tundra during the eighteenth and nineteenth centuries; most frequent occurrences were on the western shores of the Arctic Ocean as far eastward as Bathurst Inlet and the upper Coppermine River. Unsubstantiated reports from northern Keewatin District might indicate a few stragglers in that region. But at the beginning of the present century, the bears moved into the upper Thelon River Valley, and by 1940 reached the Baker Lake area. Within the past two decades, the grizzly population has grown and dispersal has progressed as far as the Dubawnt and Kazan valleys. At the same time, the bears have spread down the Back River into the barren lands of the northern Keewatin District.

LET us inquire further into the significance of this dispersal. Where did the grizzly bears come from originally? As stated previously, American grizzlies are considered to be representatives of the Eurasian brown bear and separable only on the subspecific level. The American fossil record is not extensive, but a few specimens from western Ohio, Oklahoma, California, Alaska, and northern Mexico have been considered to represent ancestral grizzlies. The oldest specimen dates from the last interglacial (Sangamon) period and suggests that grizzlies are relatively recent immigrants to this continent, much like the elk and moose. It is certain that the bears reached America across the Bering land bridge, perhaps during the penultimate glaciation (Illinoian).

It is noteworthy that their present distribution has a western concentration. The fossil record suggests that this has always been the case; good Wisconsin glacial faunal assemblages in Pennsylvania, Virginia, New York, Florida, Michigan, and Ontario have lacked representatives of the grizzly. The exception, the Ohio specimen, came from a prairie peninsula of the Great Plains now characterized by many western species, such as the prairie vole *(Microtus ochrogaster)* and the thirteen-lined ground squirrel *(Citellus tridecemlineatus)*. At this location, the grizzly specimen is about four hundred miles east of the bear's known historical range.

At the time of the last (Wisconsin) glaciation, grizzly bears were driven out of much of their northern range by the advancing continental ice sheet. They survived south of the ice front, and in the unglaciated refuge in Alaska and Yukon territory. Between 12,000 and 7,000 years ago, the Laurentian Ice Sheet, which covered the grizzlies' present range, melted back rapidly northeastward toward its crest west of Hudson Bay, and the tundra vegetation and animal life followed. It appears that the bears' route has similarly been eastward, for their distribution is discontinuous southward through the Boreal forest. The closest population in that direction is that of the recently discovered grizzlies in the Swan Hills, south of Lesser Slave Lake in northwestern Alberta. However, those bears are more closely related geographically and morphologically to the Rockies and Great Plains grizzlies.

The period between the middle of the fourteenth and nineteenth centuries is sometimes referred to as the "Little Ice Age" because of lower temperatures and lengthening glaciers in the Northern Hemisphere during that time. The earliest explorers' accounts of grizzlies were given during this period; the recent population growth and dispersal of the bears may well be associated with the amelioration of Arctic climate that started only at the beginning of the present century.

An interesting correlation exists between the distribution of ground squirrels (*Citellus* sp.) and grizzly bears in North America. Although these large carnivores are primarily vegetarians, animals do form important seasonal food supplies for them. Ground squirrels are prey for the Arctic grizzlies in early spring, before the vegetation turns green, and again in the autumn after the vegetation has been frosted. In the fall, the bears dig out the hibernating ground squirrels before the ground freezes. Naturalists have not been unanimous in their appraisal of the importance of ground squirrels in the grizzly diet, however. Adolph Murie, writing about central Alaska in *The Wolves of Mount McKinley,* estimated that the squirrel species made up only 5 per cent of the summer diet, while James W. Bee and E.R. Hall, who studied the present race on the Arctic coast, reported, in *Mammals of Northern Alaska on the Arctic Slope,* that grizzlies are more commonly observed where ground squirrels live than anywhere else. Other studies in the Rocky Mountains and Mackenzie Delta have underlined the importance of ground squirrels in grizzly diet. The Arctic ground squirrel has the same general distribution as the barren-ground grizzly in northern Canada, and even invades the stunted timberline forest. Only the rediscovered grizzlies of the Swan Hills appear to occupy a range devoid of ground squirrels.

FOR many years, rumors have persisted of the existence of grizzly bears in the Ungava peninsula of northern Quebec and Labrador. Charles Elton, British ecologist at Oxford University, reviewed the accounts of traders, travelers, and missionaries in the region, and accepted several of their stories as evidence of the former occurrence of grizzlies there, particularly in the Torngat Mountains. Later writers have also accepted several of these references. In the absence of specimens, recognition of the Ungava grizzly rests solely upon the descriptions by several traders and missionaries of rare gray, grizzled, or brown bear hides brought in by natives. Trader John McLean, post manager for Hudson's Bay Company at Fort Chimo, in the province of Quebec, from 1837-42, offered what is probably the strongest evidence for the existence of the Ungava grizzly. He had previously served in British Columbia, in about the years 1834-37, and thus should have been familiar with the species there. John McLean published, in 1849, *Notes of a Twenty-five Years' Service in the Hudson's Bay Territory.* In Volume II, he wrote that black, brown, grizzly, and polar bears occur in the district. He went on: "When we consider the great extent of country that intervenes between Ungava and the plains of the 'far west,' it seems quite inexplicable that the grisly bear should be found in so insulated a situation, and none in the intermediate

ountry; the fact of their being here,
owever, does not admit of a doubt,
r I have traded and sent to England
veral of their skins." However, sev-
ral of his statements undermine the
ientist's confidence in his identifica-
on. For instance, McLean states: "The
formation I have received from the
tives induces me to think that the
rieties of colour in bears mark them
distinct species, and not the produce
the same litter, as some writers af-
m." Because of the great variety in
lage color of grizzly and black bears,
e identification of bear hides is not
ways an easy matter. Moreover. there
e seasonal and individual variations
claw length to consider. The trench-
t differences between the grizzly and
ack bear species are in dentition and
dy proportions. yet McLean took no
ulls to confirm identifications.

The tenuousness of hearsay accounts
attested by Outram Bangs, one of
e early authorities on the Labrador
ammals, who wrote in 1910: "In my former list I included *Ursus richardsoni* Swainson, the barren-ground bear, on the strength of reports that Low had of it from the Nascoupee Indians. I am now inclined to discredit these, so far as Labrador is concerned. Indians everywhere have many traditions that persist in a remarkable manner, and often they are borrowed from tribes that live at a distance. I can find no evidence that the barren-ground bear occurs in the barrens of Labrador, and until it is actually known to be there it must be struck from a list of the mammals of Labrador." A later investigator. W.D. Strong. came to the same conclusion in 1930, after spending a year with the Naskapi Indians in the interior of Labrador.

Oshin Agathon and Donald Carter of The American Museum of Natural History conducted an unsuccessful search for the Ungava grizzly during the summer of 1953. I searched for the animal during extensive aerial caribou surveys in 1954 and 1956, and made local inquiries. but to no avail. Considering the history and present distribution of the Arctic grizzlies west of Hudson Bay, I would doubt that there ever was an Ungava grizzly. There is no known eastern ancestor: therefore an Ungava population of this species would be incompatible with the current distribution in North America.

While the grizzly bear of the Rocky Mountain region seems to be in full retreat in the face of human encroachment of its wilderness habitat. the Arctic grizzlies are apparently expanding their territory eastward across the tundra, prospering because of the more natural conditions.

EDITOR'S NOTE: As this issue went to press, the Canadian Northwest Territories Council, over the opposition of the Canadian Wildlife Service, moved to cancel its former protection of the barren-ground grizzlies, and to institute a year-round open season on the bears, of which some five hundred are believed to inhabit affected regions.

These young are from one litter, although the average litter size is two.

Insect-

ANIMAL-TRAPPING PLANTS have aroused interest and stimulated speculation among laymen and biologists for many years. The mass of literature on the subject that has appeared in scientific publications during the past one hundred years is most impressive. Most of these writings have dealt with the intricate morphology of the traps, and with their "carnivorous" significance. This carnivorous aspect was most fascinating when attributed to chlorophyll-bearing, flowering plants. Fungi have long been known to parasitize animals, even to the extent of consuming the whole body of the host. There are colorless, flowering plants that parasitize the roots of other plants. Yet to

VENUS' FLY TRAPS bloom, *left*. Their insectivorous leaves appear at bottom.

trapping Plants

By Virgil N. Argo

nd green, flowering plants catching, lling, and eating animals was a bo- nical heresy demanding inquiry.

Of the plants that so behave, one has tracted particular attention — *Dio- ea muscipula*, the Venus' fly trap, digenous to the Carolina coastal ain. Yet the microscopic vesicles of e many widespread species of *Utri- laria*, the bladderwort, are just as amatic and astonishing in their ac- on when viewed under the micro- ope. Moreover, the passive traps of e hollow-leaved *Sarracenia*, the tcher plants, the sticky leaves of *Dro- ra*, the sundew, and *Pinguicula*, the tterwort, have long been competi- rs for equal attention. A study of e literature and a field acquaintance with these remarkable plants give rise to speculation as to whether some authors did not let enthusiasm narrow the scope of their studies or influence their interpretations.

In many respects, the remarkable Venus' fly trap is a baffling plant. *Dionaea muscipula* does catch insects and in a most dramatic fashion. The leaves snap shut with startling speed and vigor. But exact knowledge of what happens to the trapped victim is not easily demonstrated. A fluid is secreted about the bodies of the insect prey, but one doubts that all the nutritious material of the insect bodies is digested and absorbed, since ants regularly gnaw holes in the leaf traps and feed on the dry carcasses, which must retain something that offers more nutrition than chitin.

The genus *Drosera* has many species scattered over the world. Three species occurring along the Atlantic coast wherever acid, boggy spots exist are *D. rotundifolia*, *D. intermedia*, and *D. filiformis*. The first two have small paddle-shaped leaves, bearing numerous adhesive-tipped hairs on their upper surfaces. The third species, *D. filiformis*, has extremely slender, erect leaves, which are closely covered on all sides by these same insect-trapping hairs. A variety of *D. filiformis* occurs on the Gulf coast; these have leaves that may reach a length of sixteen inches, and flower stalks that unroll

Mouths of traps, *above*, have trigger hairs on the inside. If the hairs are touched, spiny leaves close and form tight purse, bottom center, around prey.

racemes of blossoms that are taller.

The leaves of all *Drosera* species develop from circinately coiled leaf primordia quite similar to the fiddleheads of ferns. When the plant enters its dormant season in the fall, a compact, bulblike mass of these minute, tightly coiled embryonic leaves will be found buried under the past season's dead leaves. In the spring, these embryonic masses grow and unwind rapidly and are followed immediately by the flower stalks. Leaves that develop later grow to be larger than these overwintering ones, especially in the case of *D. filiformis*. The leaves of *D. filiformis* sometimes catch enough insects to cause the rancid odor of their carcasses to be perceptible more than a yard away. Flies and other insects have been observed to be attracted to such prey-laden leaves after following the odor upwind. It is not easy to understand how *D. filiformis* is able to digest and absorb any nourishment from the insects it catches. Their bodies have but slight, if any, contact with the slender leaf body. Insects that have been seen to come to the odor of the decaying catch may have some role in the pollination of the species, which produces a succession of blossoms throughout the summer from its slowly unrolling racemes.

It is not the present purpose to refute what has been said about insectivorous plants in the past. But it would seem that there are some approaches that could be much more thoroughly explored, particularly in relation to pollination. This article will be principally concerned with a consideration of pitcher plants, specifically the five, easily recognized species of the genus *Sarracenia* of the low, flat lands along the Atlantic and Gulf coast region of the eastern United States: *S. purpurea*, *S. minor*, *S. flava*, *S. drummondii*, and *S. psittacina*.

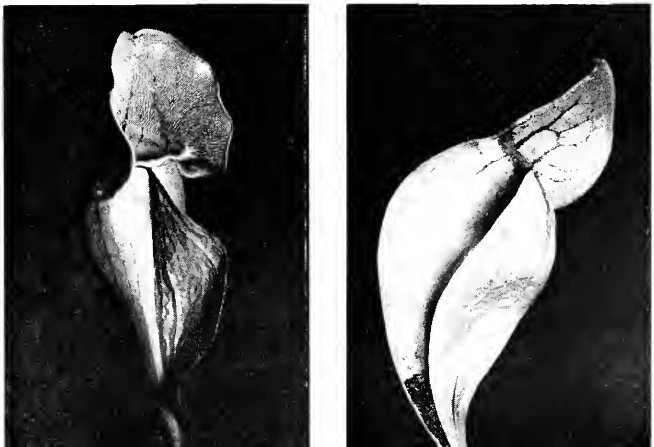
S. purpurea has the most northern distribution of these five pitcher plants, occurring as far north as Canada; it extends south into Virginia, below which it is recognized as a subspecies, *S. purpurea venosa*. *S. flava* can be found along the coastal plain from the Carolinas to northern Florida and Alabama. *S. minor* occurs from South Carolina to southern Georgia and northern Florida. *S. psittacina* is found in southern Georgia, northern Florida, and the coastal plain of Alabama, Mississippi, and Louisiana. *S. drummondii* is abundant along the Styx River in Alabama, but less so in Mississippi and Georgia. The different species hybridize readily in nature, resulting in a number of integrating forms. The illustrations on these pages are of the above-named coastal species only. There are other, entirely valid species in the genus, but either they are less abundant or are indigenous to the higher elevations back from the seacoast.

Pitcher plants can claim beauty by virtue of both flowers and leaves. The former are large and stand up conspicuously on strong vertical stems. In some species they are yellow; in others they are combinations of rose or red petals and reddish-purple sepals. After the petals fall there is no wilting of the highly decorative sepals; instead they remain as fresh, fully colored floral structures until the seeds are matured; often they have been mistaken for petals. The pistil's remarkable style is at the distal end, expanded into a large, inverted, five-ribbed umbrella with the tips of the five ribs acting as tiny stigmas. Like the sepals, this brightly colored, showy structure persists until the time of seed dispersal. This habit of style and sepals remaining as living tissue long after pollination is uncommon among the angiosperms; whatever the advantage may be to the plants, if there be any, it is not at all apparent. Curiously, in a number of species the production of flowers and the completion of pollination occur before any new leaves appear. This has not yet warranted any discussion or inquiry by most students of the group.

This gap between flower and leaf production is a particularly striking phenomenon in the cases of *S. flava*, *S. drummondii*, and *S. psittacina*, and would tend to refute any theory that the insect-trapping leaves also attract pollinating agents.

The leaves of the different species of *Sarracenia* vary a great deal in structure and color, and are all astonishing culminations of anatomical evolution. They have one thing in common—a hollow, tubular reservoir in the leaf, which may stand erect or may lie wholly or partially prostrate. The funnel-shaped leaf cavity may be completely shielded from, or partially or completely open to, the rain. The leaf of *S. purpurea* has been held to be a classic example of the insect-trapping pitcher. The semiprostrate leaves are open to the rain and insects alike. Downward-pointing and overlapping hairs line the scoop-shaped flap that leads to the tubular part of the leaf. Directly below the rim of the tubular part, the lining epidermis is entirely hairless and extremely smooth and waxy. This polished, slippery surface leads down to the water into which the insect victims invariably fall. Below this slippery zone is a final one, normally submerged, which also has downward-pointing hairs, sparser and weaker than those on the lip flap, but which might offer a real barrier to any bedraggled bug that had fallen

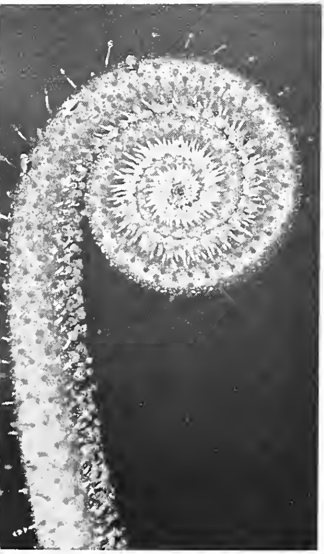
ITCHER PLANTS, of species *Sarracenia rpurea*, grow in a New Jersey swamp.



INSECTS enter at pitcher's top, end as dark remains seen in section, *right*.

to the trap during a period of rought when the water level was ab- ormally low in the pitcher.

The erect pitcher of *S. minor* is well vered by a hood that keeps out all in except that which might be blown by a high wind. Rain water does t seem to be entirely necessary to able the insect trap to function. eaves of this species were examined tensively in a region that had been



Growth of *Drosera filiformis* occurs at each uncoiling leaf tip. In photo below, distinct basal stubs are the remains of previous season's growth.

without rain for a period of weeks, and there was liquid, apparently secreted by the plants, in each one.

Outside water can enter the horizontal, hooded leaves of *S. psittacina* only if the leaves are submerged by flooding. Examinations of many leaves during a prolonged drought showed a small amount of liquid present in the basal part of each slender, tubular leaf cavity, together with some very small trapped insects. A slippery surface leading to the liquid would be of no advantage in such a prostrate leaf, but as we might expect, we find that the downward-pointing hairs extend into the region of the trapping fluid. These hairs are long, flexible, and meet in the center of the tube cross section. Any small ant, mite, or other tiny arthropod that crawls into the passage finds itself in a one-way street from which there is no return; it perishes in the small amount of fluid at the end of the cavity.

In the leaves of the pitcher plants we find a number of species of insect larvae living in the trap liquid. Some of these feed on the living parenchyma tissue just under the lining epidermis of the pitcher. They are the caterpillars of a few species of small moths in the genus *Exyra* and are found quite frequently in the pitchers of *S. flava, drummondii, minor,* and *purpurea.* The carnivorous larvae belong to the genus of flesh flies, *Sarcophaga,* and there are at least six species that feed on the insects trapped by the plants. We have found them widespread in the pitchers of all species of *Sarracenia* with the exception of *psittacina.* The frequency of occurrence of these larvae varies. Patches of *flava* have been found in which every leaf examined contained a maggot; at other times, in other patches, only about half of the leaves examined were occupied. One of the many interesting characteristics of the life history of this fly is its habit of limiting its occupancy to one maggot per pitcher, even though the female fly may have deposited upward of a dozen living larvae in each. This limitation of the number of larvae to one per pitcher is also observed in the moth genus. How they avoid the economic problems of a population explosion is not easily explained, but the value of the procedure is certainly apparent so far as the food supply of the larvae is concerned.

The adult lives of these fly and moth larvae might be more closely examined to discover if they play a role in the pollination of the pitcher plants. It should be borne in mind that the wet, boggy habitat of these plants is not an ideal place to find hibernating insects that might function as pollinators in the early spring. Some of the species bloom and are pollinated before the first leaves appear, as has been mentioned above. The adult sarcophagids have been observed in abundance around the flowers and leaves of *S. flava* after the blooming period. The previous year's dead pitchers, and other trash above the sphagnum and wet muck, would make a proper refuge for pupae or adults until warm weather initiated plant growth. Field observations have indicated that these sarcophagid adults might play an important part in pollination. At any rate, the problem seems to have been efficiently solved because, complex as the flowers are, the fruits are uniformly packed with the maximum number of seeds.

Another question that could be answered by more controlled investigation is rather complex: do carnivorous plants actually need nitrogenous food in the form of insect bodies? And if so, is the boggy soil in which the plants grow markedly deficient in available nitrogen? The first view is held by many people, and cultural directions for the growth of *Dionaea muscipula,* the Venus' fly trap, have often included an admonition against failing to provide occasional insects or even tiny bits of raw meat if robust growth is to be assured. Yet, the few specimens of pitcher plants, as well as "fly traps," which we have been able to grow successfully in "captivity," with apparent health and vigor, have thrived for years without any insect or meat tidbits.

Regardless of the often contradictory literature built up around them, the pitcher plants are rewarding to the observer. No need to make treks to obscure wilderness fastnesses; they are to be found alongside the highways of the flat lands bordering the coastline, and seem to have a particularly comforting ability to survive human contact. The areas in

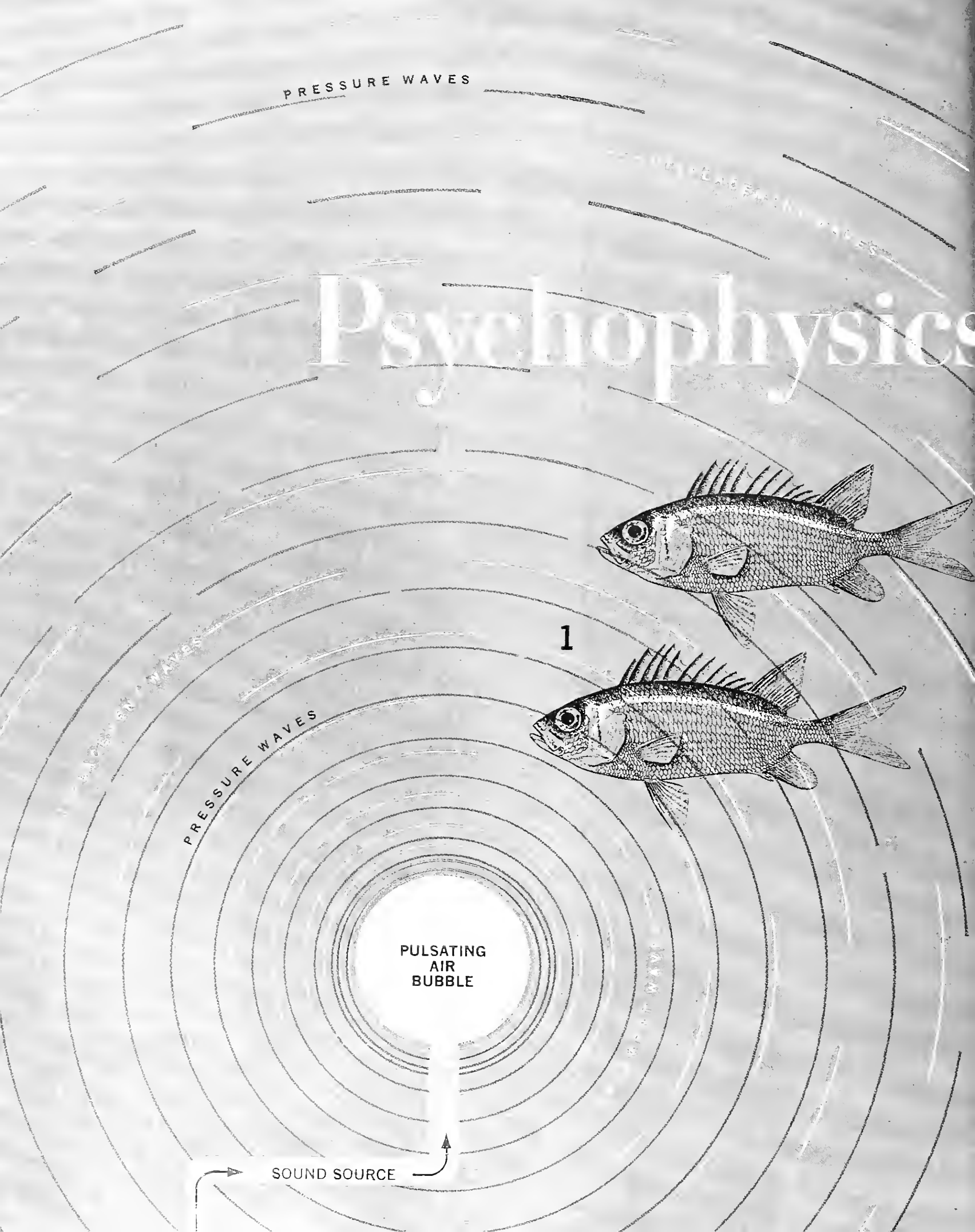
Tubular leaves of *Sarracenia minor* have hooded shields that keep out rain.

ich they thrive best are those that
e slow to be taken over by agricul-
e or by human habitation. and their
gged rootstocks are most resistant
rough treatment. even to the fre-
ent roadside grass burnings in late
nter or early spring.

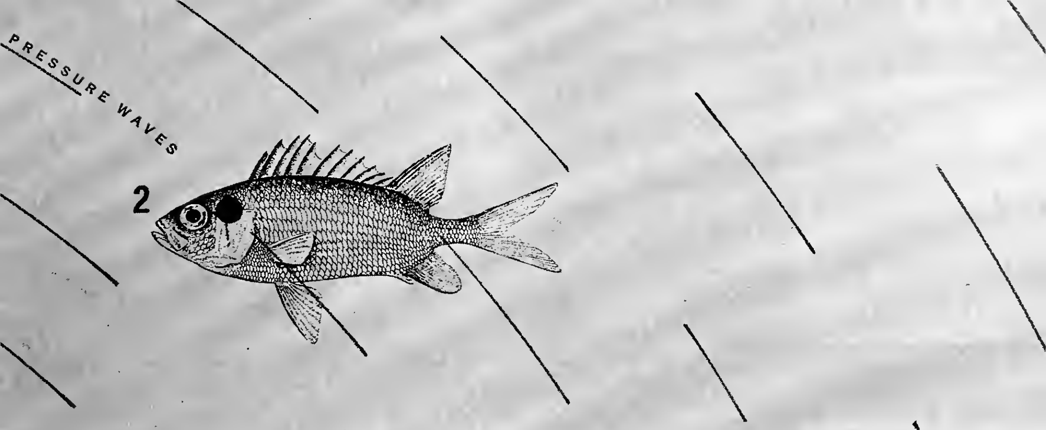
The case of the Venus' fly trap is
ferent. Its unorthodox. predatory
havior has placed it in grave jeop-
ly. It is the sole species in a unique
l isolated genus. and is extremely
ited in its distribution. occurring
where in the world except special habitats in the coastal plain region of North and South Carolina. It is not easily grown in captivity. Even under natural conditions there is a black rot that commonly kills all the leaves by the time the seeds are mature. A great reduction in numbers has occurred in the past two decades. and this decrease has been conspicuously accelerated in the last few years. It might be necessary to develop more efficient methods of cultivation for the successful propagation of specimens both in botanical and private gardens.

AQUATIC MAGGOT of flesh fly lives in secretion of pitcher. and thrives.

Psychophysics



Displacement (white rings) and pressure wave (gray rings) are two forms of underwater sound energy. Displacement, or near-field effect, is probably received by the lateral line (1), and pressure wave, or far-field effect, is received by the swim bladder and the inner ear complex (2).



and Hearing in Fish

ngenious tests determine the sounds that fish can detect

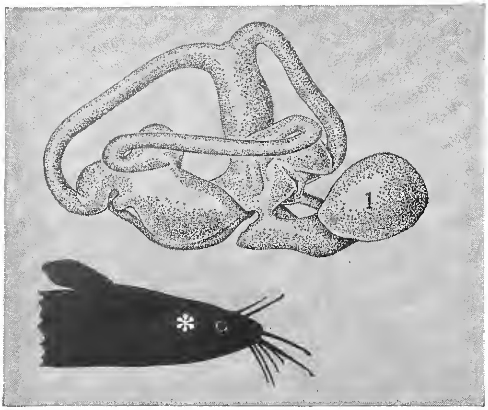
By William N. Tavolga

THE QUESTION OF WHETHER FISH CAN HEAR seemed to be well established as long ago as 1820, when E. H. ber, along with his excellent anatomical studies of the man ear, described the ears of fishes. He theorized t, although the fish has no external ear, the swim dder acts in a manner analogous to the middle ear of n. That is, it receives the sound energy and transforms nto vibrations of the fluids of the inner ear. It has taken ost 150 years to prove Weber's contention. Around the n of the century, some well-controlled experiments arly demonstrated that fish could hear. Sounds of buz-s, struck objects, and all sorts of natural and artificial nds were used, and fish were found to respond to many them. Karl von Frisch even trained a catfish to come him when he whistled. In the early 1900's, G. H. Parker orized that a fish can detect sound under water in two ys. In addition to receiving sounds by way of the swim dder and inner ear, he said, the lateral line system is o sensitive to sounds. This lateral line consists of a series minute sense organs imbedded in pits and tubes that ally form a thin, visible, lengthwise line on each side the body surface of most fish. There are also a number interlacing tubes and separate pits on the head. This ire system was thought to be primarily sensitive to vements of water currents and low-frequency vibrations.

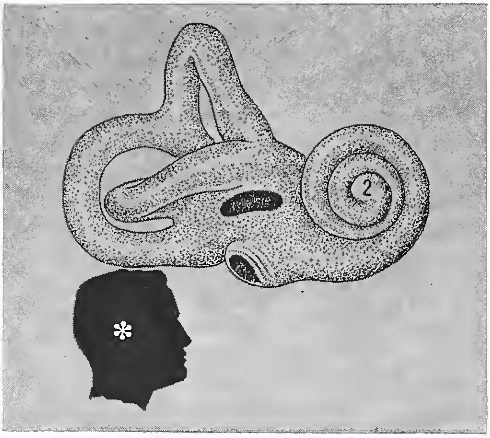
Once it was established that fishes could hear, the next estion was how well? For instance, what frequencies a fish detect? What is the minimum sound intensity t a fish can hear? The first of these seemed to interest st investigators, particularly the peripheral question: at is the highest frequency a fish can hear?

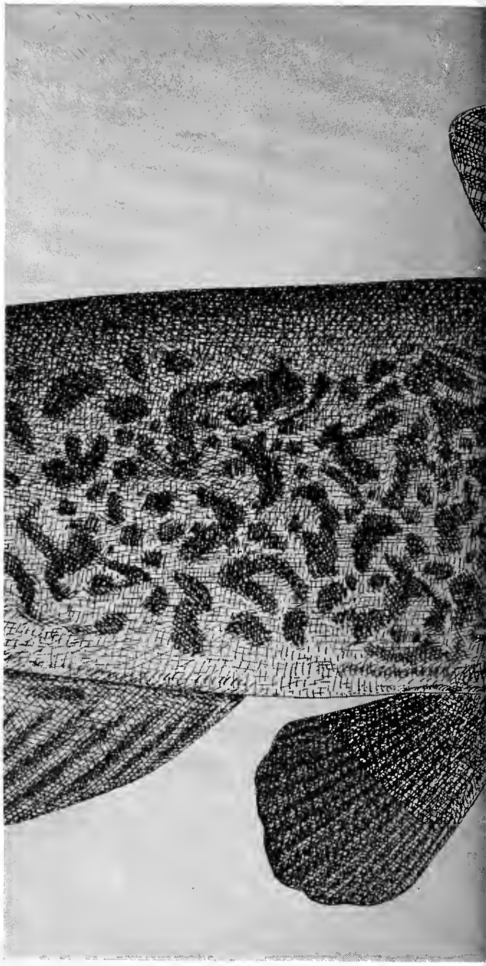
Most of the experiments to determine the frequency range of fish hearing were behavioral. That is, some response on the part of the entire animal was used as a criterion, although a few observations have been made in which the responsiveness of the sense organ was studied directly. In the latter cases, electrodes were placed on the nerve fibers coming from a receptor and the signal was "wire tapped." This technique is extremely difficult, as the auditory nerve is short and deeply imbedded in bone. Some success was achieved in sharks, whose large size and cartilaginous skulls made the technique possible. This wire tapping has also been done with the lateral line, where it is a bit easier. Such data, however, are useful only to show the potentialities of the sense organ. That is, we can tell what stimuli the sense organ can react to and what messages it sends along the nerves leading from it to the central nervous system, but we cannot know, from such information, what the animal will do with these signals. A classic example of this is one in which electrophysiological techniques have shown that the ordinary cat should be able to discriminate colors. Behaviorally, however, the cat is color-blind. It is apparent that somewhere in the central nervous system this color information is discarded. Thus, if one is primarily interested in the behavior and ecology of the organism, it is more desirable to determine what the whole animal will respond to, rather than to measure the capabilities of the sense organ.

The methods that have been used to determine auditory capacities have, for the most part, involved conditioning the animals to respond positively to a sound associated in time with the presentation of food. Another technique,



Bullhead's inner ear, *above,* has enlarged sac (1) at the posterior end that receives sound vibrations from Weberian apparatus. In human's inner ear, *below,* the hearing part is formed into a cochlea (2), where frequency discrimination takes place. Both have three canals for sense of balance.



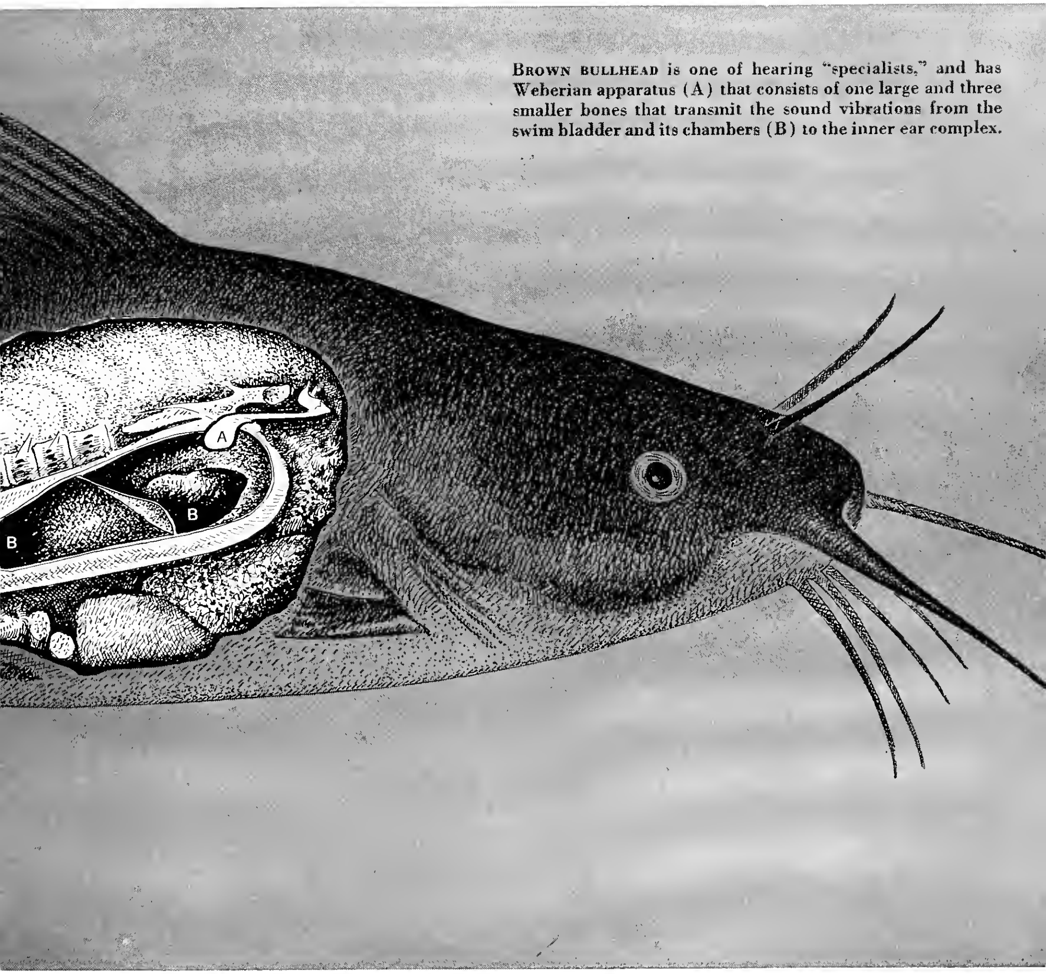


utilized primarily by investigators in the Soviet Union, is that of classical conditioning. Here the fish is exposed to the test sound and this is followed shortly by a mild electric shock. A positive response is any sudden movement, involuntary reaction, or even a respiratory or heart rate change that occurs every time the sound is made.

To summarize the results of all these investigations, fishes must be separated into two groups. The majority of species has an upper frequency limit of about 2,000 or 2,500 cycles per second (abbreviated to c.p.s.). This is a pitch about two and a half octaves above the standard middle A on the piano. The second, and smaller, group belong to the order Cypriniformes, and are considered the hearing "specialists." This order includes the catfishes (including bullheads), carps, minnows, characids, and gymnotid eels. It has been reported that bullheads have responded to frequencies up to 4,000 c.p.s., and certain minnows may hear as high as 8,000. This last is almost an octave above the highest note on a piano—a C at 4,186 c.p.s. (The Cypriniformes and others show a close association between the swim bladder and the inner ear, which will be discussed later.)

Sound intensity must also be measured. What is the minimum level at any specific frequency to which the animal will respond? Some investigators attempted to measure this, but in most cases they only tested one of a few frequencies. Only two reports I know of attempted to determine the complete hearing curve for a fish. Autrum and Poggendorf, in 1951, worked out the audiogram fo the fresh-water brown bullhead *(Ictalurus nebulosus, page 39).* In this sort of graph, the sound level is given on the left side (ordinate) and the frequency along the base line (abscissa). The lower the point on the curve, the lower the threshold, that is, the greater the sensitivity at that frequency. In 1961. Kritzler and Wood made a similar audiogram of the bull shark, *Carcharhinus leucas,* at the Lerner Marine Laboratory at Bimini, Bahamas *(page 39).*

In practice, sound intensity is measured by suspending an underwater microphone (hydrophone) in the water. Since the hydrophone transforms sound pressure into elec-



Brown bullhead is one of hearing "specialists," and has Weberian apparatus (A) that consists of one large and three smaller bones that transmit the sound vibrations from the swim bladder and its chambers (B) to the inner ear complex.

cal pressure, the voltage output of the hydrophone is actly proportional to the pressure of the surrounding und field. If the hydrophone and its amplifier are operly calibrated, the sound pressure can be determined th considerable precision. Sound can be measured in rms of pressure, that is, force per unit area. The units e use are dynes per square centimeter—one dyne per uare centimeter is known as a microbar. This, in turn, approximately equal to one-millionth of average atmos-ieric pressure.

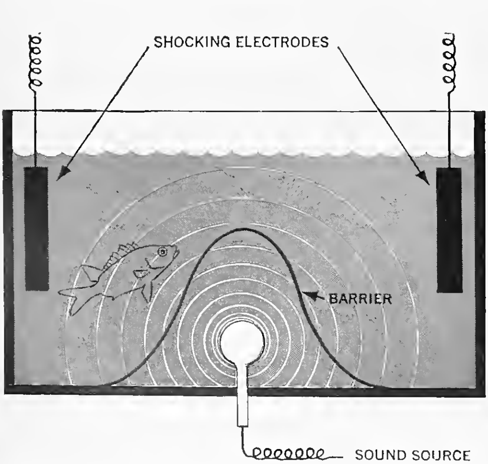
N human hearing (out of water, of course), the threshold at 1,000 c.p.s., based on an average of many individ- ıls with "normal" hearing, is .0002 microbar *(page 39)*. his value is often used as a standard, and all other sound ressures are related to it. If a person is asked to discrimi- ıte one sound intensity from another, the minimum differ- ıce he can detect is defined as a decibel, but the absolute agnitude of a decibel depends on where one starts. At low sound level, a decibel is much smaller than it would be at a high level. The decibel scale is a logarithmic one that is based upon an equation in which it is assumed that human hearing, and that of all other animals, follows a logarithmic law. Although most evidence indicates that human hearing follows some other type of equation, and that there is no reliable evidence for any other species, we stick to this decibel scale and use it in acoustics, electronics, and many other fields because it is convenient. We can decide, for example, to choose the .0002 microbar value as a reference value. This would then equal 0 decibels —as in the human audiogram. The graph and table on page 41 give a few well-known examples of sound pressure values and their equivalents in decibels. A sound pressure of 1 microbar equals about 74 decibels.

In many phases of acoustics, especially in underwater work, the 1 microbar value, rather than the .0002, is taken as the reference level of 0 decibels. This is actually a more objective reference and has come into wider usage in recent years. The audiograms for the catfish and shark shown on page 39 were drawn to that scale. Conversion from one reference level to another is a simple matter of adding or subtracting 74.

Water is much more resistant to the propagation of sound than is air. This means that to produce the same effect, sound pressure in water must be much greater. Conversely, at the same pressure, the acoustic energy in air is greater than in water. Sound volume can be expressed in two ways. The usual, and more convenient, way is in terms of pressure in decibels with reference to some standard pressure value such as 1 microbar. However, we can also express acoustic energy in terms of intensity or power. This is normally given in watts per square centimeter.

In air, the human hearing threshold is .0002 microbar at 1,000 c.p.s. This can also be expressed in acoustic power as some fraction of a watt/cm^2. It happens to be one ten-quadrillionth of a watt, more simply written as 10^{-16} watts/cm^2. Actually, we are primarily concerned with this power figure, since it is the energy of the sound wave that we receive. Pressure is a more convenient measure to use, but we must insert a correction if we compare acoustic pressure in air with that in water. This correction is approximately 36 decibels. That is, .0002 microbar in air is actually 36 decibels (of power) higher than .0002 microbar in water. To put it another way, given the same power, the pressure in air is 36 decibels lower than in water. All this is because of the higher density and incompressibility of water. Because most measurements are made in pressures, we now have to convert all our figures into equivalent power units if we are to make a proper comparison of sound in air and in water. Such a comparison is shown on page 41.

In an attempt to answer the question of how well a fish hears, I collaborated with Dr. Jerome Wodinsky, a psychologist at Brandeis University, to find a conditioning experiment that would allow a fish to give a reliable, repeatable, and unequivocal answer to a question. The simplest answers are, of course, "yes" or "no." A "maybe" cannot be tolerated. (An animal must be placed in a situation in which it has only to say "yes." It need do nothing to say "no.") This sort of limitation is particularly important in sensory studies. As the stimulus approaches its lowest detectable level, the subject, be it human or fish, becomes unsure of whether he detects it or not, and begins to try to say "maybe."



Hearing tests were run in two-compartmented tank. Fish, subjected to sound followed by electric shock, learned to cross the barrier on hearing sound, thus avoiding the shock.

The objective technique we used is called "avoidance-conditioning." It was first demonstrated in dogs by the famous Russian psychologist I.P. Pavlov. At the sound of a bell or the flash of a light, the dog had to lift its forepaw. If it did not do so, it would receive a mild, but annoying, electric shock. By raising the paw immediately upon the presentation of the sound or light, the animal "avoids" being shocked. This is a potent form of conditioning, and is retained for long periods. It also forces a clear, unambiguous response from the subject.

Most theoreticians now agree that the acquisition of this avoidance response takes place in two stages. First, the animal learns to make the response that will turn off the noxious stimulus. This has been variously called classical, or Pavlovian, conditioning. The animal, therefore, learns to *escape* from the noxious stimulus. In the second stage it learns that the sound precedes the shock and that the same escape response can be used to *avoid* the shock.

In applying this method to the study of hearing in fish, we used a "shuttle box" *(below.)* This is an aquarium with two compartments separated by a shallow barrier. The water level is adjusted so that the fish can swim from one side to the other, yet will not remain on the barrier, because the water is too shallow. The sound source is concealed beneath the center barrier, and the entire tank is shock-mounted and insulated to reduce the noise level inside, reduce reverberations, and prevent the animal from seeing anything that might serve as an additional cue. The procedure is to turn on the sound and, after a predetermined period of five or ten seconds, administer a series of short, intermittent electric shocks. The fish first learns to escape the shock by crossing the barrier, because as soon as it does so, both shock and sound are stopped. This phase takes only a few trials. Each time the fish must move from one compartment into the other and can start from either one for the next trial. The spacing of the trials must be varied, or the fish learns the length of the intertrial interval and begins to anticipate the shock.

The second stage of learning takes a little longer. In most species, three to six days of twenty-five trials a day are required before the subject begins to avoid regularly. A positive response, then, is one in which the fish swims across the barrier as soon as the sound goes on, but before it receives a shock. The response eventually becomes extremely reliable—so much so that the shock administration becomes unnecessary.

Once the avoidance-conditioning was well established we changed the sound level. Generally we started with a pure tone—a single frequency—at an intensity we felt sure the fish could hear. After each avoidance, the sound level was lowered in steps of 2 or 5 decibels, so that the intensity would be lower at the next trial. This was continued until the animal missed—that is, did not avoid, but received the shock and escaped. This was recorded as a "no" answer. After each "no" the sound level was raised for the next trial. When the results are plotted on a graph, a zigzag line stretching across the paper is produced. If the tops of the "zigs" and bottoms of the "zags" are averaged, we can calculate the threshold for that frequency. It must be re mbered that a sensory threshold is not an all-or-none uation, and there is a degree of probability that we will t some "yes" answers below the threshold and some "no" swers above it. A "threshold" is a stimulus level the sub- t can detect and respond to 50 per cent of the time, d is thus a statistical value, not an absolute one.

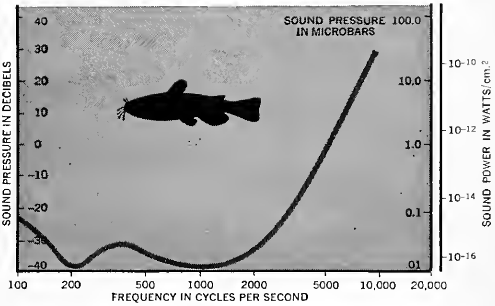
It is necessary to repeat such determinations a number times using different subjects, so that the value ob- ned for the given frequency is more reliable. Eventually, s is repeated at different frequencies, and an audio- m for the species can be plotted. For example, an audio- m for the squirrelfish (*Holocentrus ascensionis*), a rine species, is shown at right.

THER species have given us similar curves, but as many as 20 decibels higher or lower. So far we have rked out these audiograms for nine species of marine h. They represent a large majority of salt-water fish, hough none is a so-called specialist in hearing.

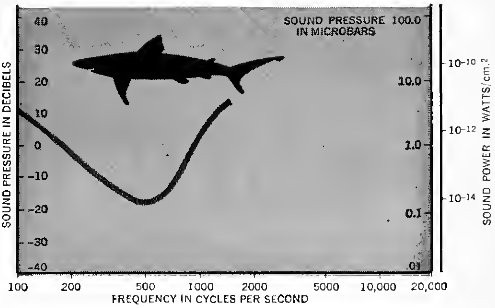
In order to make the determination less subject to human or and bias, the equipment for this study has been rtially automated, to allow us to graduate from working th a pair of hand-operated switches and watching the vements of the fish by means of a mirror. The observer s before a control panel and pushes a button. This button tomatically starts and continues a trial. The sound goes and, if the fish does not avoid, the shock continues cording to a preset schedule. When the fish crosses the rrier, a beam to a photoelectric cell is broken and the nd and shock are automatically turned off. A clock is o part of this apparatus, so that the time it takes a ject to respond is recorded. In addition, a counter eps track of the number of times the animal crosses the rrier during the intertrial interval. These data are im- rtant because we want to be informed of the activity of animal—how often it crosses the barrier and if these ertrial crossings represent "false alarm" responses. All s is multiplied by six in our apparatus, so that we can serve and test six animals in six different tanks simul- eously. Eventually, we may have to feed our data into computer so that all the calculations and analyses can be rformed on a large number of figures in a short time.

At this point, we can begin to make some generalizations to what fish—at least marine fish—can hear. For most ecies, the upper limit is about 1,500 to 2,000 c.p.s., which about one and a half to two octaves above middle A. ove this point, the sound levels become so high that ey may actually cause the animal physical discomfort pain. The most sensitive range is from about 200 to 800 .s., or a little more than the center octave on a piano. this range, the sensitivity of some species comes close that of the human ear, but we must remember that we are mparing a fish hearing in water to the human ear in air, d this may not be a fair or meaningful comparison. The er frequency limits are difficult to set, because it be- mes a matter of definition as to how low we can go and ll call it "sound." Many fish seem to be at least as nsitive to a 20 c.p.s. sound as we are, but sound under ter presents a special situation, because water is much nser than air, and is not easily compressible. This den- y and incompressibility offer resistance to the flow of oustic energy, and although the transmission may be ore efficient—the velocity of sound in air is about 1,080 et (330 meters) per second, while in sea water it is

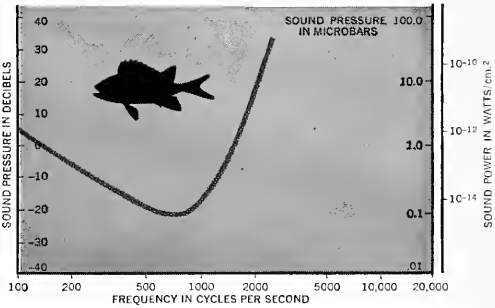
AUDIOGRAMS OF FISH AND MAN



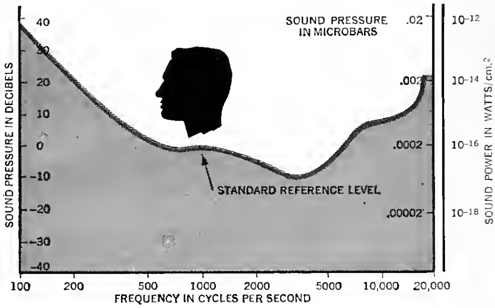
Brown bullhead, *Ictalurus nebulosus*, is hearing specialist.



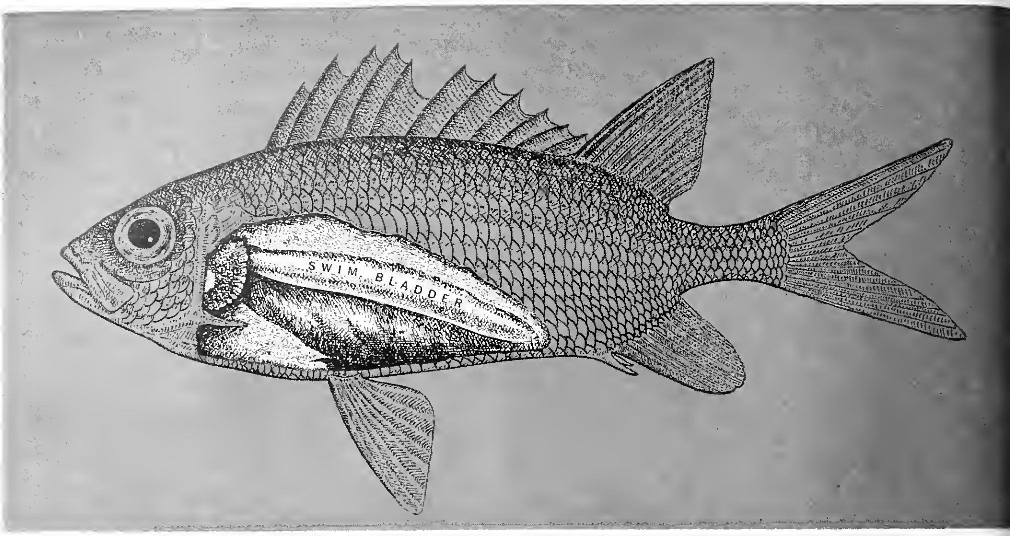
Bull shark, *Carcharinus leucas*, has narrower hearing range.



Squirrelfish, *Holocentrus ascensionis*, also makes sounds.



Human threshold shows the reference value of 1,000 cycles, which is often used as a standard. All areas below graph line represent frequencies and intensities that are inaudible.



Squirrelfish had the most sensitive ears and the broadest frequency range of many marine species tested. It lacks a Weberian apparatus, but its unusually large swim bladde lies near portion of the skull that contains the inner ea

about 4,900 feet (1,500 meters) per second—the amount of energy required to propagate a sound in water is almost 150,000 times greater than in air. Because of this, another factor becomes important—the actual particle displacement that results from the vibration of a sound source. This displacement—called the near-field effect—is of considerable significance at low frequencies and at a short range from the source. Close to the sound source, therefore, the acoustic energy is in two forms: one is the pressure wave (as exists in airborne sound) and the other is an actual physical vibration of the water itself. Which is it that the fish receives? We can safely say that at frequencies above 800 c.p.s. the fish can respond only to the pressure wave, and at lower frequencies and at distances of 20 or 30 feet or more. the pressure wave is still paramount. In the range of the near-field, however, the displacement effect is probably most important. Even when dealing with a pure far-field pressure phenomenon, however, we still get into complications. If a bubble of air is placed in the path of a pressure wave, the bubble will vibrate and produce a near-field effect in its vicinity. Two scientists at the Bell Telephone Laboratories. G. G. Harris and W. A. van Bergeijk. proposed that the swim bladder of a fish may act in such a manner. The inner ear, then, would receive this local near-field effect. In addition, there are the complications of all the reflections and reverberations that can take place under water. Not only is 99.9 per cent of sound energy reflected back from the water surface, but layers of water at different temperatures can serve as sound mirrors. These factors become exaggerated in the small aquariums in which we test the fish's hearing. All we can say at this time is that we can obtain thresholds for some form of acoustic energy, but cannot say exactly in what form that energy is received.

Now let us approach the problem of *how* a fish hears. Compared to the human ear, that of the fish appears simple. This is deceptive. The fish does not have a helical cochlea. Rather, the inner ear is a sac of fluid, with areas of hai cells protruding into a liquid (endolymph) in which floa one large and two smaller bones. Movements of the ea bones (otoliths) and liquid stimulate the hair cells, an signals are sent along the auditory nerve to the brai Thanks to the brilliant work of von Békésy, we know some thing about how our cochlea operates to discriminate o frequency from another, but there is nothing comparabl in the fish ear. How does a fish discriminate pitch—or doe it? Some studies on the goldfish indicate they may, but th evidence is not clear as to whether there is a true frequenc discrimination or if the apparent discrimination is actuall based on intensity differences.

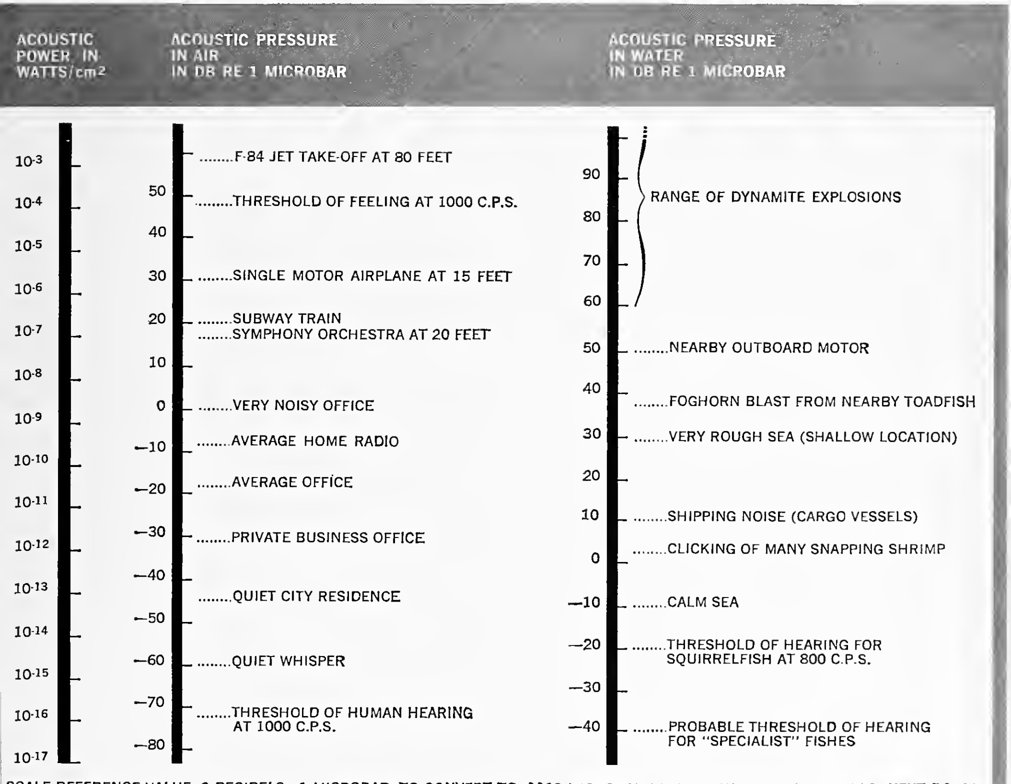
How does the acoustic stimulus reach the inner ear In the hearing specialists, like the catfish, there a series of four pairs of small bones leading from the swi bladder to the inner ear fluids. Experiments have show that damage to these bones reduces the hearing capacit The bones and their probable functions were first describe by Weber, and he proposed that they act in a manner a alogous to human middle ear bones in transmitting air v brations to the endolymphatic fluids. These ossicles hav since been named the Weberian apparatus. As mentione before, the swim bladder—even in fishes without the Webe ian apparatus—can function as a middle ear by creating local near-field effect. It is quite possible for sound vibr tions to reach the inner ear directly by way of bone co duction through the skull. Sharks do not have a swi bladder, but it can be shown that they have as good hearin as some bony fishes with swim bladders. In our own wor differences in the sensitivity of marine fishes cannot b correlated with size and location of the swim bladder.

The swim bladder of fishes has a number of function In most cases it serves as a hydrostatic organ—that is, th buoyancy of this bubble of air counteracts the tendenc of the fish to sink. By changing the volume of the bladde he fish can change its own buoyancy. In some cases, the ladder is used as a temporary reservoir of oxygen. and in few forms it even acts as a lung for breathing air directly. n many species, the swim bladder acts as a "loud-speaker" or sound production. As a hearing organ, it is undoubtedly nportant, because the body of a fish is almost transparent o water-borne sound. The bladder. therefore, can act as oth a loud-speaker and a microphone. If we project pulses f sound, as in sonar, we can locate fish by the reflections f the sound pulses. Most of this reflected sound comes om the swim bladders, and very little from the rest of e fish's body. The swim bladder, therefore. serves as an coustical discontinuity and, presumably, is of prime imortance as a sound detector.

WE must not neglect the function of the lateral line system in sound detection. The structure of the sysm's individual sense organs is ideally suited for the etection of movements of water. Indeed, it was shown by Dutch scientist, Sven Dijkgraaf, that the lateral line can ive the fish information about water currents and moving bjects, and can even be used to locate the position of obacles in complete darkness. As underwater sound prouces a significant displacement at close range to the sound ource, that is, the near-field effect. this. too, can be reived by the lateral line. Therefore, at close range and at low frequencies, the lateral line is also a hearing organ.

In this respect, the lateral line has certain advantages over the ear. Sound pressure. as such, is not directional. In humans, if one ear is plugged. it is impossible to determine the direction from which a sound comes. By using both ears, directionalization is possible, because of the different times it takes sound to arrive at each ear. In essence, the fish has only one ear. because the spacing between the two receptors is so small and the speed of sound is so high. In the near-field, however, the displacement energy *is* directional, and the lateral line organs are dispersed widely on the animal's body. Harris and van Bergeijk propose that the fish can locate the sound source, but only within the limitations of the near-field.

It is clear, then, that fishes can respond to subsonic vibrations of the water, and to sonic vibrations up to at least 2,000 c.p.s.. with some specialists able to perceive up to 8.000 c.p.s. The most sensitive range is below 800 c.p.s., and here many species appear to have a sensitivity comparable to that of the human ear. The swim bladder is the main sound receiver, transmitting its vibrations to the inner ear, but the lateral line system is also a hearing organ. The latter is particularly sensitive in the low-frequency and subsonic range, and at short distances it can locate sound sources. Such conclusions are based on cooperation among psychologists, physicists and biologists.



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SKY REPORTER

Gregorian calendar was meant to keep seasons in their places

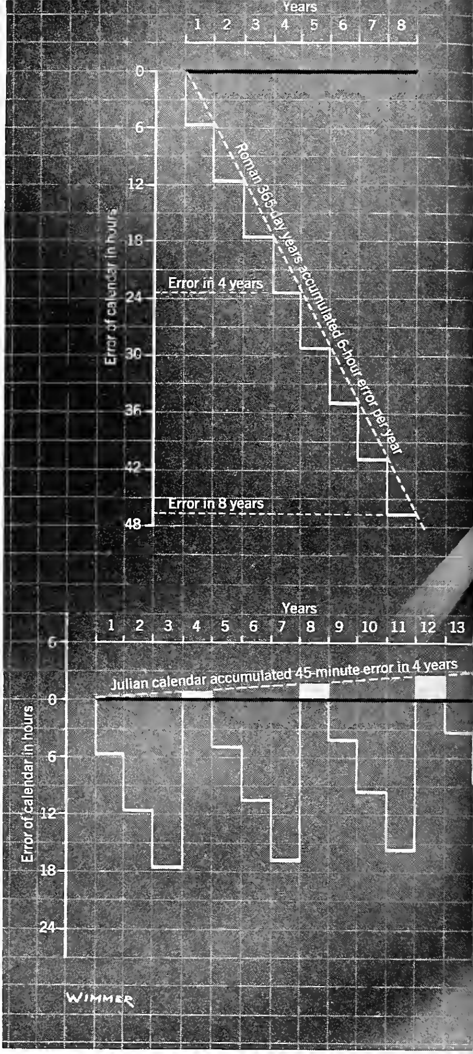
By Thomas D. Nicholson

When the modern form of the calendar was first introduced on January 1, in the year 45 B.C., one of the innovations was the shifting of the first day of the year from March to January, which had previously been the eleventh month. The calendar was called the Julian calendar, after its inaugurator, Julius Caesar. In the year the Julian calendar was adopted, the sun arrived at the vernal equinox—and spring began—on March 25.

More than sixteen centuries later, in the year 1582, inherent inaccuracies in the Julian calendar had accumulated to the extent that spring began in the Northern Hemisphere on March 10. That year, Pope Gregory XIII recommended that two major revisions be made in the Julian calendar. In one, ten days were dropped from October, so that the date following October 4, 1582, became October 15. In the other revision, the leap year rule of the Julian calendar, which had provided for a leap year every fourth year, was modified so that there would be 97 (rather than 100) leap years each four centuries. These alterations were made in order to restore the first day of spring to March 21 and to keep it there. This date was selected because, at the time of the Council of Nicaea in A.D. 325, when the rules were established for determining the date of Easter and its associated events each year, the sun was arriving at the vernal equinox about March 21. The Julian calendar as modified in 1582 is called the Gregorian calendar. This revised calendar was adopted by nearly all nations for civil purposes, although it was not adopted until 1752 in England and its colonies, and 1923 in Russia, Greece, and other east European countries.

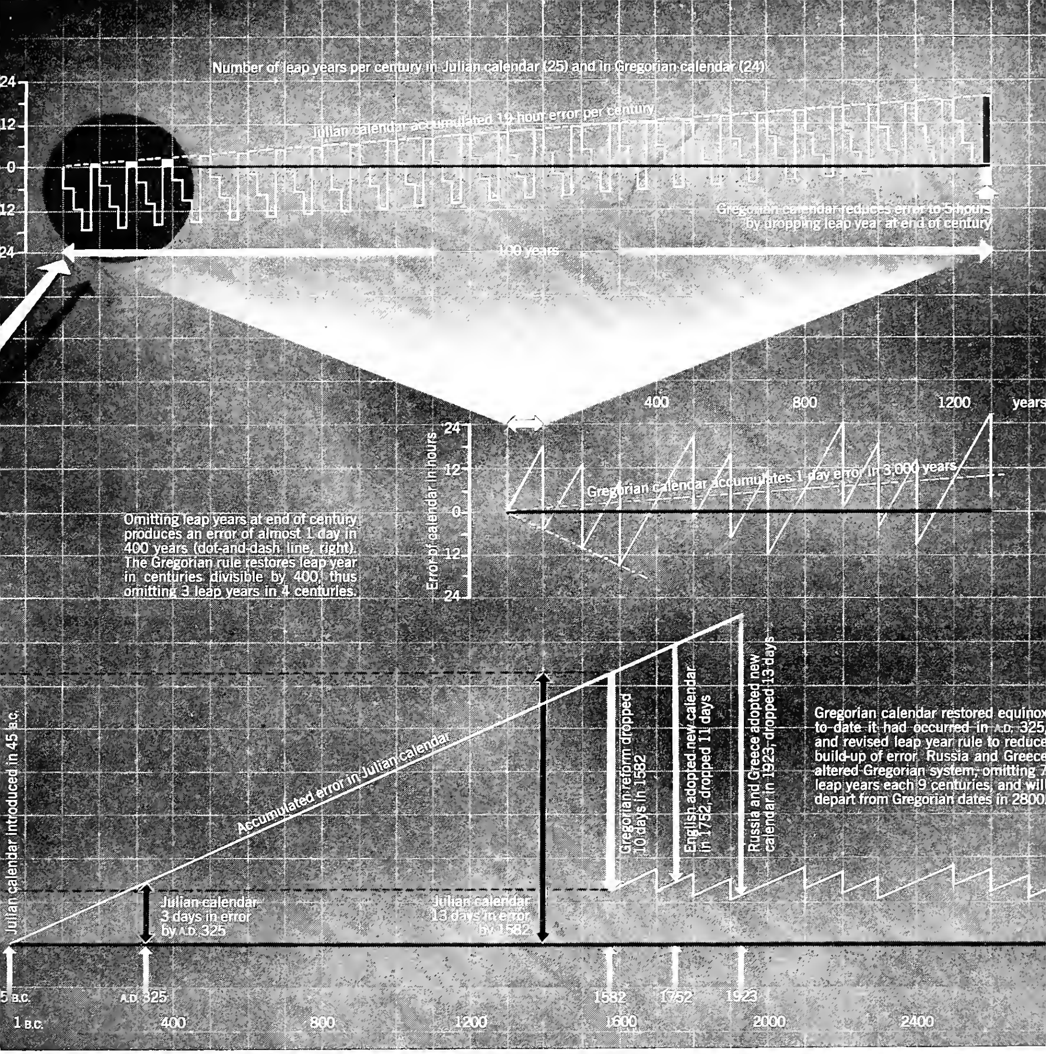
This year, spring commences in the Northern Hemisphere at 9:14 A.M., EST, on March 20, although the exact time is different in other time zones in the United States. Last year, however, spring began on March 21 in the conterminous United States and on March 20 in Alaska and Hawaii, because of local time differences. In 1965, spring will again begin on March 20 throughout the United States.

Thus, in spite of the Gregorian calendar reform, and contrary to the popular belief that spring in the Northern Hemisphere is supposed to begin on March 21, the date when the sun arrives at the vernal equinox—an imaginary point in space on both the celestial equator and the ecliptic—varies from year to year and even varies, in any given year, from place to place around the world. In many parts of the world, such as the conterminous United States, the beginning of spring occurs more often (three years out of four) on March 20 than on March 21. In other places, such as Alaska and Hawaii, it occurs on March 20 every yea
Although spring now begins on either March 20 or
every year, this has been so only since the start of th
century, and will change before the century ends.



Evolution of the calendar is shown graphically, *abo*
At top left, 365-day Roman years were 6 hours short eve
year. Julius Caesar introduced leap years of 366 days
45 B.C., but average Julian year was more than 11 minut

The trouble, of course, still lies with the calendar. T
Gregorian calendar allows the first day of spring to chan
as easily as did the Julian calendar. But the Gregorian c
endar has a built-in mechanism to bring the event ba
to the desired date every so often. This mechanism is
revision of the leap year rule. Three times in every fo
centuries the leap year is suspended, and each time t
date of the beginning of spring returns to March 21. B
the mechanism of the Gregorian calendar, too, as it no
exists, will be in need of revision eventually.



long, shown at lower left. Leap year rules are similar
1e Julian and the Gregorian calendars, but Gregorian
omits leap year at the end of the century, top right.
e of the Gregorian calendar, with 97 leap years in 4 centuries, repeats every 400 years (center diagram), but the average year is slightly long, so error slowly builds up. Although the Julian calendar was 13 days in error by 1582, only 10 days were dropped by the Gregorian reforms.

1ere is no real reason why the first day of spring
ıld fall on the 21st or any other day of the third month
1e calendar year. It does not, of course, in some cal-
ırs that are still in use today (principally for religious
ooses), such as the Jewish, Mohammedan, Indian, and
ıntine calendars. In the early Egyptian and Roman
ıdars, the beginning of the year usually occurred in
spring, and the first day of spring was generally the
day of the new year.

ctually, no calendar could keep the beginning of spring
he same date inflexibly. In the interval between suc-
ive arrivals of the sun at the vernal equinox, 365 days,
ours, 48 minutes, and 46 seconds of mean solar time
se. This interval, the tropical year, is the true length of the year of the seasons, or, in other words, the average period in which the seasons of earth repeat themselves.

A calendar year, however, must have a discrete number of days, obviously either 365 or 366. If there are 365 days in a calendar year, then it will be 5 hours, 48 minutes, and 46 seconds short of the period in which the first day of spring repeats itself. If there are 366 days, then the calendar year is 17 hours, 26 minutes, and 18 seconds longer than the interval from spring to spring. In either case, the moment when spring begins cannot be the same year after year in the calendar, and it will inevitably fall on a different date. By suitably juggling 365-day and 366-day years, however, the date of the arrival of spring

Astrolabe, early navigation instrument to determine time and latitude by star sighting, was made in 1581. It antedates the Gregorian reforms and shows the equinox on March 10.

can be kept within certain limits. The leap year rule of a calendar is simply a guide to help us juggle the years of different lengths suitably.

When the Julian calendar was adopted it was believed that the duration of the tropical year was 365¼ days. In that calendar, therefore, ordinary years were given 365 days, and each fourth year 366 days in order to keep the new calendar in step with the seasons and to keep seasonal events at the same calendar date each year.

As we know today, the true length of the tropical year is actually 11 minutes and 14 seconds shorter than the average length of the Julian year (365¼ days). In 128 years, the accumulated error in the Julian calendar amounted to a full day. In other words, the arrival of the sun at the vernal equinox came earlier by one day.

As mentioned before, spring began on March 10 in 1582, and, if the Julian calendar had been retained, it would have continued to come still earlier, until it gradually slipped back into February and then January. This would have meant that the Easter date would come, eventually, in the winter months of the calendar (although the season would still be spring).

In view of the Gregorian reforms that restored the first day of spring to March 21, it is interesting to explore the reasons why March 20 is the first day of spring some years in the present era (most and even all years in some parts of the world). This happens because, in a given century, the effect of the Gregorian calendar on the date of spring is the same as the effect of the Julian calendar; the leap year rules—the juggling of 365-day and 366-day years—are the same in both calendars in any one century.

Within a century, the average length of the Gregorian year, like the Julian year, is 365¼ days, or 11 minutes and 14 seconds longer than the true interval between successive arrivals of the sun at the vernal equinox. Thus, as in the Julian calendar. the beginning of spring comes earlier by nearly 45 minutes every fourth year. The cumulative effect of this difference is enough to bring the date of the sun's arrival at the vernal equinox to March 20, and even to March 19, in most centuries. But three times every four centuries (each century year except those divisible by 400), the leap year is suspended in the Gregorian calendar, and the date of the spring equinox reverts to March 21.

At the end of a century, the cumulative error of the Julian calendar was 18 hours, 43 minutes, and 20 seconds. In the Gregorian calendar, the last leap year of the century is omitted, so the Gregorian century is 5 hours, 16 minutes, and 40 seconds short. Four Gregorian centuries, therefore, would be 21 hours, 6 minutes, and 40 seconds short, and this, if uncorrected, would cause the date of spring to advance one day (to March 22) in a little more than four centuries.

To correct this, the leap year is restored in the fourth century year (hence the rule that provides 97 leap years every 400 years). The cumulative error (21 hours, 6 minutes, and 40 seconds short) in four Gregorian centuries is, therefore, reduced by the addition of one day, which then restores the spring equinox to March 21. The net error in four Gregorian centuries is 2 hours, 53 minutes, and 20 seconds. In 32 Gregorian centuries, this will accumulate to an error of 23 hours, 6 minutes, and 40 seconds. By the end of that period, the date of the spring equinox in the Gregorian calendar will be permanently advanced to March 20, unless the present leap year rule is somehow modified by that time.

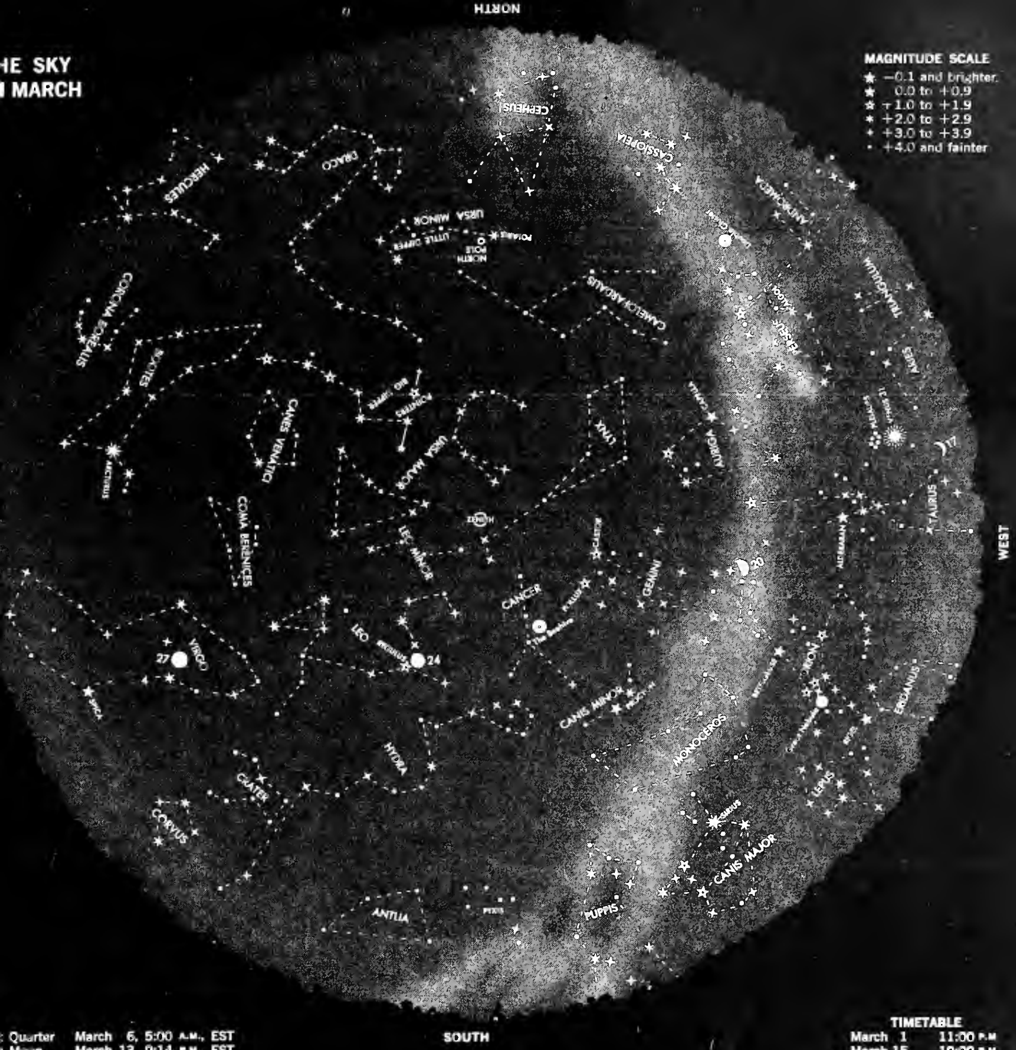
The effect of the leap year rule on the date spring begins is reflected in the calendars of recent years. In the last decade of the nineteenth century, the arrival of spring in the United States fell each year on either March 19 or March 20 (on the 20th three years out of four). The year 1900, however, was not a leap year. It was an ordinary year of 365 days. In the first decade of the twentieth century, therefore, the first day of spring came on either March 20 or March 21, more often on the latter date.

Since 1900, the arrival of the sun at the vernal equinox has been coming about 45 minutes earlier each four years. As a result, the beginning of spring during the 1960's occurs more often on March 20 in the United States, and the trend to earlier arrival of the beginning of spring will continue during the century. In the last decade of the twentieth century, the arrival of spring in the United States will fall again on either March 19 or March 20.

In most centuries, this tendency toward an earlier occurrence of spring would be corrected by the omission of the leap year in the century year, but the next century year, A.D. 2000, will not be a leap year by the Gregorian rule. The trend to earlier dates for spring's arrival will continue unchecked into the twenty-first century. By the end of the twenty-first century, spring will begin on March 19 in most years everywhere in the United States. Finally, in the year 2100, the leap year will be omitted again, and the first day of spring will revert to March 21, in at least some years in all parts of the world.

Dr. Nicholson is Assistant Chairman, Astronomer, and a lecturer at The American Museum-Hayden Planetarium.

HE SKY
MARCH



: Quarter	March 6, 5:00 A.M., EST
Moon	March 13, 9:14 P.M., EST
t Quarter	March 20, 3:39 P.M., EST
Moon	March 27, 9:48 P.M., EST

TIMETABLE

March 1	11:00 P.M.
March 15	10:00 P.M.
March 31	9:00 P.M.

(Local Mean Time)

March 3: Pluto is at opposition and is farthest from earth s year, 2.964 billion miles.

March 13: Mercury is at superior conjunction, that is, in e with the sun but on the far side of the sun from earth. rcury now enters the evening sky.

March 15: Jupiter and the moon are in conjunction at 9:00 ., EST. Although moonset occurs approximately one hour rlier, Jupiter and the slender crescent moon should appear proximity to each other in the twilight sky this evening at out 7:00 P.M.

March 16-17: The conjunction of Venus and the three-day scent moon takes place at 1:00 A.M., EST, March 17. In early evening sky on the 16th, the moon appears below d to the right of Venus, and on the 17th, above and to the t of Venus.

March 20: The sun arrives at the vernal equinox at 9:10 ., EST. Winter comes to an end and spring commences the Northern Hemisphere. In the Southern Hemisphere, on other hand, this date marks the end of summer and the ginning of autumn.

March 31: On the last day of the month, Mercury and Jupiter are in conjunction, but both are too close to the sun in the evening sky to be visible.

Venus and Jupiter are evening stars in March, Mars and Saturn are morning stars, and Mercury moves from the morning to the evening sky during the month.

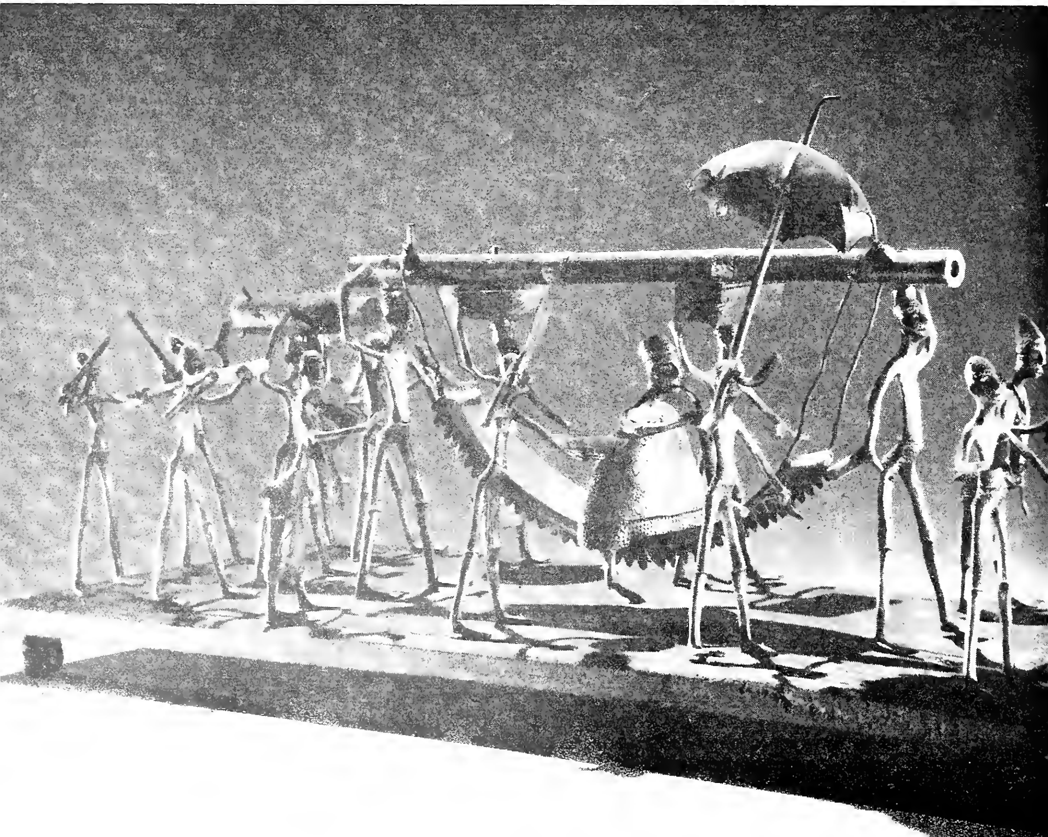
Mercury, which enters the evening sky on March 13, is too close to the sun for observation during most of the month. By the 31st, however, the magnitude of the planet is 0.7, and it may be seen low in the west soon after sunset. Mars and Saturn, although morning stars, are too close to the sun to be visible during March.

In the evening sky, Jupiter is easily visible in the early part of the month, setting approximately three hours after sunset. By the end of the month, however, the planet is too close to the sun for observation. Venus continues to separate from the sun throughout March and it continues to become brighter, attaining magnitude −3.9 on March 31. During the entire month, Venus first appears high in the western sky soon after sundown and it remains visible for nearly three hours. By the end of March, Venus is approaching the Pleiades, the familiar star cluster in the constellation Taurus.

TRIBAL ART FROM AFRICA

Dahomean sculptors capture life with precision, conviction, and wit

By COLIN M. TURNBULL Photographs by LEE BOLTIN



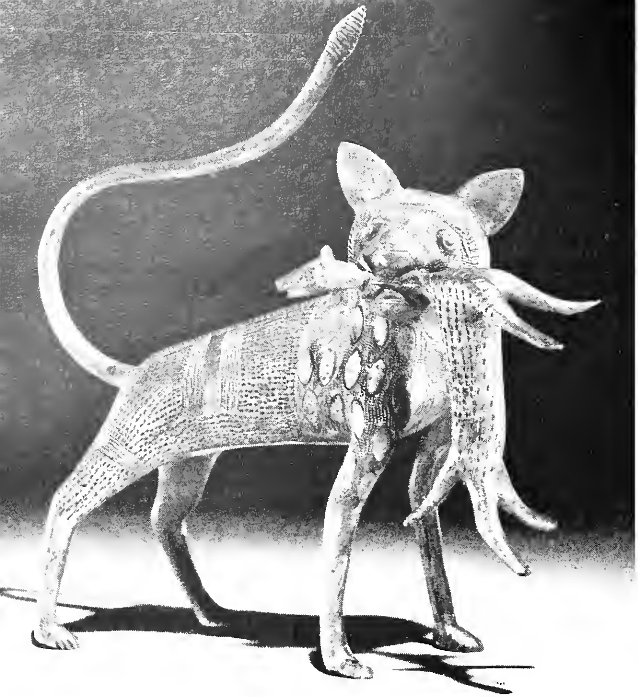
Royal procession, like works on facing page, is cast in brass.

Dahomean horseman cocks and aims his rifle.

Elder appears in the trappings of a wise man.

Brass genre figurines made by the tribesmen of Dahomey—formerly a part of French West Africa but now an independent republic—are often passed over by connoisseurs of African art because such sculpture is of very recent origin. To the eyes of some Western collectors, the figures may also seem to be inferior aesthetically to older forms of African wood and metalwork. Nonetheless, Dahomean figurines merit attention because they represent an important type of African art. The bulk of so-called African art is actually craft. However beautiful the execution of a sculpture may seem to a non-African collector, beauty has little if anything to do with the value placed upon the work of art by the tribesman. For him, the prime purpose of what we call art lies in its traditional context and in its fulfillment of a very specific function, usually ritual. Dahomean figurines seem to have been made first for the sole purpose of pleasing a nineteenth-century tribal king; these were used to decorate the royal palace at Abomey. In this respect, that is, as aesthetic decor, Dahomean figures more nearly meet some present Western standards for fine art than do the older, more sought-after African ritual carvings.

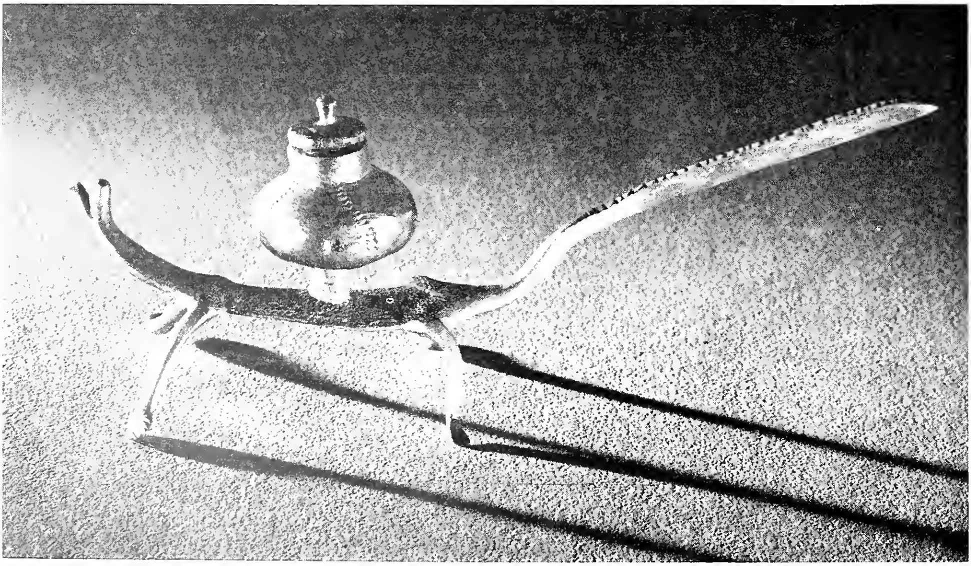
Today, Dahomean figures remain faithful indicators of the tribe's focuses of interest. The large royal procession pictured on this page conveys the vitality of a tribal group united in the belief that all men are descendants of the living king. Other figures shown on these two pages—all cast in brass—illustrate a reliance upon strength of arms for the tribe's security, and the respect paid to the wisdom that, throughout all Africa, is assumed to accrue to the community's aged.



Preying jackal probably carries domesticated animal.

Menagerie of totems and death symbols

Back of a totemic alligator supports a small oil lamp.



Standing on man it has killed, leopard symbolizes death.

Among the major interests of Dahomean tribesmen is the wild animal population that shares their environment. Some beasts, like the young gazelle shown below, are regarded mainly as sources of food; others, like the jackal, are feared because they attack and carry away domesticated animals on which the tribesman's livelihood may depend. Large predators, such as the oversized leopard shown here standing on a man's chest, are both feared and respected. In this example, the leopard is a symbol of death itself: unpredictably, silently, swiftly, death will strike man down. Nearly all animals may be subjects of the craftsman's art because they are thought of as totemic insignia. They are not direct representations of ancestors, but instead are the heraldic images by which various families identify themselves.

This young gazelle has importance as a source of food.

Archer and others on these two pages are aluminum.

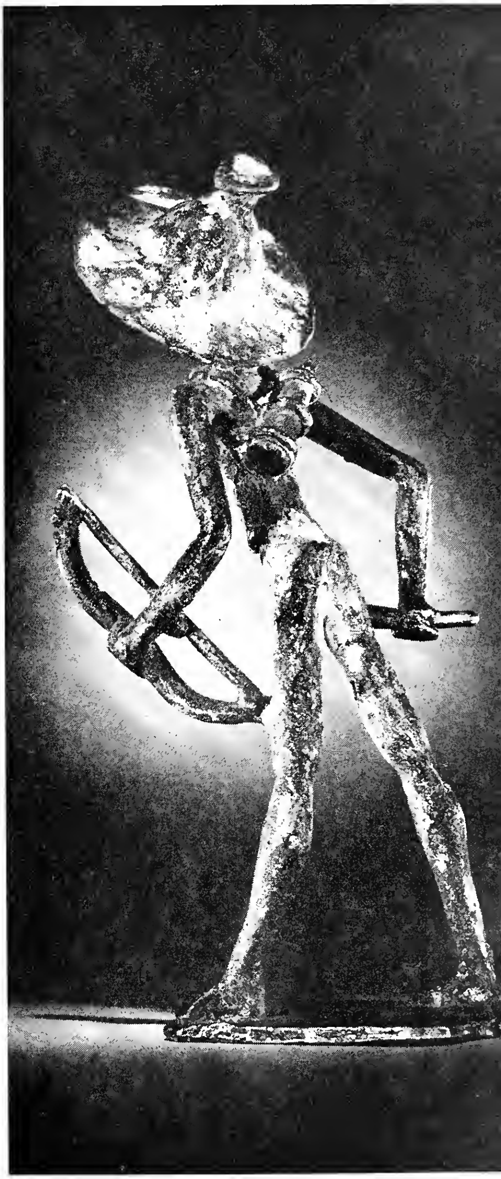
This woman pounds rice in a traditional tribal method.

Inland representational figurines

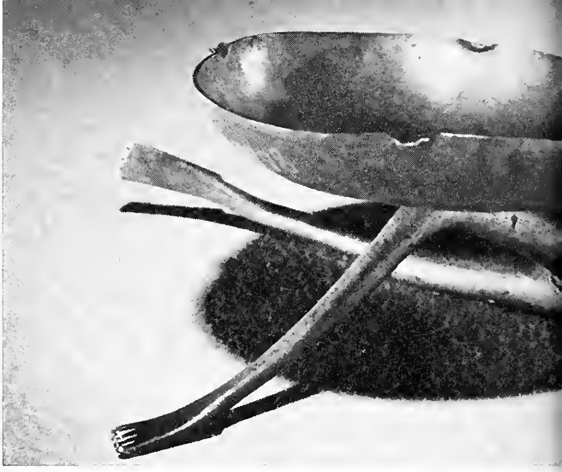
Goat is important part of the wealth of African family.

xhibiting a more primitive style than Dahomean
stal figurines, these examples of the sculptor's art
re produced further inland. They result from a cast-
process similar to that used elsewhere, but they
made of light aluminum alloys rather than pure
ss. The symbolism of sculptures shown on these
ges differs from that of the menageries and pro-
sions seen on preceding pages. Here, figurines
ebrate everyday sights—men hunting; a woman with
rtar and pestle; a cock; a lolling, domesticated goat.

Around some villages, strutting cock is familiar sight.



With quiver, bow, and club, hunter pursues his quarry.



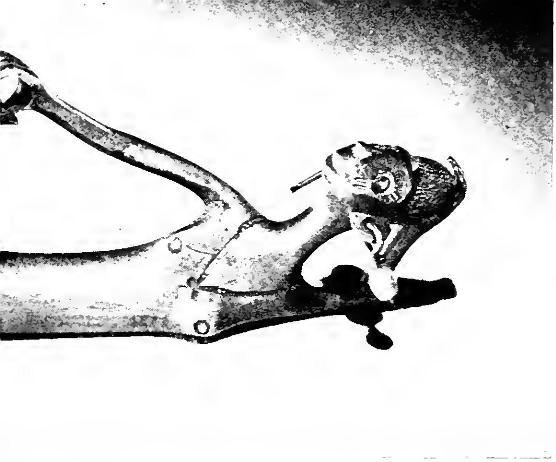
Dahomean humor is manifest in this caricature of a lazy female.

Sophisticated modes of the tribal artist

Tribeswoman gracefully supports native wares on her head.

It is perhaps the sophistication of subject matter and treatment that is the most outstanding feature of this art from Dahomey. One sculpture, shown here at left, is the representation of a domestic scene, accurately portraying a humble activity in a naturalistic manner. The photo at the top of the page pictures a caricature in metal that pokes subtle fun at the vain preoccupations of a woman of the tribe. And, at right, is shown a figurine that conveys with exceptional power another woman's deep underlying sense of religious devotion.

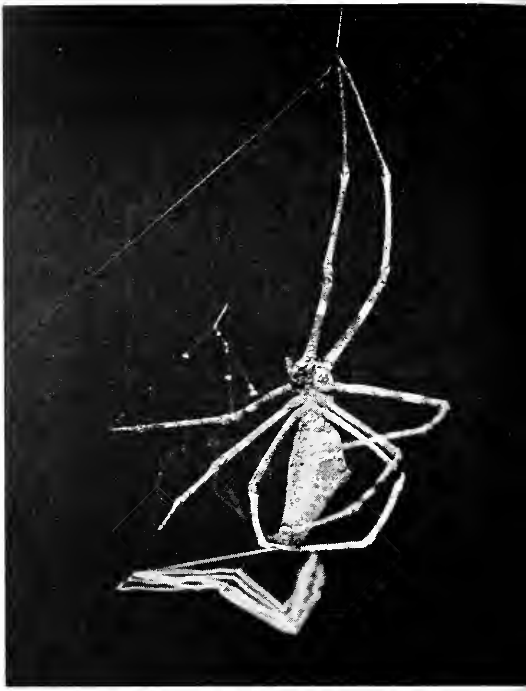
Life, to the tribal African, is not made up of separate activities performed at set times for set motives; it is an integrated whole. As seen on this and previous pages, every aspect of life, however prosaic, may be thought worthy of the attention and respect of tribal artists. The production of their figurines was encouraged under the French and became an important tourist industry. Nevertheless, today such art remains a valid expression of African culture.



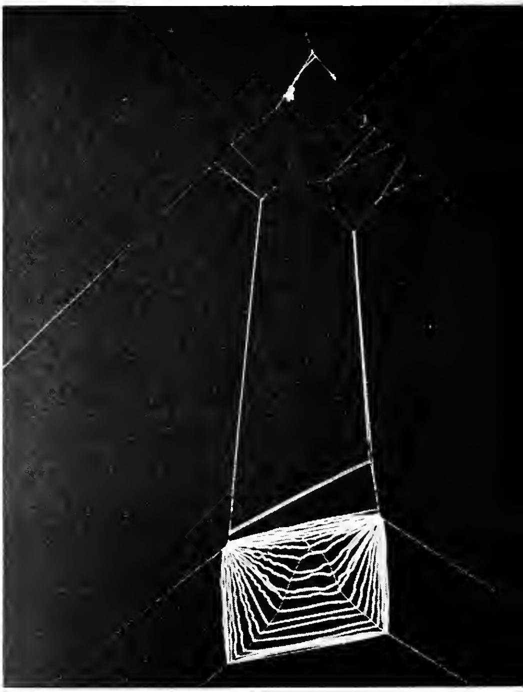
'igure of a woman, below, might suggest her deep religious feeling.

NATURALISTS' NOTEBOOK

PREDATOR NETS A SUGAR ANT

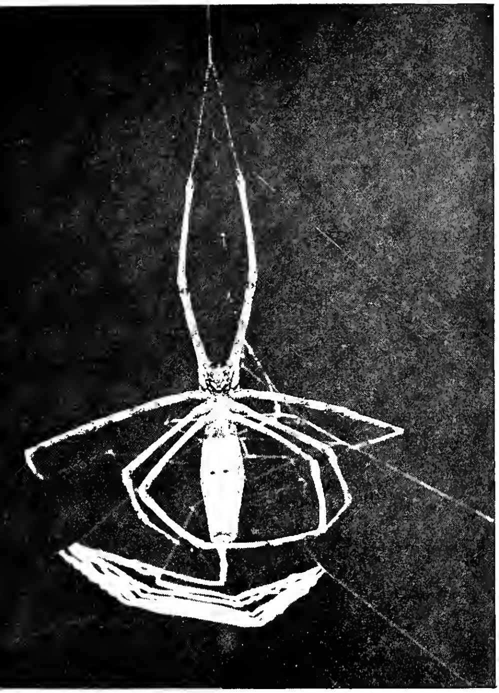


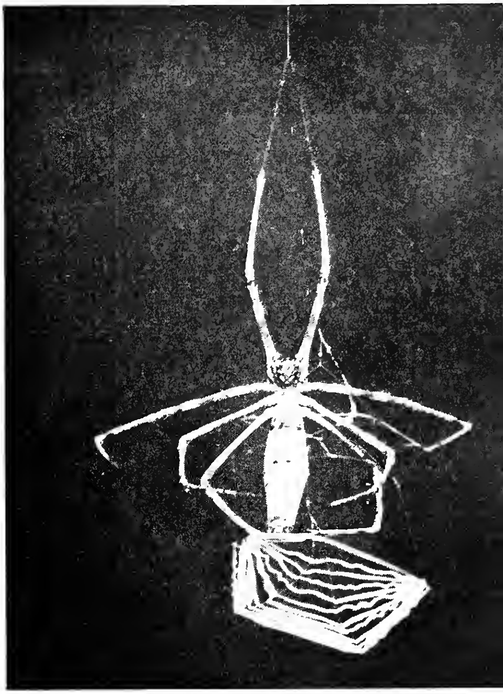
Storied Australian spider hunts by throwing web

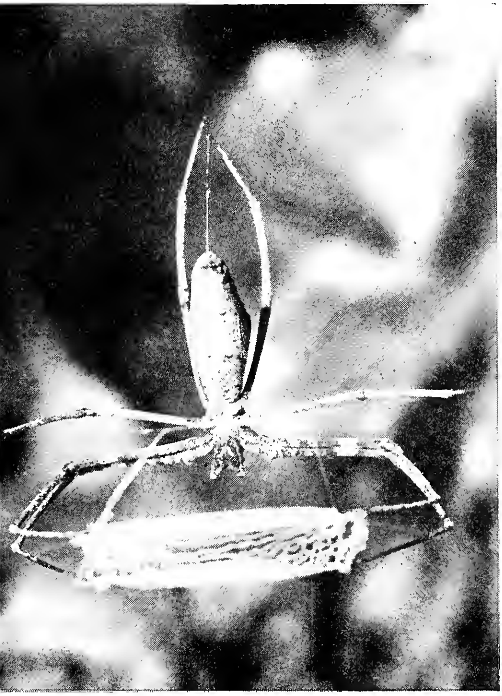


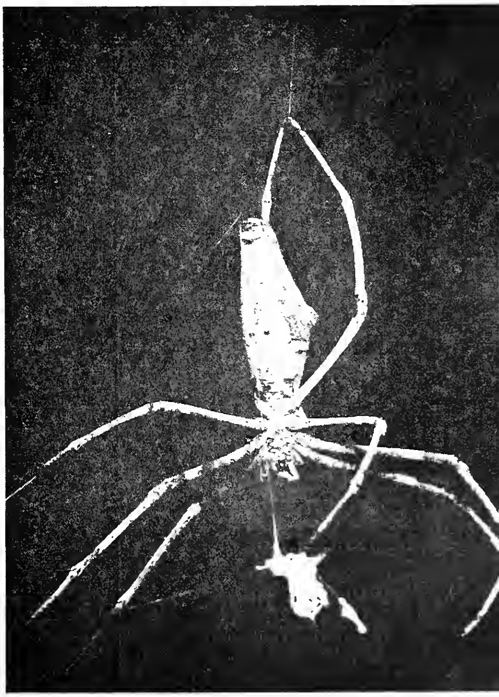
TALES OF A SPIDER that casts a net over its prey have long been related in South Africa and Australia. The Australian netting spider *(Deinopis subrufa)*, shown slightly larger than life-size in this picture sequence, practices this strange predatory method. It is a member of the family Deinopidae, which comprises the cribellate spiders. In the United States, only one genus of Deinopidae with one species is known—the ogre-faced spider *(D. spinosus)* of Florida and Alabama.

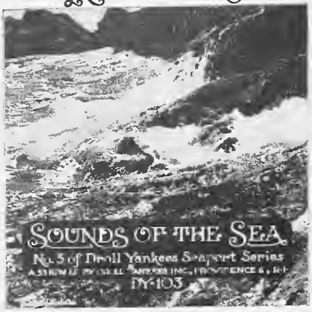
At the top, a long-bodied female Australian netting spider is seen supporting herself on a guy strand as, with her fourth pair of legs, she combs out the first fluffy threads from the spinnerets (organs for producing threads of silk from the secretions of the silk glands). In succeeding frames she is depicted in more-advanced stages of web-construction. Below, at right, is the finished web suspended from support threads. The spider takes hold of the corners of the web and awaits her prey, in this case a sugar ant. She then stretches the web taut and hurls it down over the ant, as seen in the final picture. Afterward, the voracious spider ingests both the ant and web.











About the Authors

DR. ALAN RICHARD SCHULMAN, author of "Siege Warfare in Pharaonic Egypt," is an Egyptologist who is currently teaching in the History Department of Columbia University. In addition to his teaching activities, Dr. Schulman—under a grant from the American Philosophical Society—has been engaged in research on the cult of Ptah at Memphis, as depicted on private stelae from that site. He is also a Fellow of the American Council of Learned Societies and is a member of the American Research Center in Egypt. Dr. Schulman's field work includes participation in the 1962 Joint Excavation of the University Museum (University of Pennsylvania) and Peabody Museum (Yale University) in Egyptian Nubia.

The distribution of grizzly bears—past and present—is the subject of DR. A. W. F. BANFIELD's article, entitled "Grizzly Territory." The author is Chief Zoologist of the National Museum of Canada, in Ottawa. Before assuming his present position. Dr. Banfield was Chief Mammalogist of the Canadian Wildlife Service, Department of Northern Affairs and National Resources. Among Dr. Banfield's special interests are feeding habits of the short-eared owl, big game management, barren-ground caribou investigation, Arctic mammalogy, and systematics.

DR. VIRGIL N. ARGO, an entomologist who has written previously for NATURAL HISTORY, wrote the article about insect-trapping plants. Before his retirement, Dr. Argo was Associate Professor of Biology at The City College of New York.

"Psychophysics and Hearing in Fish" is the work of DR. WILLIAM N. TAVOLGA, Research Associate in the Department of Animal Behavior at The American Museum and an Associate Professor in the Department of Biology at The City College of New York. Dr. Tavolga's studies include the embryology of teleost fish, fish parasitology, endocrinology and behavior of fish, and underwater sounds.

Vagaries of various calendar systems and why they occur are explained in this month's "Sky Reporter" column, which is regularly presided over by DR. THOMAS D. NICHOLSON. Dr. Nicholson is Assistant Chairman and Astronomer at The American Museum-Hayden Planetarium.

In "Tribal Art from Africa," MR. COLIN M. TURNBULL discusses the origins and significance of Dahomean figurines made of brass and aluminum alloys, and their equivocal position in the field of African art. Mr. Turnbull is Assistant Curator of African Ethnology in The American Museum's Department of Anthropology, and is the author of *The Forest People* and *The Lonely African*. The photographs of the figurines that illustrate the article were made by Lee Boltin.

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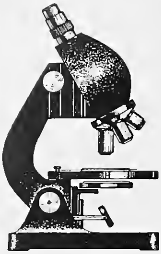


NATURE and the MICROSCOPE

Looking closely at light

By Julian D. Corrington

It is essential to understand something of the nature of light and what happens in its passage through the object and the microscope. Theories in optics lead into the most rarefied areas of higher mathematics, but a few of the simpler principles can be of great assistance to the microscopist. Light is one manifestation of radiant energy, the type of kinetic energy that radiates away in all directions from its source. Light constitutes one octave in the whole electromagnetic spectrum, which includes radio waves, high-frequency waves, microwaves, infrared rays (heat), ultraviolet rays, X rays, and cosmic rays.

All of these emanations have certain features in common: they are produced by a power source, such as an electric generator, a radio transmitter, a hot stove, the sun, an electric light bulb, a cathode tube, or by atomic disintegration; they proceed in wave fronts that are vertical to the line of propagation and pass in all directions at a uniform velocity of 186.285 miles per second; they travel in straight lines (rectilinear propagation); their course and velocity may be altered if their progress is impeded, giving rise to absorption, reflection, refraction, diffraction, and interference, which are important in microscopy.

The various forms of radiant energy differ from one another in the frequency of their vibrations (number per second) and the consequent wavelengths; in their source and in the type of receiver adapted to their recognition, such as radio receivers, heat-sensitive corpuscles in the skin, or rod and cone cells in the retina of the eye; and in our psychological interpretation of them.

Early Theories about Light

Those emanations toward the lower end of the spectrum are designated as *waves* (radio waves, microwaves), whereas those toward the higher end are *rays* (X rays, cosmic rays). This reflects the dual nature of all the forms of radiant energy and recalls the history of their discovery. In the seventeenth century Newton advocated a corpuscular, or emission, theory of light, regarding it as made up of minute particles, like ultramicroscopic bullets shot from the source. The gamma rays of radioactive nuclear disintegration would be a modern example. Newton's contemporary adve sary was Huygens, who argued for wave theory of light, contending th light does not consist of matter at al but of undulatory vibrations propagate as waves in a hypothetical "ether."

Owing to the great influence of New ton upon scientific thought, the corpus cular theory dominated in his day an throughout the eighteenth century. A the beginning of the nineteenth centur Young, and later Fresnel, demonstrate that the phenomena of diffraction an interference demanded an undulatory, c wave, theory of light, and the emissio theory was abandoned. Maxwell showe that light waves were electromagneti waves of a particular band of frequen cies. With the twentieth century cam the discovery that a beam of light pla ing upon the cathode of a photoelectr cell causes the production of an electr current. This phenomenon, called th photoelectric effect, demanded a retur to the corpuscular theory of light. More over, Planck showed that the energy c radiation was not emitted continuousl but in discrete packets, which he calle quanta. A quantum of light energy wa designated a photon.

Early in this century, physicists teach ing optics were in a difficult positio One wag suggested that professors teac the corpuscular theory of light on Mo days, Wednesdays, and Fridays, and th wave theory of light on Tuesdays, Thur days, and Saturdays. Today light is r garded as an emission of photons a companied by wave action, but a fu explanation of this dualistic interpret tion and reconciliation of conflictin views remains a task for future scientist

Vibrations Cause Waves

When a stone is thrown into a qui pool of water we see concentr circles of waves spreading outward, ar it is difficult to realize that water part cles do not move outward from the cent of the disturbance. On a windless da for example, a cork in the path of th waves bobs up and down but does n move laterally. Vibrations, then, resu in undulations, which are measured frequency (the number of vibrations p second); in wavelength (the distan from the crest of one wave to the crest the next); and in amplitude (the amou

he vertical displacement of a wave).
1 the electromagnetic spectrum,
sehold electricity of the 60-cycle al-
ating current variety consists of
es with lengths measured in thou-
ds of kilometers; wireless and radio
es are hundreds of meters long;
t radio waves and microwaves are
isured in meters and centimeters.
h infrared, we need new yardsticks
void unwieldy figures. The common
isurement for objects seen under the
roscope is the micron (μ), a thou-
dth of a millimeter; the millimicron
ι) is the thousandth part of a
ron; and finally the Angstrom (A) is
ten-thousandth of a micron. Since all
isurements in modern physics use the
imeter (cm.) as the standard unit, a
imeter is 0.1 cm., a micron is 0.0001
a millimicron is 0.0000001 cm., and
Angstrom is 0.00000001 cm., the hun-
l-millionth part of a centimeter.

Shorthand" for Big Numbers

HESE are extremely awkward figures
o use and they invite typographical
rs. Therefore the denary system—in
ch the number of zeros is expressed
exponents—is now almost universal.
he denary system a micron is 10^{-4}
a millimicron is 10^{-7} cm., and an
strom is 10^{-8} cm. Millimicrons and
stroms are used in measurements of
elengths of light, ultraviolet, X rays,
ma radiation, and cosmic rays. The
d in the spectrum occupied by
elengths of visible light runs from
0^{-5} to $4x10^{-5}$ cm., which can also be
essed as 8,100 to 3,900 A. The fre-
ncy of light waves runs from $4.3x10^{14}$
$.5x10^{14}$ vibrations per second.
igures in such categories stagger the
gination. It is easy to understand
physicists are not fond of trying to
ent mechanical models for the lay-
, but themselves deal almost wholly
mathematical expressions. The ve-
ty of light is such that an electro-
netic wave in the light band (or any
r) will travel more than seven times
nd the earth at the Equator in one
nd. Light from the sun, at a distance
3 million miles, will reach the earth
little more than eight minutes, and
1 Alpha Centauri, the nearest star,
ur years. Astronomical distances are
red in light-years, the distance a
e of light travels in one year, and far-
y galaxies are on the order of two
on light-years from earth. This
ns that we view them, as with the
-inch telescope on Mount Palomar,
as they may be today but as they
e two billion years ago.

Phenomena that Affect Light

SERS of optical instruments, such as
the microscope, are particularly in-
sted in what can happen to a ray of
t as it proceeds from its source.

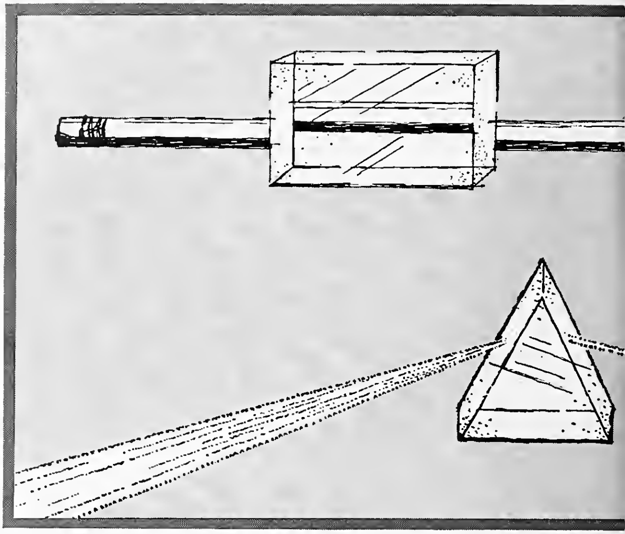


IMAGE OF PENCIL seen through a block of glass does not line up with object

because of deviation. Prism breaks wh
light into spectrum through dispersion

Light, like other emanations of the electromagnetic spectrum, can show absorption, reflection, refraction, diffraction, interference, and the Doppler effect when its passage is impeded. We discussed reflection in NATURAL HISTORY, November, 1963, so we will now define the other effects briefly.

Radiant energy may be absorbed by the substance upon which it falls. Thus a black cloth will absorb more and reflect less light than will a white cloth. A certain amount of the light passing through lens systems in a microscope will be absorbed and lost, and this is one reason why high-power optical systems, with their numerous optical components, require stronger illumination than do low-power objectives.

Refraction is the bending of light rays as they pass from a medium of one density into another medium of a different density, as from air into glass. This bending, also termed deviation, enables the construction of glass lenses that diverge or converge light rays that pass through an objective and, along with diffraction, permits the formation of magnified images.

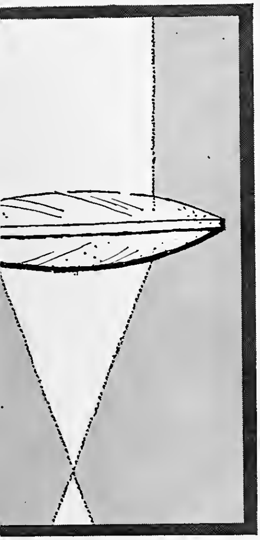
Diffraction is the slight bending of light rays as they pass by an edge of an opaque body or through a narrow slit. To observe this phenomenon, cut a slit in a card, hold it close to and directly in front of one eye, and look through the slit toward a light. You will see a number of fine black vertical lines in the slit that are spurious images of the slit caused by diffraction. A fine-toothed comb makes another good demonstrator. Light diffracts around particles in the
fine detail of an object observed w
the microscope, and continues on to
produce this detail in the image.

Interference occurs when beams
light from two different sources hit t
same target. If the two waves arrive
phase—with their crests coinciding—i
constructive interference, or reinfor
ment. If they arrive out of step by h
a wavelength, so that the crest of c
wave coincides with the trough of t
other, we have destructive interferen
or cancellation. Thomas Young, ab
1803, demonstrated to amazed Lonc
audiences that it is possible to achi
blackness on a screen by throwing t
beams of light upon it if they are out
phase. Thus, the alternating light a
dark bands seen when looking throu
the slit in the card or the teeth of a co
result from the combined effects of c
fraction and interference.

Apparent Frequency Changes

THE Doppler effect—which is impo
ant astronomically but has no be
ing on microscopy—occurs when t
emission source, the observer, or b
are in motion with respect to each oth
If you approach the light source y
will encounter more waves per seco
than if you stand still, and if you retr
you encounter fewer waves per seco
This means, for example, that there
an apparent increase in frequency a

DR. CORRINGTON, who is well know
in the field of microscopy, recentl
retired as Professor of Zoology a
the University of Miami in Florida



ıvex lens refracts a beam of light
ıat the light is brought to focus.

ease in wavelength of light from a ınt galaxy of stars if that galaxy is oaching our own, and the converse is receding.

ght also exhibits the phenomenon olarization, and certain microscopes accessories are designed for use with rized light. This subject will be ed in a future column.

ne of Newton's important discoveries that white light, as from the sun, be broken up into a rainbow of col- by passage through a glass prism. distinguished red, orange, yellow, n, blue, indigo, and violet, each color ding into another to form a con- ous spectrum. This is the phenom- of dispersion, which occurs because e light does not consist of uniformly ogeneous wavelengths, but is com- d of all those between 8,100 and 0 Angstroms. Each wavelength re- ts at a slightly different angle as it es from air into the prism and out air again. The longer wavelengths refracted less than the shorter waves, ch bend more sharply, so the beam white light is spread out into many nct components. Actually, they are colored; they are simply electromag- waves of differing lengths, but sub- ively they appear to us and to certain r animals as colored bands. They ct nerve endings in the eye and pro- the psychological sensations we call r. We see longer wavelengths as red range, shorter ones as blue or violet. otally color-blind person lacks this ity to see color; everything appears arying tones of gray. Newton carried experiment further by placing a sec-

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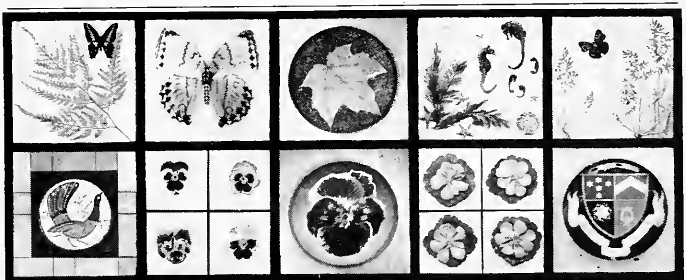

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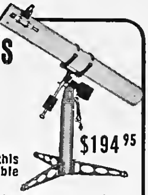

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ond, inverted prism after the first one. The second prism recombined the spectral color band into white light.

Aberration and Magnification

ONE conclusion that must be drawn from Newton's experiments is that we cannot refract light without breaking it up: deviation compels dispersion. Lenses for the microscope or telescope must cause deviation of light in order to produce magnification, but the concomitant undesirable dispersion causes color halos in the enlarged image. In the early days of optical instruments, microscopes and telescopes had single lenses and the objective was called an object glass. Today we refer to such objectives as uncorrected. In contrast, modern objectives contain optical elements made up of two or more lens components that are calculated to cancel out each other's deficiencies as much as possible. These objectives are called corrected and are termed achromatic (without color), although correction can never be perfect.

So objectionable was the chromatic aberration of early instruments that Newton and later observers gave up making refracting telescopes and turned to designing reflecting telescopes that used the concave mirror. Since light rays do not enter the mirror but are reflected from its surface, there can be no dispersion and hence no chromatic aberration. Today we use both kinds of telescopes, but the reflectors are superior for observations of such far-distant objects as galaxies. Reflecting microscopes have also been made but have not as yet established themselves as successful competitors with the usual refracting instrument.

The case of the spectroscope is very different. Here, dispersion is the essential phenomenon in providing what the operator desires—a spectrum. A slit light source passes rays through a prism and the resultant spectrum is examined with a low-power telescope. Thus the physical occurrences of deviation and dispersion play their various roles in our three primary families of optical instruments.

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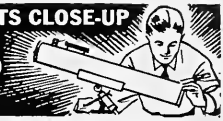

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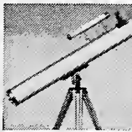

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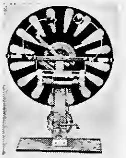

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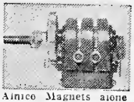

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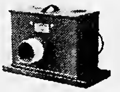

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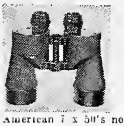

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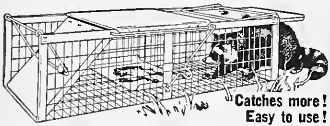

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"The *n'rn* at the Battle of Kadesh." A. R. Schulman. *Journal of the American Research Center in Egypt*, Vol. I, pages 47-53, *Boston, 1962.*

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Spiders, Scorpions, Centipedes and Mites. J. L. Cloudsley-Thompson. *Pergamon Press, N.Y., 1958.*

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y Air and River Boat to the Sites and Temples of Egypt and Nubia Tours depart on November 6 and November 27. Guest lecturers accompanying the two cruises are: r. T. G. H. James, M.A., Asst. Keeper of Egyptian Antiquities at the British Museum. essor H. W. Fairman, M.A., Professor of Egyptology at the University of Liverpool. Professor C. A. Trypanis, M.A., Ph.D., the University of Oxford. These Nile Cruises have been immediate "sell-outs" in the past, due to the high quality of leadership and services provided.

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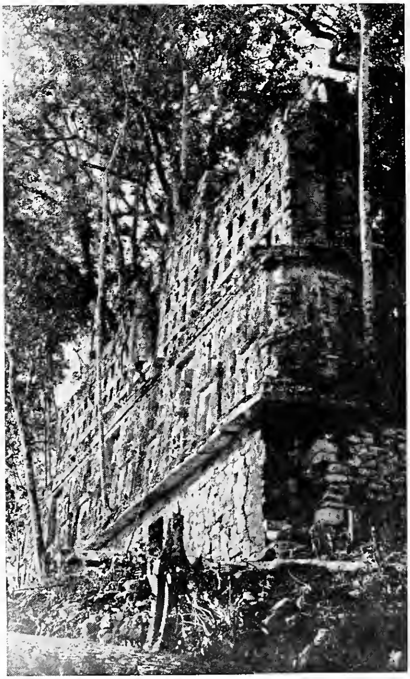

Natural History

Incorporating Nature Magazine

THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTO

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COVER: The polychromatic, dragon-like apparition rearing up from the twig which it rests is a caterpillar of *Brahmaea wallichii*, a moth that is found India and parts of Southeast Asia. The larva shown here is in its fifth inst and has consequently shed—with its old skin—the four hornlike head process that lent it a formidable appearance in previous stages. Pale blue opalesce spots, two of which are visible in the picture, replace the processes and lo like eyes when the caterpillar assumes this defensive position. The photogra was taken by Paul Villiard, whose article about caterpillars begins on page 2

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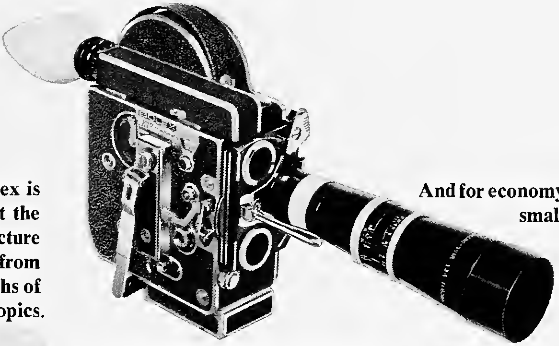

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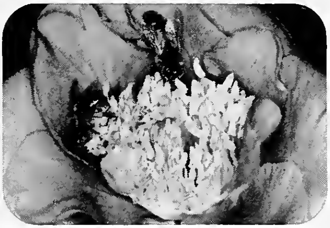

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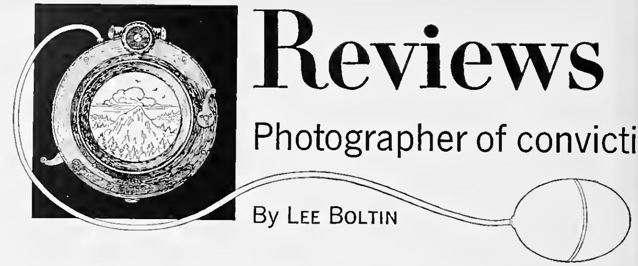

Reviews

Photographer of convictio

By LEE BOLTIN

THE ELOQUENT LIGHT, text by Nancy Newhall, photographs by Ansel Adams. *Sierra Club, $20.00; 175 pp., illus.*

THE miracle of photography is so much an accepted element of our time that, sadly, little notice is made of its many variables. The large area this system of reproduction embraces is too often considered commonplace. There is, however, a range beyond the ordinary spectrum of photography that few practitioners of the art achieve. For, while there are thousands of users of the photographic system, there are comparatively few true photographers. Several conditioning factors are involved: one is time—time in the sense that so much has gone before that an uncommon approach is not easily come by—another is conviction. The making of a photograph must be by conviction, else routinely and sadly, it is simply a job, with a correlative banality and boredom. As Nancy Newhall shows in her book, Ansel Adams grasped time and, ignoring previously established patterns, brought a new clarity and a new depth to his expressive use of the camera. The sense of conviction is evident in every photograph printed, and there can be no question as to what the photographer sought and what he achieved.

Ansel Adams is one of the formidable giants, pioneers, convinced practitioners —call it what you will—of the photographic art. Perhaps it was his good luck that he was born and raised in that faraway California of sixty years ago, but the strong feeling that comes from this ideally printed volume assures the reader that the man embraced his environment and extracted from it the elements on which to nurture himself. He then returned its gifts many times in his life's work. By the second decade of the century he was an accomplished musician and could have elected a career as a pianist. Happily for his inheritors he chose to express himself in photography, and thus left a wondrous legacy of visual images—pertinent and wise comments on what can be contained in photographic expression. As a battler for conservation he stands above the crowd.

Mrs. Newhall, Mr. Adams, and the Sierra Club are to be complimented on this handsome work. In a time when the so-called art books are redundant, first part of a two-volume biograph Mr. Adams is unique. Perhaps beca I, too, am a toiler in the photogra vineyard and thus know that ph graphs are seen in their original qua by very few, I also know that the mate form on the printed page suffe major loss in quality and presence. I therefore, with particular pleasure I salute the book's engravers and pr ers. They prove that a photogra image in reproduction can bring the of the photographer to each viewe though he were the possessor of an or nal print. *The Eloquent Light* tells be tifully of an eloquent man.

FLIGHT, by Jacques F. Ormond. *Hill Wang, Inc., $6.95; 92 pp., illus.*

THE poetry of flight is achieved in volume of European photogra Rarely has the world of wings b given such coherent expression. tempo of visual change is beautif realized and, with minor exceptions, book accomplishes its purpose.

A small cavil is the quartet of drawings and renderings that are sup fluous, and nothing is gained by author's comments on his photograp technique. This is essentially a coll tion of photographic illustrations an needless burden of words does noth to improve the effect of the pictures.

The book begins with a striking p ture of a night heron in climbing flig the power of the wing stroke formi a pattern of strength and line that fa lessly conveys the sense of a rise towa the sky. Immediately following t opening we are exposed to a hodgepod of woodcuts that almost founders t work. Fanciful they doubtless are, b their inclusion reduces the impact the photographs in the early pages the book. It is only after this false st that the sense of soaring, fluid flight presses itself again; and it contin ever stronger until the conclusion. foldout at the end of the book supplie complete listing of the picture and bi identifications. Buy it and fly!

Mr. Boltin, who acts as contributi photographer for Natural History, known for his pictures of primitive a

KES, by H. W. Parker. *W.W. Norton ., $5.95; 191 pp., illus.* SNAKES OF CA, by Richard M. Isemonger. *as Nelson & Sons, $4.00; 236 pp.,* LIFE WITH IONIDES, by Margaret . *Viking Press, $5.00; 180 pp., illus.*

w human beings can ignore snakes. lost of us know at least enough t them to be biased, whether we re- them with suspicion, fear, awe, re- on, or admiration. For snakes, ugh they evolved much later than other major group of reptiles, moved nearly all habitable parts of the d long before man did, and he en- tered snakes virtually everywhere— he penetrated the coldest regions. omous snakes closely resembling can cobras inhabited Europe when ncestors were just beginning to di- e from the apes. For more than ty million years, therefore, we have associating with snakes and worry- bout them.

r knowledge of snakes in recent s has expanded almost as rapidly as lemand for new books dealing with . Of the three new books reviewed , two are about snakes themselves one recounts the exploits of a snake er in Africa. Despite some overlap eir coverage, these books differ as ly as the backgrounds, interests, and s of their respective authors.

. W. Parker, long recognized as the ing British herpetologist, provides most erudite of the three accounts in *Snakes.* Without resorting to techni- argon, he deals with snakes from the dpoint of the anatomist, the ecolo- and the student of animal behavior. ough earlier books on snakes also r such topics as locomotion, feeding, oduction, and sensory mechanisms, ker adds new information or novel rpretations to his discussions. His k is avowedly a summary, but never- ess it contains an impressive amount nformation in fewer than two hun- l pages. The style is lucid, despite ker's tendency to ride for a page a half without changing paragraphs. *nakes of Africa* is more provincial overage and is intended primarily as ide to the snakes found south of the ara and east of the Congo. Richard Isemonger's chatty discussions of hs, venom, snake-catching, and simi- topics make it readable. The author's st entertaining accounts are those de- bing his personal adventures. His cussions of reptiles outside the con- s of Africa, however, reveal a woeful k of knowledge.

or obscure reasons a chapter entitled vana Nyoka" is inserted between the s of species and their peculiarities. ana Nyoka proves to be an intelli- t, engaging non-conformist, C. J. P. ides, who went through Rugby and Sandhurst before he became a snake hunter—and something of a celebrity—in Tanganyika.

He receives fuller treatment in Margaret Lane's *Life with Ionides,* which provides a sympathetic but unbiased account of life in this part of Africa, where the author stayed with the old hunter. In her well-written book she describes Ionides, seen from the side, as having the appearance of "an emaciated and aristocratic goat." Miss Lane's descriptions of snakes and other animals are equally as interesting.

The illustrations in all three books vary in quality from good to inferior. Parker's book could profitably have been better illustrated; Isemonger's book contains a few plates in color that are not bad, but the figures leave much to be desired; Ionides appears in several of the plates in Miss Lane's book, along with his African assistants, a snake or so, and occasionally a photogenic young lady. Presumably this is Miss Lane, who describes the difficulties she encountered in her efforts to obtain photographs of snakes. Those reproduced show that she was not exaggerating. Her talents are those of a writer, not of a photographer.

C. M. BOGERT
The American Museum

THE REPTILES, by Archie Carr. *Time, Inc., $3.95; 192 pp., illus.*

THIS is a scientifically impeccable account of reptiles—their place in nature, their relationships and history, and their way of life. Dr. Carr is to be complimented on his clear, well-written, and well-organized text dealing with the reptile "fraternity." The editors of the "Life Nature Library" also deserve praise for their selection of illustrations, many of which are photographic firsts of outstanding interest and merit.

Too often in popular books on natural history, the public is cheated with a tired and jumbled rehash of third-hand information, but not in this book compiled by an outstanding herpetologist, who is a dedicated naturalist and a fine writer.

The reader, if this is his introduction to the world of reptiles, should learn a great deal. He should also assimilate some of Dr. Carr's empathy and true understanding for this frequently persecuted group. The gruesome fascination that leads many people to their first contact with reptiles may be dispelled by new insight that can be gathered here. Reptiles have had a long and diversified history—they "ruled" the earth, only to fall from their seat of biological dominance. But their descendants are still about us, leading their respective cold-blooded lives in many ways.

Dr. Carr's final chapter is an unsentimental reminder that the destruction of all primitive nature, including the reptiles, is but a matter of time, unless humanity's conscience and responsibility are somehow awakened. He visualizes, sometime in the future, the last snake as it confronts a man. The latter unthinkingly picks up the last stick lying on the ground. He raises the stick, then lowers it, then raises it again. Dr. Carr's vision fades at this point.

More books like this one may make such a vision more remote.

GEORG ZAPPLER
The American Museum

1001 QUESTIONS ANSWERED ABOUT FLOWERS, by Norman Taylor. *Dodd, Mead & Co., $6.00; 335 pp., illus.*

THE question-and-answer method of nature study instruction lends a certain zestful and entertaining quality to a self-teaching text such as the present book, which is similar in format to the previously published titles in the popular "1001 Questions Answered" series.

Norman Taylor, the well-known author of numerous botanical and horticultural works and editor of *Taylor's Encyclopedia of Gardening*, has arranged his 1001 questions and answers in eight main categories and has subdivided these under more specific subjects. The major groups include: "Form and Function of Flowers," "The Orchids," "Eastern Wildflowers," "Western Wildflowers," "Older Cultivated Flowers," "Cultivated Flowers Today," "Flowers from Trees and Shrubs," and "Some Tropical and Subtropical Flowers." As examples of the smaller sections, under "Eastern Wildflowers" we find: flowers in swamps, bogs, or water; flowers in moist places; woodland flowers; shrubs and trees; flowers in open, but not dry places; flowers in open, dry places; introduced flowers.

Here is a helpful, informative book for junior groups and a refresher-stimulant for older readers. An excellent index adds to its usefulness as a ready-reference guide.

ELIZABETH C. HALL
N. Y. Botanical Garden

BIOLOGY OF BIRDS, by Wesley E. Lanyon. *Natural History Press.* Paperback, *$1.25; 186 pp., illus.* Cloth, *$3.95; 175 pp., illus.*

BIRD biology books used to be few in number; they dealt with such topics as fossil record, comparative anatomy, feathers, migration routes, schedules, and breeding habits. Of late, general treatises have been bulky and costly or rather limited in coverage. Lanyon's book is of field guide size. It includes the older standard topics, usually tersely ("Classification of Birds" gets twenty lines), then goes beyond into many of the concepts from the current broad spectrum of avian biology. The reader encounters the biological species, the physiological basis
migratory behavior, navigation, orien
tion, habitat selection, functions of
plays, population turnover, and so on
smattering of fairly technical terms (
ample: Homoiothermy) are defined w
used. The sixty-four illustrations rel
closely to the accompanying text; sc
is worldwide. There is an appendix
vernacular and technical names, sugg
tions for further reading, and a good ind

Anyone with a field guide level of
terest in birds will do well to broa
his store of general information by re
ing this book. It will impart an idea
all sorts of variations in birds and p
vide an introduction to the diversity
approaches currently applied to study
the living bird. This is a good book, av
able at a modest price.

RALPH S. PAL
Univ. of the State of New Y

THE VIEW FROM A DISTANT STAR,
Harlow Shapley. *Basic Books, In*
$4.95; 212 pp.

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name of any living astronomer. What
has to say about *Homo sapiens*—his pla
in the universe, his possible chances
survival wherever in the universe he m
have appeared, and what he had bett
do to insure that survival—is well wor
reading and pondering.

Many men have written about the i
possibility of complex life on any of t
other planets of the solar system a
about the statistical possibility of life
planets in orbit about stars other th
the sun, but few have done so as well a
as excitingly as Dr. Shapley. His opini
is "we are in a proper position to say co
fidently that there must be life—livi
biochemicals—all over the universe."
know that there is, in any event, an obje
that must be a planet in orbit about o
of our neighbor stars—Barnard's Star.

Having made his point in explicit d
tail, Dr. Shapley goes on to present t
narrow range of essentials for the d
velopment of human beings from certa
of these biochemicals, and the equal
narrow range of conduct that must
observed if man, once developed, is
survive. The last and probably most i
portant of the rules for survival is th
living creatures must be "so condition
by ignorance or morality that they w
not destroy all life, including their ow
by poisons or planet disruption."

As for the inhabitants of this parti
ular "minor object in one small corne
of the immense universe of planets, stars
and galaxies," they would do well to rea
and think deeply on these words of
wise and, I believe, a great man so tha

ir days may be long in the land. The t half of the book is a prescription survival on our planet and should be ernationally required reading.

JAMES S. PICKERING
The American Museum-Hayden Planetarium

E INSECTS, by Peter Farb. *Time, Inc., 95; 192 pp., illus.*

LTHOUGH an increasing number of L popular books dealing with one or ther aspect of entomology is appear- today, few encompass the entire field. s gratifying, therefore, to see that this k is a good introduction to the ecol- , evolution, anatomy, physiology, de- opment, and behavior of the six-legged hropods. The author, Peter Farb, not y presents a balanced account of in- ts; he does so in a most masterful hion. I have never seen so much in- esting and entertaining material in- porated in such a small space for sentation to the lay public. The lucid, lanatory style paves a smooth path the reader through such complicated jects as hormonal control of metamor- sis, and communication among the eybees. Especially welcome is the nplete avoidance of the entomology tbook approach so often encountered volumes for a general audience.

s in other books of the "Life Nature rary," illustrations and photographs an important feature of the presenta- 1. Relatively simple but effective wings placed in the margins illustrate cific points in the text. To supplement text, the editors have included after h chapter a pictorial—primarily pho- raphic—essay. For example, the chap- dealing with insect metamorphosis is owed by "Forms in Flux," demon- ating the extremely interesting work hormonal control of metamorphosis in *Cecropia* moth and showing the vari- stages in the development of a num- of insect groups. The quality of the tures throughout the book is gener- superb and, combined with the text, kes this a vivid, exciting view into the -history of insects.

JEROME G. ROZEN, JR.
The American Museum

STUDY OF BIRD SONG, by Edward A. mstrong. *Oxford University Press, 0.50; 335 pp., illus.*

some respects this book is a com- plementary volume to W. H. Thorpe's *d-Song*, for much of Edward Arm- ong's material in *A Study of Bird ng* is taken from field natural history, ereas Thorpe's approach was largely experimental one. Both works use the m "song" in the very broad sense to lude all utterances, as well as non- al sounds, and therefore are treatises acoustic communication in birds.

Armstrong's book, the culmination of a lifelong interest in bird behavior, is similar in format to his earlier volume, *Bird Display*, which became a classic in its field. Some of the photographs from this earlier volume were re-used, and those that have been added are not especially informative or well chosen—they only add to the cost of a volume that is already excessively high in price. By contrast, the many graphs and tables add considerably to the text. Included in the text is a consideration and classification of vocalizations according to the information they presumably convey, their form and structure, and their relationships to the birds' annual cycle. There is a review of the development of vocalizations and the subject of mimicry. The subject of geographical variation and the use of avian vocalizations in systematic work appears to have been better covered here than in Thorpe's book. However, there is only superficial treatment of sound production and hearing, subjects that were given greater emphasis by Thorpe. The influence of the physical environment on vocalizations, and bird song as "play" and "art" round out the coverage.

Naturalists and biologists in general will find much of interest in this carefully executed treatment of a very popular subject. Some may take issue with Armstrong on certain of his views, for example, his concept of "subsong" and the degree of plasticity that he ascribes to song after the latter has become fully developed. The author maintains that it is probable the songs of blue-winged and golden-winged warblers are "inborn," but this seems quite improbable to me.

Research-minded ornithologists will find *A Study of Bird Song* most useful, however, for its review of the literature and for the provocative problems it raises and leaves unsolved. In addition, there is an impressive bibliography and an addenda section that includes literary citations as recent as 1962. The volume has been carefully indexed, further increasing its usefulness as a research tool.

WESLEY E. LANYON
The American Museum

THE MAMMALS, by Richard Carrington. *Time, Inc., $3.95; 192 pp., illus.*

THE increasing interest in mammals is reflected in the large number of books devoted to them in the past decade. This volume in the "Life Nature Library" series is an excellent contribution and should add measurably to this awakening interest. The book is divided into eight parts, the first of which examines the variety of mammals, including characteristics of the orders and adaptations for life in different environments. Mammalian evolution is adequately discussed, with excellent representation of some evolutionary highlights. Modes of movement are then presented, followed by mammal diets. Adaptations for food-getting, feeding habits, specialized feeders, and food storage are included.

Methods of attack, defense, and survival are outlined, followed by an account of predation and survival devices. Home life, migration, and hibernation are discussed in some detail. Reproduction, the life of the young, and family behavior are ably presented. The last part of the book deals with the evolutionary history of man, with emphasis on primate radiation into a variety of successful types. Eighty-three well-selected references and a suitable index complete this interesting volume.

The illustrations, both colored and line drawings, are the best this reviewer has seen. Not a single one has been selected merely to embellish the text; rather, they complement it. The marginal picture essays are particularly good and briefly but accurately detail a fine biological account of the mammals. This very readable work will be of considerable value to the student of biology, and should find a place as supplemental reading in every mammalogy course.

W. J. HAMILTON, JR.
Cornell University

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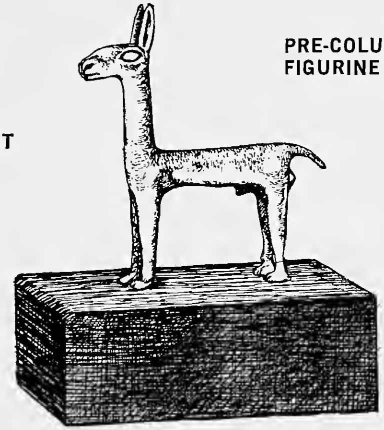

PERUVIAN LLAMA

PRE-COLUMBIAN
FIGURINE PIN

.INGIT RAVEN This is a reproduction of a 19th cen-ry stone pipe carved by the Tlingit Indians of coastal aska. The figure is a young raven with open mouth d is 3" high. The Tlingit regarded the Raven as a clan cestor, and he was considered a culture hero of the rthwest Coast tribes. $6.00 ppd.

:ITY PIN AND PENDANT An adaptation from the nter of a wood carving—"The Magic Circle of the ve Protectoresses." Approximately 2½" high. Gold ectroplated. Pin . . . $4.00, Pendant . . . $4.25 tax in-uded ppd.

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Old Africa's "People of the Village"

by ARTHUR LEIPZIG

For many years, doctors and scientists had hoped to find and examine a population that lived in virtual silence, so that they could assess the hearing capability of the human ear in a natural environment uncontaminated by the noises of a modern industrial society.

In the 1950's, stories circulated in medical circles in Europe and the United States of an African tribe known as the Meban, which inhabited an isolated and extremely quiet part of the bush country of the Sudan near the Ethiopian border. Reliable information on the Meban was scanty because the tribe had been almost totally bypassed by anthropologists. Neighbors of the Meban—the Nuer, Dinka, and Shilluk tribes, among others—have been the subjects of some thoroughgoing anthropological studies, but literature on the Meban is speculative and contradictory even today. There is no consensus about the name of the tribe, which has been variously referred to as Barun, Burun, Mabaan, and Maban in some literature, and is known by other names locally.

In the past three years, however, three expeditions went into the Sudan to study the Meban. All were under the leadership of Dr. Samuel Rosen, consulting ear surgeon at Mount

Meban villagers are seen in a hamlet in the bush country of Sudan. Meban culture, physiology, and hearing were the subjects of recent scientific study.

Sinai Hospital, New York, and a member of the faculty of the College o Physicians and Surgeons, Columbia University. Expedition members conducted broad studies of the hearin and physiology of the Meban tribes people, and gathered informatio about their culture.

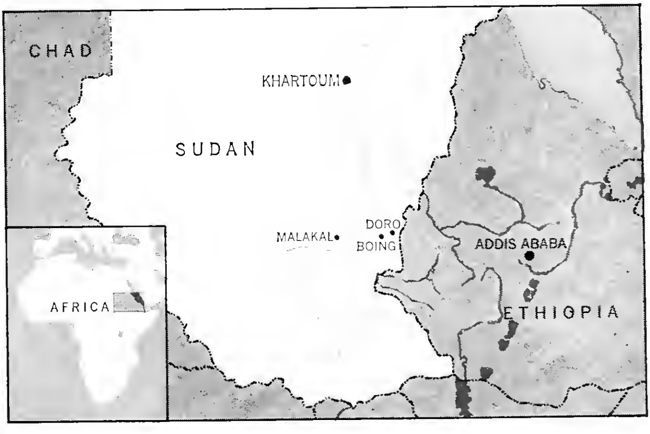
In March, 1963, in Khartoum, capital city of the Sudan, I joined the mos recent of Dr. Rosen's expeditions a an observer and photographer. Whe I arrived, most members of the expedition were already in Khartoum an had nearly completed preparations fo the coming 650-mile trip into bus country. Expedition headquarter were in the Grand Hotel, which stand

Gasoline can is used to carry water. Woman bearing can is married, which is signified by "tail" of beads she wears.

s the street from the Blue Nile
-. Around the hotel one saw the
ish in white shorts, white knee
s, white shirts, and pith helmets,
when I met the members of the
dition, many were similarly
ed. Dr. Rosen's team included ear
eye specialists, physiologists, a
iologist, an epidemiologist, and a
hiatrist. Dr. Mohamed Satti, the
emiologist, was Sudanese, and had
l as chief expediter for the trip.
he time of my arrival, he had se-
d trucks, Land Rovers, drivers,
Sudanese personnel.
the company of Drs. Satti and
en, I went to the warehouse to in-
t the expedition's gear. The equip-
t included noise-level meters
hing forty to fifty pounds each,
four audiometers of about thirty
nds each. The latter were tran-

Elderly woman smokes a pipe that is a special example of tribe's handicraft. Most local artifacts are much simpler.

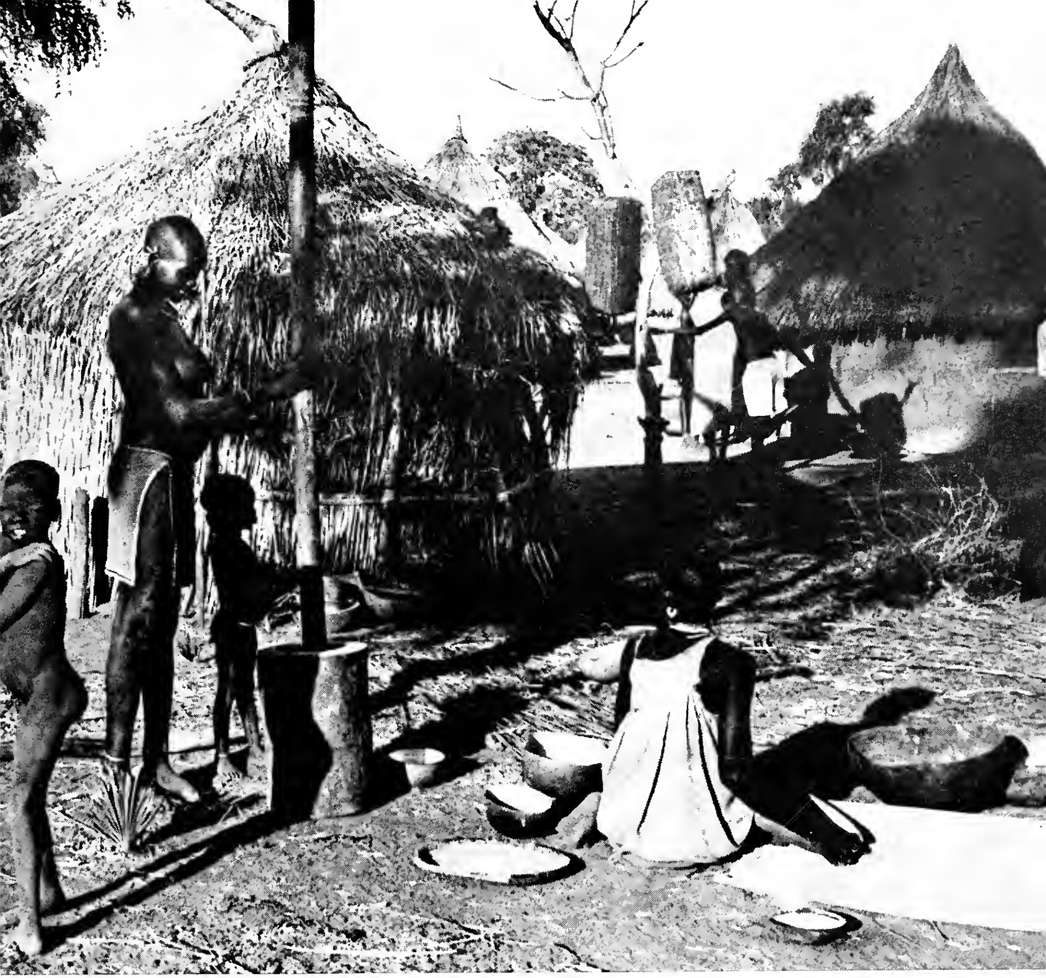
Meban live in the southeastern Sudan. From Khartoum, doctors went to Boing, where study of tribe was carried out.



Aeration removes moisture from *dura,* a millet seed that is used in making a gray gruel, various breads, and a beer.

sistorized and battery powered, an had been "tropicalized" to withstan high temperatures and humidity. I wa also shown a variety of more familia medical equipment, including bloo pressure gauges, tongue depressors ear and nose speculums, and ea syringes. In the same warehouse wer our provisions and hundreds o pounds of beads, safety pins, rings toys, and other trinkets that were t be gifts for the Meban.

During the short time that remaine for us in Khartoum, I could not hel acting the part of the tourist. The cit of small brown adobe houses, with th



Mother and a child grind *dura* with pole outside their home. The tribe is polygamous, and each wife has own hut.

ert in the distance, reminded me countless French Foreign Legion ıs I had watched as a boy. Arabs l native markets are reminiscent of days of Gordon and Kitchener: sques bring alive the Mahdi and his ıatic followers.

was on a Thursday that the first section of the expedition—lorries ded with equipment and provisions eft the city. Drs. Schulze and Jans- ı, physiologists of the Max Planck stitute in Germany, traveled with caravan in their own vehicle. Most embers, including Dr. Rosen and his fe, left by air two days after the otor caravan had gone. I was in the st plane to depart—a two-engine ssna that would take us to a mission- y landing strip at Doro, near Boing, our final objective. Once inside the plane, the pilot had second thoughts; he argued that he did not know how to reach Doro, nor did he want to make the attempt, for he believed the mission runway would be too small for the Cessna to land safely. Dr. Dietrich Plester, of Düsseldorf, Germany, and Dr. Satti assured the pilot that they knew the way from previous expeditions, and he took off. When we were airborne, the two men handled the navigation, pointing out familiar landmarks.

When the Cessna finally put down at Doro, we were welcomed by some 150 beautifully bluish-black Meban and a few white missionaries. After those following by air joined us, the expedition drove to Boing in the company of missionaries and local officials. In the language of the Meban, Boing means "Arab settlement." It is the main center of trade for the tribe, which numbers 20,000. The tribespeople exchange their agricultural surplus for the clothing, jewelry, pottery, and hardware of the merchants. I discovered later that a merchant who desires some specific article of Meban craftsmanship—a musical instrument for instance—will send a runner through the countryside to make the announcement. Anyone who owns the specified instrument brings it to the merchant if he wants to make a trade. Boing is made up of the shops of the Arabs, a shoemaker, a slaughterhouse, a government radio shack, a newly built

Boul Boady, who has on his forehead lines incised when he was a Nuer slave, is Meban tribal council's elected chief.

public school with dormitories, and a prison. On Sunday evening, the motor caravan finally arrived in Boing, and the expedition's work began in earnest the next morning.

In the weeks that followed, hundreds of Meban came to Boing to offer themselves as test subjects. At the suggestion of the Sudanese, we gave gifts of clothing to each testee. For this purpose, local merchants had made hundreds of pairs of pants and shirts. When given a choice, however, the Meban preferred trinkets, such as safety pins and dime store jewelry, because they had little need for clothes. Of the many gifts taken to induce the Meban to co-operate back in 1961, those things that Dr. Rosen had believed most likely to please them often proved least effective. For example, on his first expedition he anticipated that women would like shiny bottle caps, perhaps to string like beads and wear around their abdomens. When he took inventory, he found that thousands of the bottle caps were left over, but that almost the entire supply of safety pins had been taken. Traditionally, both men and women have worn jewelry made of snail shells in their ears, noses, and lips, and the pins proved popular as decorations for the same parts of the body. But gadgets that made sparks were the most successful gifts offered. Crowds of Meban, Dr. Rosen recalled, gathered whenever anyone operated a sparking toy.

The Meban are an extremely comely people. They have a graceful carriage, well-developed muscles, and erect posture. Until recently, if they wore any clothing it was no more than a loincloth. These days, though, the women may sometimes dress in a simple shift, and the men occasionally wear the undershirts and shorts provided by missionaries. School children dress for classes. In addition to the jewelry men and women wear in their noses, ears, and lips, necklaces and finger rings are common, and married women usually wear a colorful, beaded "tail" suspended from a waistband.

Facial markings are traditional and ubiquitous. The Meban marks, made

Slivers of wood in this boy's lower lip and nose keep open holes pierced for the tribe's traditional ornaments.

Mother shows cosmetic marks cut into her skin when she was young girl. Lip and nose rings are gifts from doctors.

n both men and women, are three ashes on each cheek. These begin at e cheekbone and extend down the heek about two inches. Children re-eive these marks when they are eight r nine, and we were told that the arking is done by women. Four omen hold a child down; a fifth akes the marks with a sharp stone nd then puts hot ashes into the ounds to prevent smooth healing. At ome point after puberty, boys and irls mark their own bodies; some ay ask other members of the tribe to o it for them. The designs are elabor-te representations of plants and ani-als, or are geometric abstractions. he tribe produces very little pottery, o metalwork, some beautifully shaped ipes, and simple musical instruments, ut the rare decorations that I saw on heir earthenware and woodwork were ruder than the designs the people ade on their skins.

At puberty, all children have the wo lower incisors removed. Boys are xpected to conceal pain, but girls may ry out. If a boy is remembered for is lack of courage during the tooth ulling, he may well be rejected when he time comes for him to seek a mate.

The Meban, unlike many tribes, do not circumcise children. The few circumcised adults we encountered were old, onetime captives of the more aggressive neighbors of the Meban—Arabs, Nuers, and others—and had been circumcised in their days of slavery.

TODAY, the Meban are still far more peaceful than their neighbors. Meban, in the tribe's language, means "people of the village." According to George P. Murdock, an eminent ethnologist now with the University of Pittsburgh, Meban life runs true to the pattern of all early Negro settlers of the Nile. They live in large, compact villages or groups of hamlets, and are sedentary in that they do not go far from home either to hunt or for any other purpose. Meban houses are usually round huts, with walls of wattle and mud, and a cone-shaped, thatched roof. The tribe practices polygamy, but Sudanese law limits each man to four wives. Normally, a family occupies a compound within which each wife has a hut to raise children.

Most Meban marry at seventeen or eighteen, and the newly married couples live in seclusion for about ten days, with simple cloth pennants flying from the tops of their huts. They sometimes fast while in seclusion, drinking water brought to them by a relative. The parents of the couple generally arrange the marriage at the request of the man, but not against the woman's wishes. The marriage contract may include some cattle, paid to the parents of the bride by the groom. More often the groom will make payment in spears, goats, or pigs, because the Meban are cattle poor.

A young man without the means to purchase his wife can pay for her by working for her father. Sometimes suitors have toiled for as long as two years. A popular woman has many suitors, all of whom may be working for her father at the same time, and it was such a situation that led to the only altercation we observed while in Boing. Briefly, the mother of a rejected suitor was accused of casting a spell on a young woman because she had married a man other than her son. The spell was believed to have caused the bride to miscarry. In retaliation, her groom killed the accused witch's son.

In this agrarian society, the division of labor does not appear to be influenced by magical or religious considerations. In general, men and boys do the heavy work and women and girls busy themselves with less exhausting but myriad chores. During the harvest, for example, parties of men—with as many as thirty in each group—pool their efforts and work the land of each member of the group in turn. The wives of the property owner whose crop is being harvested prepare meals for the workmen, and send a midday drink into the fields. The chief grain food is a millet seed *(Sorghum vulgare)*, locally called *dura*, which grows to maturity in three months. Several crops are planted annually. After the men harvest *dura*—stamping the stalks with their feet, or cutting them to the ground—the stalks are sun-dried for about a month. Women take over at this stage and go into the fields to separate the grain from the stalk by hand. Then they store the grain in family bins. Girls make flour by pouring *dura* into a hole or hollowed-out log and pounding the grain with poles.

The chief product of *dura* flour is a gruel that looks like gray mud. *Dura* is also used to brew a beer, *marisa*, and to make a hard bread that is also known as *dura*, as well as a thin, fermented bread called *kisra*.

Dry-season fishing, in the marshes along the Yabus River and in the river itself, provides fair quantities of fish as a dietary supplement from November through May. The women cook the fish, often together with okra, in oil extracted from dried wild dates. Men and boys spear some of the fish, but the great majority are caught by the women. They form a line across the river and move slowly upstream in an unbroken rank, using cone-shaped baskets like a broad dragnet.

In addition to the above foods, the men raise small patches of maize and tobacco near the village, and women keep a few chickens near their huts. Finally, the tribesmen kill, with curved throwing sticks, some small game, such as rodents and wild guinea hens.

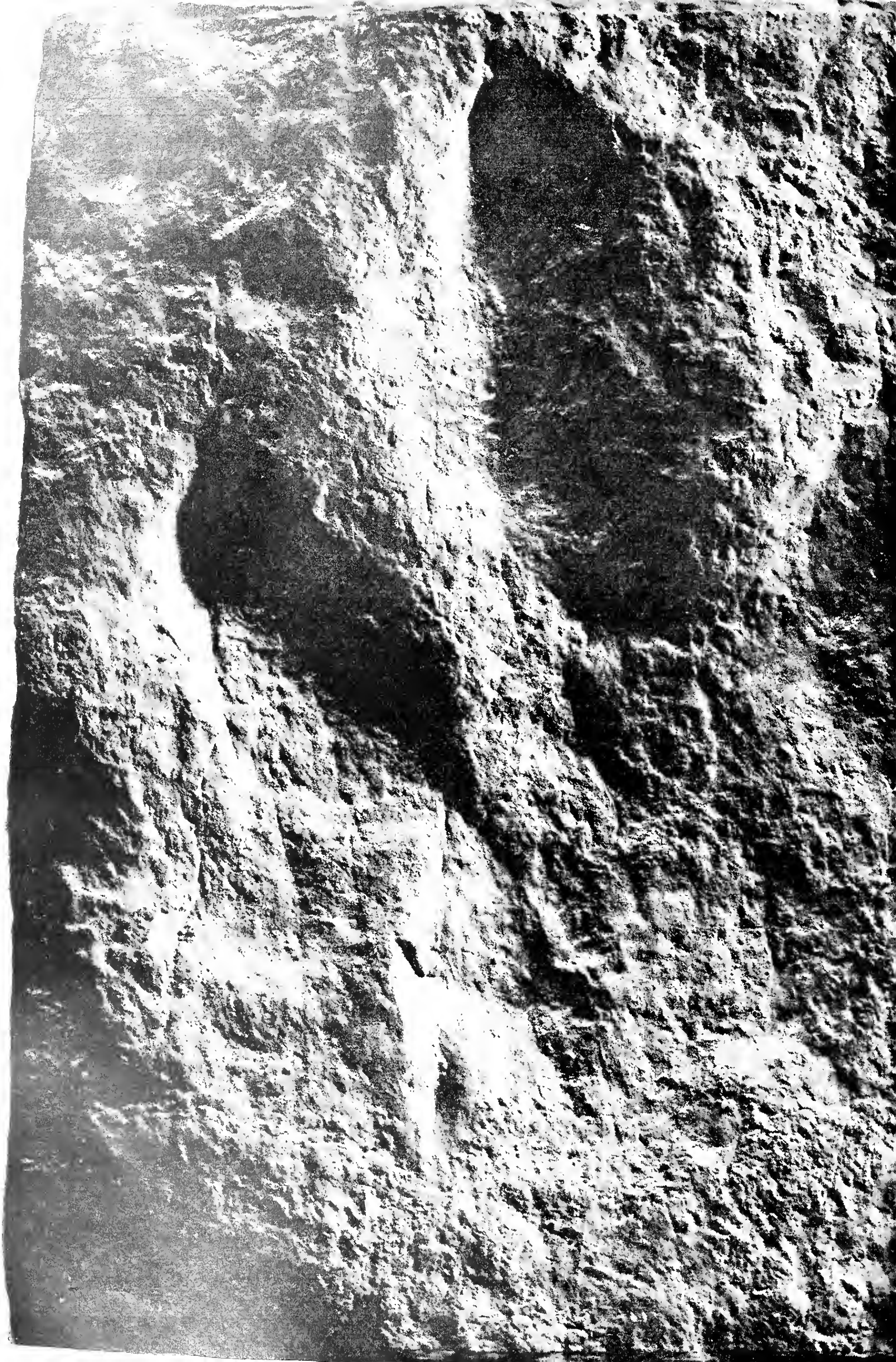
HARVEST is traditionally a time for choosing mates. Men and women dance every night during the period of reaping, and drink considerable amounts of *marisa*. The accompanying instruments include a five-string lyre, a log split in half and hit with a stick, and one-note woodwind pipes up to three feet long—the typical band has ten woodwinds. The dance is informal and unpatterned, depends on improvisation, and looks to a Westerner like a combination of the twist and cha-cha. Men and women usually face each other during a dance, but dancers of opposite sexes rarely if ever touch one another. The harvest festivities begin about 7:30 P.M. and often go on until 3:00 in the morning. Yet at 6:00 in the morning, the Meban get up and go back into the fields. I joined the festivities one night, and had the privilege of dancing opposite the best woman dancer in the tribe. By 10:30 P.M. I was exhausted and half-choked with dust raised by the shuffling feet.

Except for slight contact with merchants and Sudanese officials, the Meban have lived in cultural isolation for many, many generations. One of the main concerns of the Rosen expeditions was to record the way of life of the Meban, because more and more of the tribe's children are being educated in Sudanese schools, where they learn about the Moslem religion, the United Nations, and the awakening Africa beyond their own borders. To many of these children, the tribal ways may soon appear shamefully primitive. In a changing Africa, the customs that existed at the time of Dr. Rosen's expeditions may soon vanish forever.

(To be continued in May)

uring harvest, all evenings are spent ncing and mates are chosen. Usually, me sex dance together, as seen at left.

Excitement of harvest dance shows in face of musician, who has put down his one-note woodwind pipe for a breather.



FOOTPRINT of a Festningen *Iguanodon*, *left*, is over 2 feet long and almost as wide. Casts of 13 prints are made on nearly vertical sandstone wall, *above*.

Dinosaurs of The Arctic

New find extends Cretaceous tropics

By EDWIN H. COLBERT

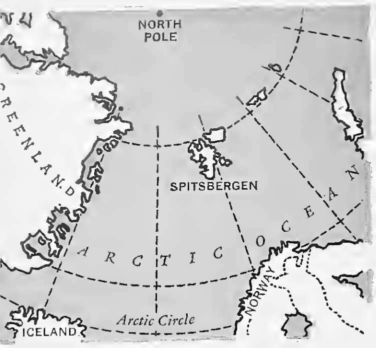
IN THE LATE AFTERNOON of August 3, 1960, a small group of geologists from several countries made its way along the top of a sandstone cliff on the coast of West Spitsbergen, one of the islands halfway between the northern tip of the Scandinavian Peninsula and the North Pole.

They were members of a field excursion under the leadership of Professor Anatol Heintz of the University of Oslo and his associates, arranged and sponsored by the Twenty-first International Geological Congress. This particular excursion had sailed to Spitsbergen on the ship *Valkyrien*, from which, as a base, the members of the group explored the island.

They reached the Festningsodden beacon, located on a vertical sandstone cliff of Cretaceous age, and two members of the group — Professor Albert F. de Lapparent of Paris and Robert Laffitte — climbed down the cliff to the shore. As they looked up at the wall towering above them, they saw on its surface, highlighted by the long, slanting rays of the late afternoon sun, the impressions of huge footprints. Within a few moments the rest of the group had clambered down the cliff to look at the tracks.

They counted thirteen footprints, each distinctly three-toed, and each about thirty inches in length. Seven of the prints formed a trackway some twenty feet long, quite obviously made by an animal walking on its hind legs. The other footprints were scattered in various directions. There could be no doubt in the minds of the viewers that they were looking at the footprints of a large dinosaur. At first the geologists were inclined to think that the impressions were those of a gigantic, meat-eating dinosaur of Cretaceous age, similar to *Tyrannosaurus* or *Gorgosaurus*. But careful examination of the prints showed no traces of claws, and it was therefore concluded that they were probably made by one of the large, blunt-toed, herbivorous dinosaurs. Subsequent study of the prints convinced Professor de Lapparent on several counts that these were made by the Lower Cretaceous plant-eating dinosaur *Iguanodon*.

The discovery of these dinosaurian footprints was exciting and frustrating. In the words of de Lapparent: "As this discovery was entirely unexpected, we were unable to make cast-



ings. . . . We did not even have a piece of chalk, to show up the outlines of the prints. . . . After having measured the footmarks and made sketches, we were obliged to leave, as the *Valkyrien* was waiting to depart. . . ."

THE importance of these tracks was such, however, that plans were made to return for the express purpose of making some casts. (The problems of trying to cut any of the tracks out of the rock were too great for any such attempt to be seriously considered.) Accordingly, members of the staff of the Paleontological Museum in Oslo, notably Miss Lily Monsen and Mr. Arne W. Martinsen, experimented during the winter of 1960-61 with different casting methods and materials, in preparation for the trip. The cliff on which the tracks are exposed is vertical — even slightly overhanging — raised to this position from its original horizontal condition by earth forces acting through geologic time, and this presented great difficulties to moldmaking. Second, temperatures are low even in summer. Finally, the air is humid and the cliff is frequently moistened by salt spray, which, together with the low temperatures, affects the setting of casting compounds.

With all experiments and plans made, the expedition set out to make the casts in August, 1961. Miss Monsen and Mr. Martinsen were among the party, as were Dr. Natascha Heintz of the Norwegian Polar Institute, who had been especially concerned with the organization of the previous year's trip, and Mr. E. Ståhl of the University of Uppsala. Dogged persistence, combined with hard work and ingenuity, enabled the party to complete a series of latex emulsion molds, and the expedition returned to Oslo with some excellent casts as a record of the *Iguanodon* of Festningen.

If the members of the 1960 field conference were rightly astonished with their discovery of these large dinosaurian tracks in Spitsbergen, it is fair to say that since then many paleontologists throughout the world have been equally astonished. *Iguanodon* is a dinosaur hitherto known from England and northern Europe, where numerous skeletons and some footprints have been unearthed and described during the past century and a half. To find indications of this large dinosaur in Spitsbergen means, of course, that in Early Cretaceous times there must have been some sort of land connection between what is now an Arctic island and the European continent. It requires no great stretch of the imagination to think of Spitsbergen as part of the continent in a former geologic age, for today the ocean between Spitsbergen and North Cape is less than three hundred fathoms deep.

What is of particular importance is that this discovery extends the range of Cretaceous dinosaurs—of any dinosaurs, for that matter—far north of previous limits. Festningen Point is at Lat. 78° 06′ N. In other words, it is 12 degrees from the North Pole. Hitherto, the most northerly records for dinosaurs have been at somewhat less than 60 degrees, and for Cretaceous forms at about 52 degrees in Eurasia and 56 degrees in North America. We have long known that dinosaurs were spread across the globe during Cretaceous times, but the discovery in Spitsbergen has extended their range to much greater limits.

The northwardly extension of the dinosaurs of Cretaceous age, interesting though it may be in expanding the recorded range of these reptiles during the culminating phases of their evolutionary development, is of added significance in its implications concerning the environments and climates in which they lived. We may assume, and quite rightly, if our knowledge of modern reptiles is to have any bearing on reptiles long extinct, that the giant dinosaurs of Mesozoic times were tropical and subtropical animals. We may also suppose that the dinosaurs, like modern reptiles, were ectothermic vertebrates, animals in which there were no internal temperature controls, and in which the body temperatures were closely correlated with the temperatures of their environments. Such being the case, the dinosaurs mu
have lived in tropical and subtropic
climes, as do modern crocodiles. Ce
tainly they were far too large to bu
row underground to escape co
waters, as the lizards and snakes d
Upon the basis of this reasoning it c
be stipulated that the footprints
large dinosaurs were made, and the
bones were buried, in lands of pe
petual summer, no cooler than sout
ern Florida is today.

Consequently, the discovery
Iguanodon tracks in Spitsbergen rei
forces and even extends the idea, lo
held by many geologists and paleo
tologists, that the Cretaceous wo
was largely tropical. Equable clima
allowed large dinosaurs to exist fro
the tips of the southern continents a
from Australia through the mid
latitudes and north into what is n
Canada, northern Eurasia, and on
Spitsbergen. It would seem to ha
been a world in which there were
polar icecaps and in which there we
probably very poorly defined temp
ature belts. If there were temper
regions as we know them, they m
have been at the poles, while all t
rest of the globe enjoyed subtropi
and tropical climates.

How is such an ancient world to
explained? One explanation, ess
tially the one that has just been
counted, supposes a world of gene
climatic uniformity, with the co
nents in their present positions. T
evidence for such a supposition is
the rocks; one need only to postul
that for some unknown reason, p
haps extraterrestrial, climates of th
ancient days were not zoned.

MANY geologists today are, ho
ever, not satisfied with such
explanation. For more than half
century numerous students of ea
history have favored the theory of c
tinental drift, which supposes that
present land masses were origina
combined in a single ancestral c
tinent, Pangaea, and which furt
supposes that Pangaea fragmented,
different components drifting throu
time to their present positions.
cording to this theory most of
drifting was along the lines of latitu
consequently, continental drift d
not offer any explanation beyond
previous one to account for dinosa
—and, correlatively, tropical clima
—being found in high latitudes.

In recent years another theory, t

polar wandering, based on studies
paleomagnetism, has attracted much
tention and gained many adherents.
ıe study of rock magnetism would
em to indicate (if certain assump-
ɔns are made) that in former geo-
gic ages the poles were not situated
they are now in relation to the
ntinents. Thus, the interpretation of
leomagnetism in Cretaceous rocks
ight show, according to some author-
es, that the North Pole during that
ologic period was at a point in
ɪrthern Siberia or, according to
her authorities, near the tip of
aska. But in either of these inter-
etations, Spitsbergen would have
en in far northern latitudes—say at
or 60 degrees—and we are still
ced with the necessity of supposing
widely tropical world to account for
e Festningen footprints.

Consequently, no matter which
eory of past continental relation-
ips or polar positions is advocated,
e must almost, perforce, postulate a
rgely tropical world to explain the
de range of Cretaceous dinosaurs.
ıder no theory is the significance of
e Spitsbergen footprints diminished.

Iguanodon was first described in
25 by Gideon Mantell, a rather ec-
ntric physician-scientist, who spent
ıch of his life collecting and study-
g fossil bones from the Lower Cre-
ceous, or Wealden beds, of southern
ıgland. To Mantell, the bones of the
ealden revealed an England of an-
ent ages quite unlike the England of
neteenth-century days—one of tropi-
l aspect, inhabited by gigantic rep-
es. Through the years this concept
s been extended by the successors
Mantell until today it encompasses
e world. And it has grown by the ac-
mulation of separate discoveries,
e by one, and year after year. The
otprints of Festningen constitute one
the latest and especially important
scoveries in the long sequence of
ientific effort that began almost a
ntury and a half ago. They confirm
d extend the tropical world of Cre-
ceous times and they record the wide
ınderings of *Iguanodon* through
ngles that can now be seen only
thin the limits of the Tropic of Can-
r and the Tropic of Capricorn.
ıey take us back to a vanished world.

ECONSTRUCTION shows the dinosaur's
obable appearance. It may have been
ɔout 40 feet long and 16 feet high.

Multicolored World of Caterpillars

by Paul Villiard

Much has been written about butterflies and moths, their beauty, and the strange and wonderful defense mechanisms they exhibit, but comparatively little has been said about the earlier stages of these insects. Actually, in the larval stage, butterflies and moths are often as beautiful as the adult form, and many put the adult to shame in design, color, and "personality." Despite the gaudy colors many caterpillars exhibit, their camouflage effect is such that most people go through life without seeing more than a few stragglers of the commoner species, and generally these are discovered by accident.

Several types of camouflage occur in caterpillars. Cryptic mimicry, for example, consists of patterns or apparently random designs that allow the insect to blend into its background until it is almost invisible, or at least very inconspicuous. Often caterpillars are brilliantly colored, yet, when they are feeding on the leaves of a bush or tree they are almost impossible to detect by virtue of their gaudiness. The markings take the form of zigzag lines, dots, and short lines running horizontally, vertically, or diagonally on each of the segments. Bright colors in irregular blotches or patches all help to break up the continuous outline of a caterpillar.

Many species have brilliant metallic spots on their sides. Gold in some cases, silver in others, these mirror-like areas simulate sunshine or moonlight glimmering through the leaves. The result of this simple device is that the predator loses sight of the outline of the caterpillar itself. This, coupled with the ability of caterpillars to remain motionless for extended periods of time helps create the illusion that they are not actually there.

Often this mimicry is assisted by a characteristic attitude assumed in time of danger. Because of their short vision and poor hearing ability, if any, probably the first danger warning caterpillars receive is the shaking of the branch as a bird alights. This triggers an instantaneous assumption of a defense posture, and it is often at such times that the greatest beauty of the caterpillar can be seen.

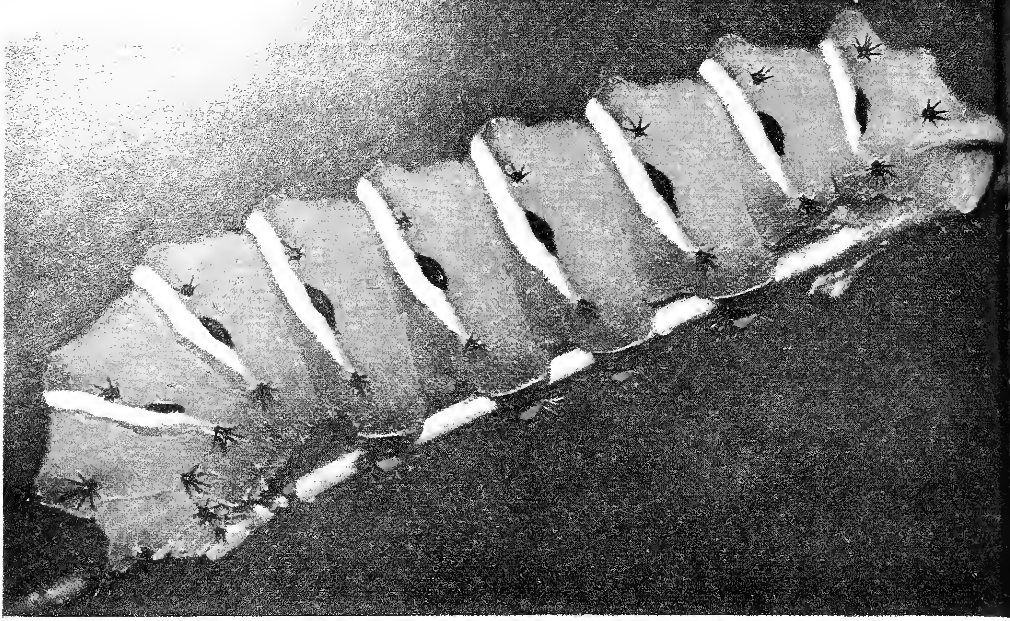
In aposematic mimicry, the caterpillar adopts the warning colors of some creature inimical to a predator, or of some unpalatable substance. An example of the latter is the almost perfect resemblance to bird droppings found in the early instars (periods between molts) of many species.

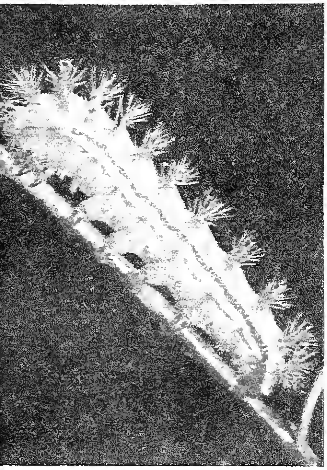
Combinations of coloration and aspect can sometimes be very striking. One such example is the "horned" caterpillar of *Brahmaea wallichii* (for a picture of the adult of this moth, see NATURAL HISTORY, June-July, 1963). In time of danger, the head and first two segments curve down tightly under the ventral surface. This posture exposes and stretches the skin between the third and fourth segments, enlarging two oval black spots located between them, and two smaller spots in the fold between the second and third segments. The latter form the "nostrils," and the large spots are the "eyes" of what appears to be a great staring face surrounded by four menacing "horns" that stand straight out from the body. The caterpillar whips its fore parts back and forth across the branch, as though it were about to spring at its foe. After the fourth instar the horns on this caterpillar disappear. They are shed with the skin and replaced with four pale blue, pearly spots. The sides of the first three segments are now lined with black in such fashion that when the head is lowered in its characteristic defense position, the caterpillar resembles a scaly reptile. When the body rears up on the branch, it looks extraordinarily like a Chinese dragon in miniature.

Another important defense mechanism found in a large number of species is the growth on the bodies of urticating (stinging) spines in greater or lesser abundance. Perhaps this does not afford too much protection for some individual specimens, but a bird or other predator will learn to avoid a species after having been irritated enough times, and the remaining members survive. However, the hirsute coverings, whether or not they are urticating, provide no defense against parasitizing enemies, and so even these well-armed species form the food sup-

Second stage *Brahmaea wallichii* has four large, black head processes. They disappear after the insect's fourth molt.

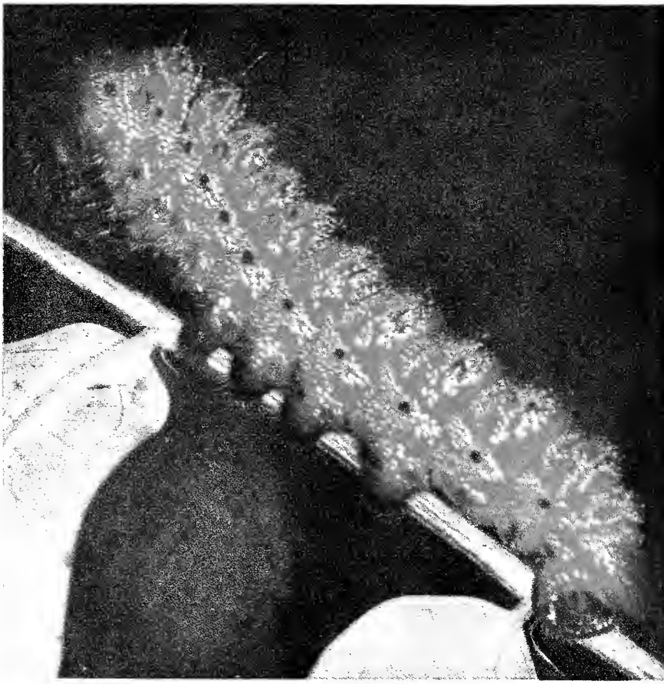
Native to Japan and other parts of Asia, a *Dictyoploca japonica* is shown here at more than twice its actual size.

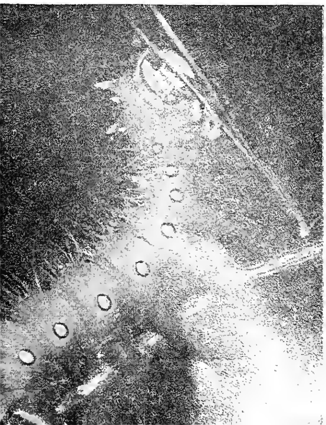




Bunched spines of *Automeris io*, at the left, are highly urticating. It spins fragile cocoon on ground under leaves.

White stripes of this *Rothschildi* *speculifera* caterpillar become orang when larva is about to begin pupation





An *Eacles imperialis* in green phase clings to twig, *left*, as it feeds on pine. The caterpillar also has a brown phase.

African species *Nudaurelia cythere* was raised on sumac, *Rhus glabra*. Th insect passes pupal period in groun y for a host of other creatures. It is tonishing that any at all survive hen one considers the tremendous edation pressures under which these sects constantly live. Michael Collins d Robert Weast. in their studies of lk moths of the United States. estiated that it would take about 40.000 rtile ova to maintain a race of 200 lults of a given species.

Some non-indigenous caterpillar ecies seem to have a limited adaptality to temperature. Below 65° F. ost tropical and exotic species show nsiderable reduction of their feeding te and the attendant rate of growth. or instance, *Attacus atlas edwardsi* rvae feed sporadically or not at all, ing quiescently along the twig or on e leaf for days at a time. If they rvive to pupate. the majority either not live through that process. or ey die later in the pupal stage. The w who may emerge as adults are genally weak and fail to expand their ings completely. Progeny from such lults are rarely healthy and vigorous. t temperatures ranging below 55° F., number of exotic species and most opical caterpillars fail to survive if e cold continues for a long time.

On the other hand, the feeding rate many caterpillars accelerates treendously as the temperature rises. ouble-brooded species. such as *ctias luna* or *Antheraea pernyi*, mainined in a constant temperature of out 85° F. will feed to maturity, pate, emerge, mate, and oviposit, d the second brood larvae will be arted, while members of the same ood kept at a temperature of 65° F. ill be only in their second or third star. Temperature differences affect e rate of growth of domestic species, so, but not to nearly so great a deee. Moreover. species that are ingenous to the temperate zones seem tter able to withstand prolonged riods of cold than do those from armer regions, although they may be tarded for a considerable period if e temperature drops suddenly or if rains for many days. During this me they either stop feeding or eat ry little. However, when the weather arms again and the sun dries the liage, the larvae will recommence eding. and apparently the only effect the hiatus is to move the time of aturation back by the approximate ngth of time the larvae were deterred om feeding by the cold spell.

Hickory-horned devil is one common appellation of the *Citheronia regalis*, which is frequently seven inches long. It pupates in the ground and. despite the caterpillar's large size. it develops into a relatively small, orange moth.

In addition to temperature, humidity—or the lack of it—is the cause of many failures in the rearing of foreign species. *Antheraea mylitta* of central and southern India and Ceylon, for instance, demands a great amount of humidity. In fact, actually dripping foliage is even more to its advantage. That this insect is highly adapted to wet conditions is brought strongly to our attention when we note that the camouflage of the caterpillar simulates drops of water to a remarkable degree. Almost all tropical species do best in a fairly humid environment. On the other hand, some larvae—such as our domestic species, *Pseudohazis hera*—that feed on sagebrush in hot desert areas of the western states can tolerate extremely dry and arid conditions, if they have enough fresh food.

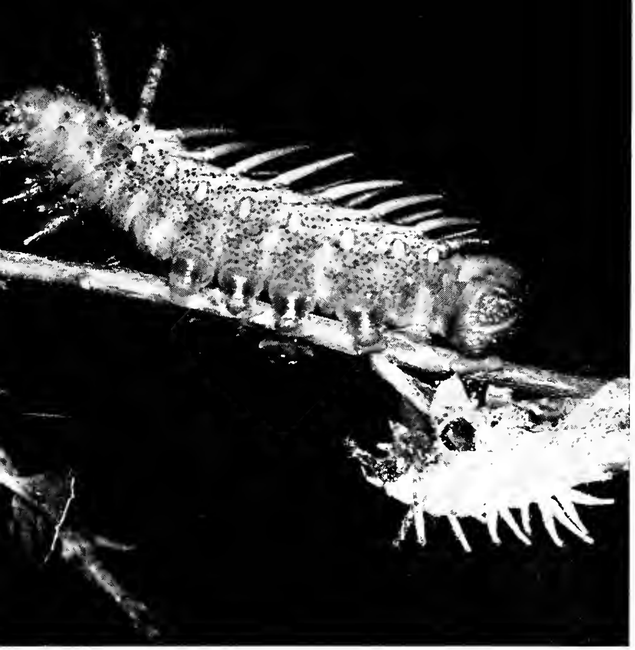
Another important factor governing the growth rate of caterpillars is the freshness of their food. Certain of them survive only with difficulty when cage-reared on cut leaves or branches. Many times they mature as stunted or crippled adults, and the second brood is very weak. Unless the American breeder of the exotic species lives in one of the few areas where tropical plants can be grown or has access to a greenhouse that he can stock with the proper growing food plants, he must depend on substitute foods in order to rear the species.

Frequently the insect does not readily accept substitutes and generally, in these cases, drags out a long and miserable existence, nibbling at whatever leaf supplies a chemical stimulus to feeding and, for the most part, expiring in the pupal stage or before. However, many species readily accept alternate foods, and can be reared quite successfully under unnatural conditions on unnatural food plants. It is often found that such species are polyphytophagous in their natural habitat (that is, they feed on a variety of plants) and that one or more of their natural foods is identical with or closely related to our northern varieties of trees. Often, too, these insects are not much smaller or less robust than those that have been reared in their natural habitat.

In two studies of the species *Samia cecropia* in the summer of 1961 and of *Actias selene* in the summer of 1962 I obtained some interesting results. In the case of *S. cecropia*, their natural food—the wild cherry *(Prunus)*—was

Before each molt, the *Attacus atlas edwardsi* develops adhesive white coat, *above*, resembling zinc oxide ointment.

The *Rothschildia orizaba* seen above has distinguishing traits that include a hirsute underbody and bare back. A



almost obscures the pale, translucent
eenish-blue hue of larva. Discarded
in is left on the twig, at right above.

ocile and phlegmatic insect. *Antheraea*
rnyi feeds on an oak, *above*. Adult is
nown as the "Chinese oak silk moth."

used. A tree was topped to about seven feet and enclosed within a four-foot-square cage eight feet high. Fertile ova were collected from a pair of moths selected for their color and size and refrigerated for three weeks at a temperature of 40° F. to retard them enough to allow the caterpillars to carry over into July and August before hatching. Some of the ova were hatched in a plastic sandwich box, to be reared in a cage indoors. The remaining ova were placed outside to hatch on the tree. Leaves from the same tree were used to feed both broods. Approximately 60 per cent of the inside brood reached maturity as compared with better than 95 per cent of the outdoor brood. The disparity in size between the mature insects was considerable. A typical male was selected from both lots. The specimen from the living tree measured 14.7 cm. across the forewings. That from the indoor group spanned but 11.5 cm.

The results obtained with *Actias selene* were even more dramatic, because they were reared on alternate food plants in an unnatural climate. Apple was selected as being the most readily accepted alternate food. Because the tree was very large, I resorted to sleeving individual branches rather than topping and caging entire trees. (Sleeving is a method of surrounding a branch loosely with some sort of material—usually netting—and tying it at each end. This prevents escape or predation from the trunk terminus of the branch, and at the same time permits access by the breeder from the tip end of the sleeve.)

Again, leaves from the same tree were used to feed the indoor brood, which showed a marked tendency toward stunting, and pupated at a much smaller size and about ten days earlier than those on the outdoor tree. This seemed to indicate an adaptation to adverse conditions, because the cut food dried out considerably during the course of the day, with the result that for much of the time the caterpillars fed on hard leaves or on scraps that had fallen to the bottom of the cage. The gradual accumulation of frass—refuse or excrement of larvae—in the bottom of the cage also created a condition not found in their natural surroundings. The lack of changing light, sunshine, and circulating air were all contributing factors toward the total condition. The early pupating time

Extremely rare *Argema mittrei* is a ative of Madagascar. Not until 1963 vas one raised in captivity off the island.

thus could be seen as an escape from these conditions. As in the case of *S. cecropia*, typical specimens showed great differences in size after emergence. From the growing tree a male measured 13.3 cm. across the forewings and 12.8 cm. from the tip of the forewing to the bottom of the hind wing process. The cage-reared specimen that had developed indoors spanned 9.3 cm. across and only 8.7 cm. from top to bottom.

As a final note on adaptability, the frequent inability to adapt to foreign climatic conditions often results in tropical species' exercising their proclivity toward a second brood so late in the year that the rearing of the larvae is virtually impossible because of a lack of food plants. Many attempts have been made to augment the nutritive value of sere leaves by means of chemicals or combinations of chemicals applied to the leaves before feeding them to the larvae. These methods have met with some success, and there is room for much more work in this field. Most caterpillars show a general reluctance to accept dry leaves, even after they have been soaked in water to make them pliable. Perhaps there is a way to make such food a bit more palatable for specimens, in which case fall broods would pose fewer problems to breeders.

Anyone who has reared a number of species of lepidopterous larvae has learned that the caterpillars possess "personalities." Some are highly nervous in captivity, and react strongly each time they are disturbed for feeding or cage cleaning. They exhibit all their defense mechanisms and show many distress signs. At the opposite extreme are phlegmatic species that seldom react to anything done to or around them. If the twig upon which they are feeding is snipped off they will continue to munch until the leaf is finished and then look for more. One may find a range of behavior between these two extremes. Some caterpillars, such as *Rhodinia fugax* from Japan and our native *Citheronia regalis,* squeak when disturbed. Many species seem constantly active, restlessly wandering about the cage or within the sleeve. Sometimes this wandering is so unrelieved that the insects suffer from lack of nourishment, as they seldom stay in one place long enough to eat much. Completely covering their cages with some sort of light barrier to darken the interior may help to quiet them. A paper sack inverted over small cages or a cloth draped around larger ones will often be all that is needed. If this barrier is kept in place until after the second molt, at least, the caterpillars will usually feed normally and cease their incessant wandering.

Some species do well in their cages, and are undisturbed by the introduction of fresh food or by cage cleaning. However, as soon as they are taken from the cage for photographic or other study, they begin to move about actively. One of the worst offenders in this category is *Dirphia curitiba.* Indigenous to the Argentine and other sections of South America. *D. curitiba* is also one of the severely urticating species. The photograph on page 31 is the result of more than thirty attempts to make it remain quiet long enough for me to focus on it.

Gregariousness marks some species during their entire larval life. Others group together only in the first one or two instars, while still others lead solitary existences from the time they are hatched. Some of the latter carry this to the extreme of being unable to survive if an attempt is made to rear them in a high population density.

One habit displayed by some caterpillars is that of releasing their hold on their support when approached and dropping to the ground, where they quickly disappear among the leaves and grasses. Often they curl into a tight ring as they land, which makes them even more difficult to detect. A number of the "dropping" species do not fall all the way to the ground, but let themselves down with astonishing rapidity on a delicate strand of silk. If left alone, they will climb back to the perch after a few minutes, ingesting the silk as they go.

Many species are adept at finding ways to get out of their cages. Cracks or holes in frames, or slight gaps in doors that appear to be impassable are broad avenues of escape to them. The unusual caterpillar of the beautiful little East Indian moth, *Loepa katinka,* is a classic example of escaping ability, possibly because it has a small head in relation to its body size. Once it succeeds in working its head through a crevice, it can stretch its soft body out enough to pull itself through.

Most species remain in the caterpillar stage for only a few weeks or a couple of months during the summer, pupating in the fall in preparation for the dormant period that precedes emergence. There are, of course, exceptions to this rule. Some caterpillars feed for a week or two, become semidormant (they may come out and wander on warm, sunny days), and finally emerge in the spring to finish feeding. They pupate in the summer, emerge as adults within a week or two, and start the new cycle. Still other species remain for two years or even longer in the caterpillar stage. *Cossus* is one of these. This genus feeds only on the living wood of trees, and remains within the trunk, boring tunnels until the tree is killed, after which the caterpillars move to another host. *Cossus* has been called the goat moth, because of the caterpillar's disagreeable smell. Such species are impractical to rear because of the specialized food requirements and the length of time involved. Literally hundreds of other varieties, however, are available for persons who are interested in the life histories of these insects, or who wish to raise them solely for their beauty.

Brazil's *Dirphia curitiba* is one of the most urticating. It has a pinkish-gray color, with magenta and black tracery.

Bass Rock Gannets

Aggression seems dominant theme in behavior of these birds

E GANNETS fight with interlocked dibles in territorial dispute. Bill ions are altered with great speed.

BASS ROCK, three miles from mainland off English-Scottish border, gave the specific name to gannet, *Sula bassana.*

By Bryan Nelson

HE SULIDAE is a compact family of plunge-diving, fish-eating birds ivisible into the pantropical boobies enus *Sula*) and the true gannets of mperate or relatively cool-current gions. The latter form a closely reted trio comprising the North Atntic Gannet, the South African, or ape Gannet, *Sula capensis,* and the acific, or Australasian Gannet, *Sula rrator* (some authors use *Morus* as e generic name). These may perhaps st be regarded as three forms of one ecies, although more usually they e given specific rank.

The lovely old Gaelic name for the nnet is *Ian Ban an Sgadan,* "White ird of the Herring." No bird more eserves such a fine name. Gannets are eautiful, strong birds—bold fliers ith a six-foot wingspread, spectacur plunge divers, and fascinating olonial nesters that mate for life. hey are of striking appearance, with ow-white plumage, black primaries, olden or orange-buff heads, pale blue es, and a conspicuous facial patrn of black lines. A fold of black skin ns centrally between the rami of the wer mandible and stretches enorously to accommodate large fish.

In February, 1961, soon after the rst adult birds had returned to the mous Bass Rock, from which they erive their specific name *Sula bassana,* my wife and I took up residence a small hut perched on the windvept south face. The Bass Rock, three iles from the mainland, is the last in chain of volcanic outcrops that retch across country just north of e England-Scotland border country. bout a mile round the base, 340 feet high, and bluntly conical, with some seven acres of "top," it rises sheer on three sides, and more gradually on the south-facing slope. Apart from three lighthouse keepers, it is inhabited mainly by hordes of sea fowl.

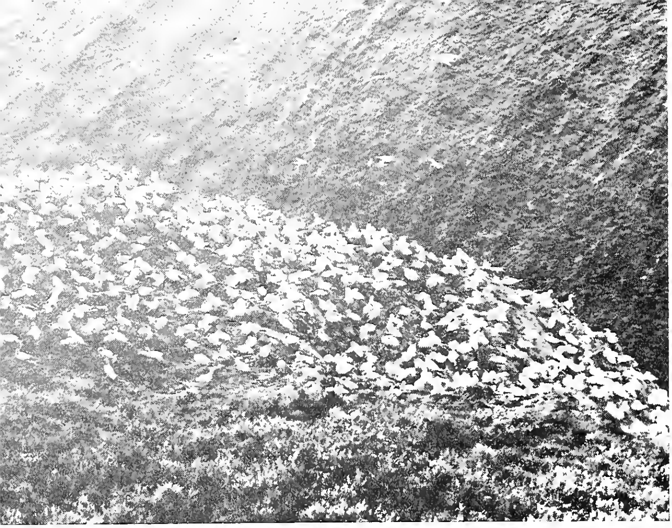
Between February and October for three successive years we seldom left the Bass. Our aim was to keep a continuous record of the gannets' return to the breeding colony from their oceanic winter life, their method of establishing a site and forming a breeding pair, their egg-laying, incubation, and chick-rearing behavior and, in particular, the striking displays shown at the breeding colony. From blinds we watched a study area containing about 250 pairs, many of them individually recognizable by different combinations of colored bands, and we mapped their nests in relation to features of the local landscape.

World gannet numbers are at present increasing—the Bass colony as a whole grew from about 12,000 individuals in 1949 (including the nonbreeding birds) to about 18.000 in 1962—and we were able to follow the expansion of our study group very closely. Gannets are long lived—usually they do not even breed until their fifth year, and our mortality figures indicated that adult gannets have a life expectancy of approximately sixteen years.

Part of a gannet's life is spent far from land, and once a juvenile has made its spectacular leap from the cliff down to the sea, we can only piece together fragments of information to follow its life until it returns to the breeding colony. As juveniles, North Atlantic Gannets migrate south from the British Isles as far as equatorial Africa, then gradually work their way back into northern waters. Thereafter, they do not usually migrate far south again. From records of banded birds, it seems that many, perhaps most, return to the colony of their birth, usually when they are two or three years old, but occasionally in their first year. Sometimes an old colony becomes so densely packed that newcomers in excess of the numbers required to replace dead members cannot find a footing and are forced out.

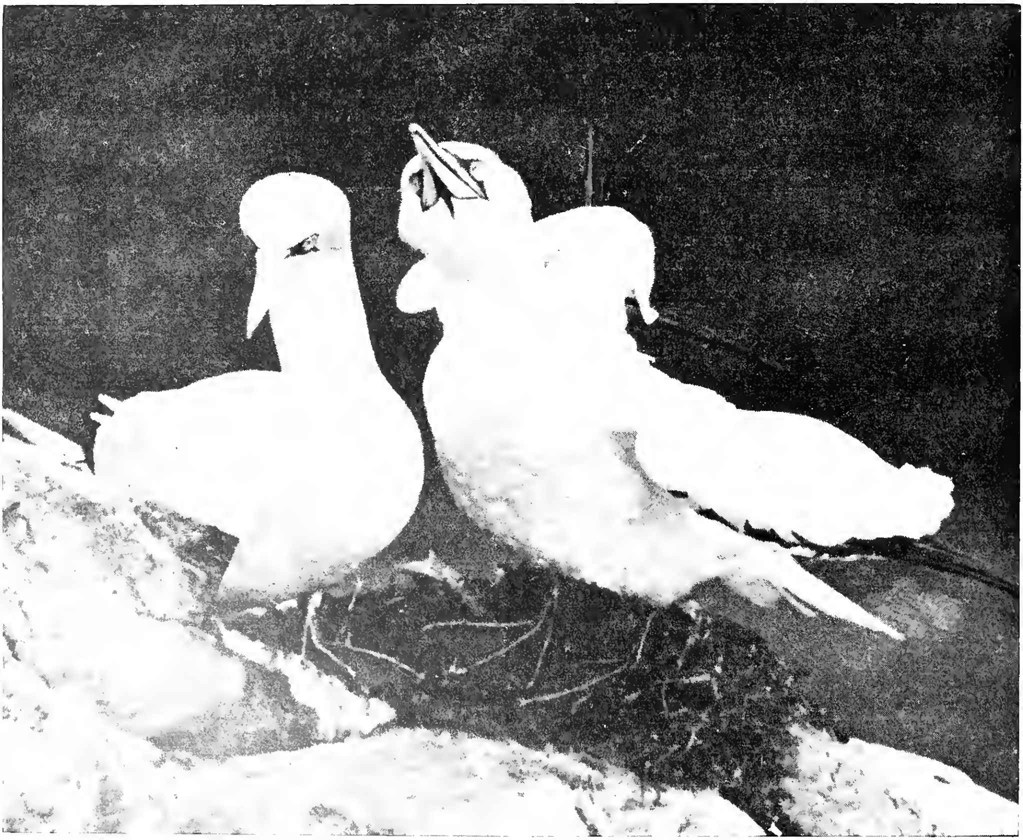
Immature birds fly endlessly over and around the colony—a process that probably familiarizes them with the colony, and perhaps particularly the area on which they later nest. They gather mainly near the top of the windward side of the Bass in "nonbreeding clubs," where they form temporary pairs, usually made up of birds the same age. Although there is no reason to suspect that a club pair afterward becomes a permanent pair in the colony proper, they at least go through the rites of pair formation under the less competitive conditions of the club. Also, time spent around the breeding colony probably helps them learn the local wind conditions (often very tricky) and the colony's main feeding grounds. For a time, then, immature birds lead a nomadic life, fishing far afield and returning periodically to the now-familiar Bass. We have noticed that gannets continue their fishing trips even in dense mist and seem very little inconvenienced.

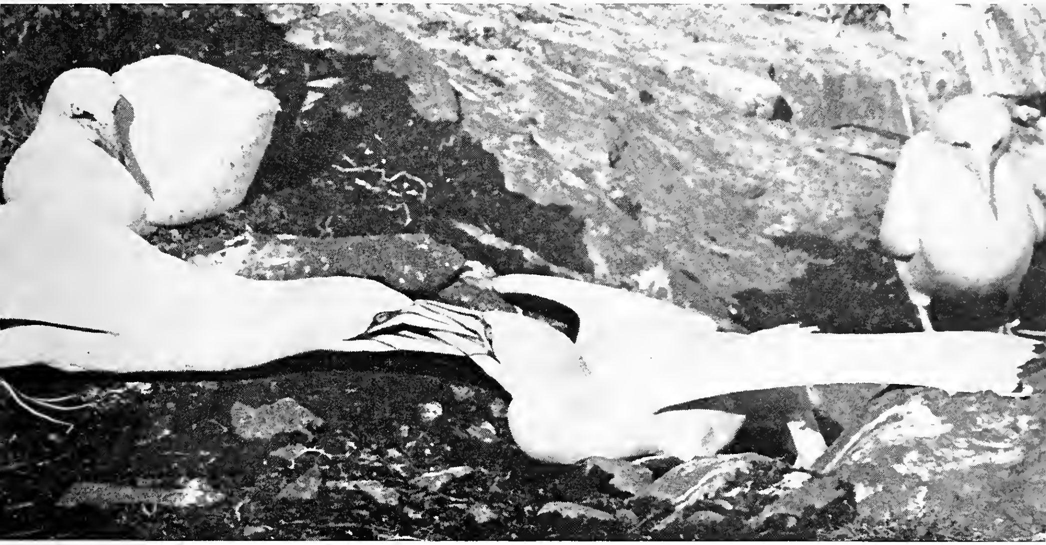
An important period in the male's life occurs in his fourth year, when he establishes his permanent nest site. By the time he returns from his oceanic winter life, most of the birds that have bred previously at least once have been back for a long time and have reclaimed their previous year's nests. The older the bird, the earlier it tends to return to the colony. Indeed, some sit out the icy gales of February on the barren rock, and may remain until early November. However, some old males have died, usually through accident (our color-banded male 5068 ended up in a native stewpot in Senegal in the winter of 1962/63, and each year several are drowned in fishermen's nets or killed at sea), and a few others return late. There are thus several unoccupied nests even in April. These attract site-hunting males, which fly low over the colony looking for empty spaces. Site



Observation colony of some 250 pairs was studied for three successive years. Maps were made of nest sites, the birds were banded, and behavior recorded.

Rotary head shake and wing flapping at nest are "comfort movements." Bird in this way loosens its feathers and then settles down on the nesting site.





Birds on adjoining nest sites watch a typical fight, which may be between either two males or two females. The bills are always the focus of attack.

hment becomes strong only after or three days of undisputed pos- on, so, if newcomers settle on a that turns out to be already ıed, they relinquish it without a ;gle. In territorial species, owner- confers great advantage in dis- ;; the owning bird fights more ·ously and usually wins. In the first stages of site establishment ıs much a part of a bird's adaptive vior to flee as it is, later, to stand fight. Some authors believe that .g birds can only acquire "in- r" sites at the fringe of the group, nust later graduate to better ones. ever, in a stable population, and rds tend to keep permanently the hey first establish—as gannets do s belief cannot be true. The new- ·rs merely take over the nests of ased birds. Such nests occur with l likelihood at all points in a p unless one area—the edge, say— .rticularly prone to predation.

TER a few days on the site, per- haps with short absences or none l (male gannets may remain at ıest site for five days at a stretch), site owners are extremely hostile l other males. A high proportion ll established sites involves the in at least one and sometimes ·al severe fights. Gannets were ably cliff nesters originally, al- gh they now nest on flatter ground ell, and it may be at least partly because their fighting method is primarily adapted to cliff ledges that it becomes so damaging on flatter ground, where contestants cannot fall off, be pushed off, or escape.

Gannets are gregarious in activities other than breeding—for instance, they fish in flocks, gather nest material communally, and rest on the sea in groups—and fighting of the male birds is entirely restricted to territorial disputes. Their bills are usually the focus of attack, although other parts of the face, head, and neck are also frequently gripped, as are sometimes wings, legs, or feet. Mandibles of fighting birds are strongly interlocked, so that withdrawal is often impossible unless the contestants break off simultaneously. With extended neck, they attempt to drive the opponent in front of them, tightening and relaxing their grip convulsively, the dominant bird shaking his opponent violently. Bill positions are altered with lightning speed, and often the tip of the upper mandible is pushed into the opponent's eye. However, gannets' eyes can withstand a great deal of punishment. After fighting in mud—perhaps for up to two hours—the plumage may be so filthy and matted that normal flight is impossible, and the birds career from the cliff top into the sea, leaving a muddy wake when they hit the water. Yet, we have known such a contestant to return, immaculate, from the sea in 48 hours.

Even old males may have to fight occasionally, but usually they successfully defend their nests either by threat behavior or by a specific display that is aggressively motivated, announces ownership, and repels other males. The display is a good example of "ritualized" behavior—that which, by a process of evolutionary change, has acquired enhanced value as a signal. The movement resembles a bow; the bird sweeps its head down beneath its outspread wings, raises its head, shakes it from side to side, and repeats the procedure, meanwhile calling aggressively. This is related to the aggressive nest-building behavior.

After a fight, victorious males bow to show their ownership of the nest site, but beaten ones never bow. Exhausted individuals may sleep for three days—a phenomenon comparable to battle fatigue in soldiers. Even if the frenzy of the fight takes both birds yards from the site, the winner rushes back and bows only from the site. Bowing in this context occurs most frequently early and late in the season when, we know from other evidence, the males are most aggressive. Sometimes the bow elicits attack, rather than repelling other males. During his lifetime, a male gannet bows thousands of times in response to in-

ADVERTISING MALE, at right, does not call, and wings are tightly closed. Female, beak slightly elevated, approaches.

EACH TIME male returns to nest site he bites mate hard enough to dislodge feathers: she averts head from attack.

AGGRESSION is also present during copulation, when male repeatedly bites female vigorously with his powerful bill.

truders, and often when there is no particular threat to his supremacy. I have seen gannets suddenly wake from a sound sleep, bow vigorously, and immediately return to sleep.

It is interesting that females give a less complete and less frequent version of the site ownership display. This is in keeping with their weaker attachment to the site. Thus, they do not establish the site in the first place, do not spend as much time on it as the male does, and on the death of their partner they are not as likely to remain faithful to the site (77 per cent as against 94 per cent in the male).

Young females, usually in their fourth year, begin to look for a mate within the colony—I call them "prospecting" females. These behave rather like site-hunting males: they fly over the colony and then settle on a suitable vantage point—perhaps a rocky spur or an empty spot between nests. Unmated males do not restrict their metaphorical advances to prospecting females; they will "advertise" to any female, mated or not, that passes nearby. The male's advertising is rather like an extremely modified version of his site ownership display, with the aggressive bowing elements reduced, the wings tightly closed, and no calling. Advertising males look faintly ludicrous as they shake their heads vigorously and make slight reaching movements and inhibited bows toward the object of attention.

If unmated males advertised only to unmated females and stopped advertising as soon as a female had responded, and if such a female re-

NESTS of gannets are about 2½ feet apart on the average and are often cemented to the precarious site by the excrement of the breeding pair.

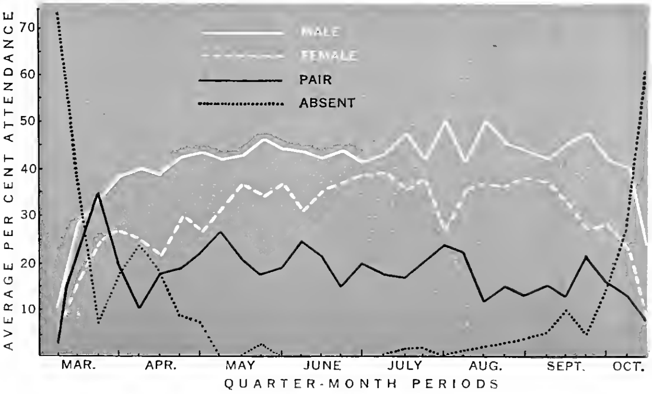
ined with the first male she ap- ached, all would be well. However, emale may respond to an adver- ng male and remain with him, but e he goes off to fish she may have interest in the nest site as such and ckly respond to another advertis- male. Therefore even a "success- " male must continue to advertise risk finding himself mateless. Thus, continuing to advertise, males ally acquire more than one mate, l some acquire as many as six. If females chance to meet on the site r both are strongly attached to one le, they fight viciously. The males not consistent in this situation— netimes they accept the winner, but en they reject her. Frequently, they fer the one with whom they have n most recently.

When the female approaches the ad- tising male, often hesitantly, he y attack her vigorously. Her pres- e within his territory releases ression strong enough to express lf by a real attack, despite the in- ition resulting from sexual "in- est" in her. Aggression is one of the net's most striking features and is spicuous both toward intruders l in the normal pair relationship. h time the male returns to the nest he bites his mate emphatically ugh to dislodge feathers, even if y are an old established pair. He bites her during copulation—at st one hundred times each season— l whenever a neighbor threatens or attacks him, he turns on his mate in redirected attack. The female accepts an astonishing amount of punishment without retaliation, but has a behavior pattern that tends to reduce the severity of the male's attack. She turns her bill away from him, or "faces away." This is one of three gannet "appeasement postures." The other two are the "pelican posture" of adults, in which the bill is tucked medianally into the breast, and the "beak hiding" of the chick, in which the bill is hidden beneath the ventral surface of the body. There is also a fourth posture, in which the bill is directed vertically upward, usually performed immediately before flight or movement on foot away from the nest site. However, there is considerable doubt about its function as an appeasement posture.

NEW pairs usually attend the nest site and defend it vigorously for a six-month season—or part of one, if they are late in establishing themselves—before attempting to breed. This is not necessarily because of their age. Although five is the usual breeding age, four-year-olds of both sexes can breed without a preparatory season. However, young females lay later than old ones and also have eggs lighter in weight. Before the single egg is laid the pair copulates whenever one returns from a long fishing trip (sometimes they remain away for three days or more). The frequency of copulation increases in the two or three weeks prior to egg laying, and since the male almost always gathers nest material after copulation, an extra spate of nest building precedes laying and produces a well-built nest to receive the single egg.

Gannets frequently depress their tails while excreting and "direct" the excreta onto the side of the nest. This enables the birds to cement their nests to otherwise untenable places.

On several occasions we saw gannets lay eggs and noticed how they used the tail to direct the egg into the nest—a nice adaptation for a cliff-nesting bird, where a misplaced egg cannot be retrieved. Even on flat ground gannets are usually unable to retrieve eggs that ground-nesting species could easily roll back into the nest.



TOTAL TIME adults spent at or away from nest is graphed. Aggregate of times (broken or solid lines) in any one period equals 100 per cent.

If the male is present, he takes the first long incubation stint almost immediately after the egg is laid and, in fact, takes slightly longer spells than the female throughout incubation. However, she is less willing than is the male to leave the egg when brooding periods on the nest are reversed.

Like other members of the family, gannets lack a brood patch and incubate their egg by overlapping their webbed feet on top of it. There is some question whether heat is transmitted through the webs, but these certainly become vascularized and warm during the incubation period and are probably a better source of heat than is the bird's feathered body. Broken or stolen eggs are replaced, usually within a fortnight, although new pairs have a much weaker tendency to produce replacement eggs than have experienced birds. Gannets invariably lay single-egg clutches (any observed exceptions were probably due to two females laying in one nest), which hatch in 43 or 44 days. Soon after the egg begins to pip, the adult transfers it to the top of the webs and so prevents the weakened shell from crushing and lacerating the chick, which is brooded on top of or between the webs.

BASS ROCK gannets have no serious predators except man. Herring Gulls dare not venture within the nesting ranks to steal eggs unless the gannets are disturbed and fly off temporarily. Young gulls, unsteady on the wing, were torn to pieces when they fell among gannets. Yet, small birds like Rock Pipits ran between the nests with impunity. In undisturbed groups, the hatching success averaged 82 per cent of all eggs laid, although females breeding for the first time were less successful at incubating than were the older ones.

Newly hatched gannet chicks weigh less than 80 per cent of the newly laid egg and lose more weight during the first day. They are blind and naked and, unlike newly hatched young of many other species, appear to be fed without having to beg. The adult gently "engulfs" the chick, which apparently wallows about in the mass of semidigested, regurgitated fish in the parent's mouth and often emerges with fish piled on top of its head.

A large chick begs for food by whetting its bill against that of the adult and "yipping" loudly. Then it pushes its head into its parent's mouth, and with vigorous pumping movements manages to move fish from the adult's throat to its own. Whole mackerel slide from adult to young in this manner, which efficiently transfers food and keeps the nest relatively free from fragments. The chick is fed several times a day, unlike some sea bird young, which are fed at infrequent intervals, and at the age of six weeks a gannet weighs as much as its parents. Strangely, the adults do not appear hard pressed to gather enough food for their offspring, and the only time that we recorded chick starvation was when one of the parents died.

One parent or the other (and, for

CHICKS—this one may be four or five days old—are hatched following an incubation period of 43 or 44 days.

AT ABOUT ten weeks the young bird is speckled and oddly ruffed. The old name for gannets at this stage of life is "parliamentarian goose."

DARK REPLICA of parents exercises its wings at 13 weeks, just prior to its departure from nest. Once it has left the nest, it does not return.

Gannets invariably lay clutches of one egg. They have no brood spot, and incubate egg under their feet. Broken eggs are usually replaced in two weeks.

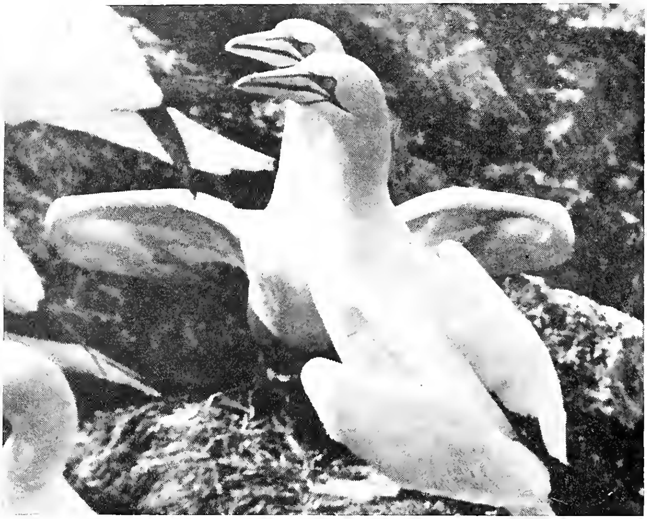
out a sixth of the daylight hours, th) constantly guards the nest. This necessary in the gannet, because un- ded chicks, even if they do not nder, are liable to be attacked and led by neighboring adults. Al- ugh the chick attempts to reduce severity of such attacks by hiding beak beneath its body in a submis- e attitude, this appeasing behavior netimes does not work. We saw four cks killed by strange adults.

The adults' fishing trips usually take between six and fifteen hours, d probably cover a normal range of least a hundred miles from the ss. If food is hard to find, the range certainly much greater—perhaps as ch as three to four hundred miles. The gannet's capabilities in feeding voracious chick, which at about e weeks weighs one and a half times adult weight, were so impressive t we tested it with two offspring by nating an extra egg or chick to a ies of nests. These artificial twins re weighed regularly, and their wth compared with ordinary single cks. To our surprise, the extra bur- n made little difference either to the growth of the twins or to their fledging success, although we found that the twins survived only if they were very nearly the same age. They took an average of 94 days to fledge against 90 days for a single chick. However, the final weight of the twins was not significantly different from that of the normal single chick, so it is likely that their survival to adulthood would not be significantly less successful.

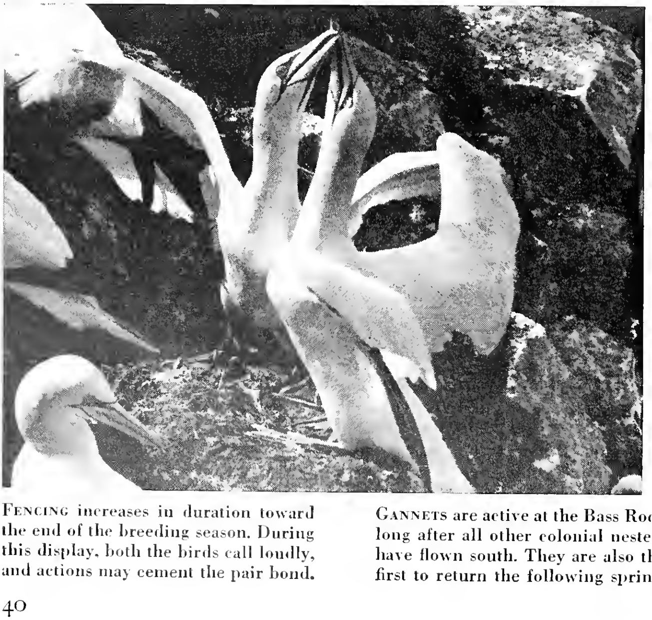
The main question raised by this experiment is why, if gannets can incubate two eggs and feed two chicks, they lay only one. It is possible that the extra strain endured by the parents shortens their reproductive life, so the advantage of rearing two instead of one might be offset by the harmful effect on the parents. There is some evidence from the lore of the old gannet hunters that adults are fat in spring and lean in autumn, which suggests that the rearing of a chick imposes some strain. To set against this unproved statement are the facts that gannets, like other large sea birds, have adaptations permitting them to withstand great temporary weight loss, and that the period during which the chicks make heavy feeding demands on adults is limited to about two months out of the twelve. I have described this aspect at some length because, together with other aspects of gannet breeding biology—notably the extended period before it first breeds—it raises basic questions about the factors controlling the reproductive rate of sea birds.

During the thirteen weeks that the young gannet spends in the nest, it changes from a ball of fat covered with long, white down, into a somber replica of the adult—in shape, stance, and size, but utterly different in color, being slaty-black, finely speckled with white. It is fed until the day it leaves the nest: the widely held idea that adults refuse to feed the chick during its last two or three weeks on the nest to induce it to fly is false. Until then it dare not move from the nest, either for fear of falling, if on a cliff ledge, or attack from neighbors, if on flatter ground. Thus, large chicks tend to run away from humans on more level areas, but young of the same age on cliff sites usually stay firmly on the nest. Gannets have therefore no need to recognize their own young—only the nest site. In fact, they will readily accept strange chicks in place of their own, even when there is a wide age difference. It is very important, however, that the substituted chick should be on the nest when the adult returns. If any chick approaches the nest when an adult is on guard, it is attacked like any other trespasser.

Several hours before jumping off their nests in the fledging flight, the young gannets seem to "concentrate" for long periods, staring into the sea. (They are too large to be attacked by gulls, so they can leave at any time of day, unlike young guillemots, which usually leave their nests at dusk, presumably to reduce the risk of gull attack.) When a young gannet does jump it either flounders through the nesting ranks and is vigorously attacked on the way (it may even be killed) or, if lucky, it becomes airborne immediately. The first flight is naturally a little wobbly, but even so the young bird can fly for several miles at the first attempt and may even gain considerable height. Once it alights, however, it is unable to rise again, and swims out to sea—at least in the cases we have witnessed. Even now its troubles are not over, since many young gannets, particularly those that have fledged early in the season, are severely attacked on the sea by adults. The parents do not show any interest in the departure of their offspring, and



Mutual display occurs when a pair meets at nest after feeding flight. They stand breast to breast, wings spread, and fence with their bills.



Fencing increases in duration toward the end of the breeding season. During this display, both the birds call loudly, and actions may cement the pair bond.

Gannets are active at the Bass Rock long after all other colonial nesters have flown south. They are also the first to return the following spring.

ainly do not accompany them to Instead, they remain together on nest until October or early Novem- performing their ownership dis- s, adding to the nest, and showing esurgence of "interest" in each r, including actual copulation.

HE conspicuous and well-known mutual display, which occurs never the pair meet at the nest r an absence of some hours, in- ses in duration toward the end of season, although it also occurs ughout the entire breeding cycle. ll it "mutual fencing," because the s stand breast to breast with out- ad wings and fence with their , calling loudly. Occasionally they their heads in a movement similar owing. The whole spectacle im- s a friendly, sometimes an ecstatic, reunion, and in fact one function of the display is to cement the pair bond. It provides a friendly outlet for elements of fear and aggression, which, together with strong sexual interest, are engendered when they meet on the site after a long absence.

When the pair is newly formed, and particularly in those cases in which the male is uncommonly aggressive to the female, the mutual fencing is always particularly lengthy and intensive. In a stable pair and in midseason, when aggression is at its lowest, mutual fencing may be perfunctory.

A visit to a gannet colony in late October could, weather permitting, still reveal a scene of tremendous activity. Long after all the other colonial sea birds have left the Bass Rock, gannets continue to sail round the cliffs and display at their nests. Well before the others return for the new season the gannets are back. The nest site, for the gannet, has become of prime importance, and apparently its successful defense has favored unusually long seasonal attendance and, above all, aggression so strong as to be unique among British colonial sea birds—perhaps even among all such species. Whether fighting, threatening, or bowing, whether males are attacking their mates, or both are attacking chicks, aggression seems a dominant theme in the birds' lives. For the juvenile, this all lies four or five years ahead. Before then it must perfect its fishing skills, return over the seas from great distances to the speck that is its nesting colony, and gradually acquire adult plumage and behavior. Then it will take up its position in the colony and the cycle will once again be completed.

Cross-Pollinatio of an Orchid

Structure of C. reginae makes insects instruments of surviva

By H. Lou Gibson

The flowers of orchids, members of the large family Orchidaceae, have remarkably specialized structures that insure cross-pollination by insects. The photographs on the opposite page were taken during the visit of a bee to a Showy Lady's-slipper, *Cypripedium reginae,* an orchid that grows in swamps and wet woods from Newfoundland to Georgia, and west as far as North Dakota. Its large flowers are single on a stem, and their intricate construction has the effect of making self-pollination unlikely. Self-pollination tends to keep a species unchanged, slowing, but not eliminating, its evolution. Consequently, the self-pollinating plants are often less adaptive to environmental changes and are thus less likely to survive over long evolutionary periods.

From the time insects appeared during the Tertiary Period some seventy million years ago, their relationship with plants has proved in most instances to be mutually beneficial. Flowering plants have furnished food and occasionally shelter for insects, and insects have cross-fertilized plants, a function that was performed in previous millenniums mainly by the wind.

Flowers are exclusively reproductive organs. In most species, a color, shape, and odor have evolved that attract only those particular insects with anatomy suited to transferring the pollen of that flower. Thousands of plant species would disappear if this were not so. Plant-insect relationships have become so specialized that some flowers may be visited only by bees, while others are cross-pollinated exclusively by wasps, moths, or flies. Insects are not the only animal-pollinators of plants, however. In the tropics and in South America, birds are pre-eminent in the role, and some part is played by nectar-drinking bats and other mammals.

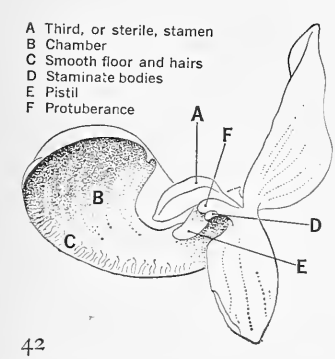
The parts of the Showy Lady's-slipper that virtually guarantee cross-pollination are the same structures that make the flower exotic to the human eye. The third, or sterile, stamen (A in diagram), which is thick and in the shape of an elongated heart, is yellow at the tip and is spotted with crimson. This infertile stamen attracts insects such as the bee seen in the photographs. The construction of the orchid is such that a bee alighting on or near this stamen practically falls into the chamber (B) that is formed by the enlarged posterior petal. At the moment the photograph at the upper left was taken, the fore parts of the bee had already entered the chamber.

A cross section of the interior of the chamber is shown in the bottom picture. Once inside, the bee crawls over the smooth floor (C) toward the pistil (E). The bee is encouraged to move in this direction by fine, slanting hairs that are inclined forward along a route to the pistil and prevent the bee from reversing its path. Moreover, the inner walls of the chamber are smooth and steep. Therefore, the bee has lit choice but to advance toward the tu nel that leads under the stigma—t part of the pistil that receives poll grains, and on which they germinat There are actually two tunnels in t Showy Lady's-slipper, but both w bring the pollen-bearing bee into co tact with the pistil. The sticky stign catches and removes from the bee back any pollen the insect carries fro other flowers it has visited, and cros pollination is thus achieved.

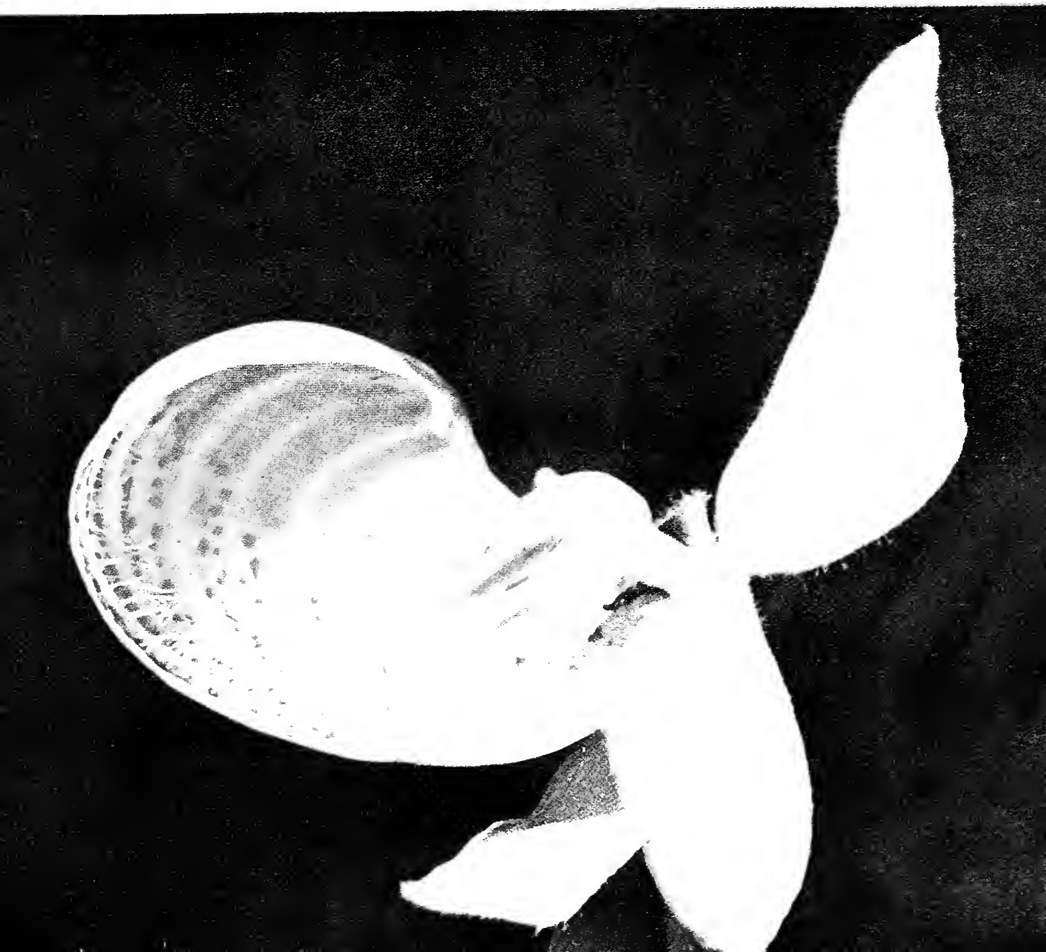
In the top right photograph, the be has squeezed past the pistil in its a tempt to crawl through the narro passageway and leave the flower. Onc past the pistil, the bee cannot bacl track. If it should try to move bacl ward, the exit lips and the protube ance (F) of the Showy Lady's-slippe will tighten around it. If this were nc the case, the bee, after having mad contact with a staminate body (D) might carry back to the orchid's pist pollen from one of the flower's stamens, causing self-pollination.

After the bee has picked up polle from a staminate body and escaped, it may then fall into the trap o another member of the species anc again effect cross-pollination. But i an unusually large bee were to enter a Showy Lady's-slipper, it would probably be unable to move all the way through the flower's passages. In fact many large bees do become trapped ir these orchids and perish.

In the field it would have been extremely difficult, if not impossible, tc photograph a bee entering a Showy Lady's-slipper because of the speec with which entrance is accomplished. This technical problem was solved by chilling a bee until it became sufficiently sluggish to use as a model.



OWY LADY'S-SLIPPER, an orchid, is cross-pollinated by
e, which is attracted by infertile stamen (yellow tip).
e enters chamber formed by a large petal, *above left*. The chamber's smooth walls and "hairy" floor, *below*, prevent bee from moving in direction other than toward the pistil, staminate bodies, and, ultimately, exit lips, *above right*.



NATURALISTS' NOTEBOOK

A very young toad is scrutin

A snail has withdrawn into

Pond is site of nature adventur

Exploration at the Pond

hotographs by ARLINE STRONG

ate spring and early summer are a special time of year or the young. A puddle, pool, or pond may mean wet eet, but it also means a laboratory where living things are iscovered, admired, and—sometimes to parental dismay -are brought proudly home. In or near these wet places, hildren may be first exposed to the lives of other animals, nd, through curiosity and observation, generate an in-erest in the natural sciences. There are so many questions be answered. Will it bite? Does it grow any bigger? here does it go in winter? What does it eat? And on ese same questions are based adult studies in biology, xonomy, animal behavior, physiology, and ecology.

Tadpole comes to light in sieve.

Texture of garter snake is felt.

Snapping turtle is held gingerly.

Fowler's toad is child's handful.

ISTORIC MENHIR, or
e-standing stone,
s the symbols of its
tianization, which
place *ca.* A.D. 900.

IGNMENTS AT CARNAC,
ance, are creations of
ehistoric people who
ıy have used them
religious ceremony.

Megaliths and Men

uropean rock monuments are relics of nascent civilizations

y Glyn E. Daniel

OME FIVE THOUSAND years ago,
three millenniums before the Age
Pericles in Greece, the rain forests
western Europe were gradually
ing thinned by men engaged in mak-
the most important social and eco-
mic revolution the world had ever
own—the New Stone Age. For the
st time in Europe, people had be-
n to domesticate animals, to till the
l, and to establish villages.

In this era, not very remote from
days of European man's complete
pendence upon cave shelters and
ture's bounty, Egypt and the Aegean
untries had already extended arms
primitive commerce across the
editerranean Sea. The routes sailed
were in sight of shore much of the way, and reached to the Spanish peninsula, Brittany, the British Isles, and Norway. Colonizations, migrations, and invasions pressed westward on the coastline of the continent parallel to the sea lanes. It was during this era that the European megaliths (from Greek *megas*, "large," and *lithos*, "stone") made their appearance.

Early in this period, the distribution of megalithic monuments and tombs appears most concentrated near the waters that carried trade, but eventually the megaliths spread across much of the Western world. Objects buried with the dead always help to reconstruct the culture of the builders, and these abound: polished stone axes, decorated and plain pottery, beads, objects of copper, and the remains of animals—perhaps leftovers from funeral feasts, or burial offerings.

Significantly, Mediterranean chamber tombs often contain small figures of the Earth Mother Goddess carved in bone or flat stone. Because the eyes of the goddess are emphasized, she is sometimes called the Eye Goddess. The eye motif frequently appears as a spiral on pottery, and some western European tombs were decorated with pocked or incised motifs of the goddess figure. These motifs and the custom of collective burial can be traced back from tombs like New Grange, in Ireland, and Gavrinis, in Brittany, to the Sicilian and east Mediterranean cultures of the beginning of the third millennium B.C., when Egypt was in

Mounded tomb at Los Millares, Spain, held remains of prehistoric seafarers.

incipient stages of unification and Troy had only recently been founded.

The builders of European tombs and monuments, which almost certainly originated in the east Mediterranean, colonized the central and western Mediterranean. They set up small townships, such as Los Millares in Spain, and were precursors of the Minoans, Mycenaeans, Phoenicians, and Greeks. They established sea routes that modern Basque, Breton, and Galician fishing boats still use today—from Portugal and Brittany to Ireland and Britain, and then on to Scandinavia.

Megaliths comprise the oldest surviving buildings in western Europe, although groups of holes in which posts to support walls once rested are evidence of earlier structures of wood and wattle and daub. Many of the stones used in the surviving megalithic monuments are truly enormous. At Stonehenge, the largest is 29 feet 8 inches in length. In southern Brittany, the Grand Menhir Brisé, which now lies broken into three pieces, was once some 68 feet long. The capstone, or roofing slab, of a megalithic tomb in County Carlow, Ireland, weighed about 100 tons, and one of the capstones of the great megalithic tomb of Bagneux near Saumur in central France weighed more than 86 tons and provided a roof area of some 23 square feet.

In most European monuments and tombs, the great stones usually appear to be undressed, or only very roughly dressed by stone mauls. The surfaces of some were smoothed and polished, though, and the highly finished inner "walls" of Stonehenge provide a supreme example of this dressing. So do some of the megalithic temples in Malta, which lies farther back along the east-to-west path by which the megalithic tradition reached Iberia, or the Spanish peninsula, and Britain.

Including those in Britain, five main types of megalithic monuments existed in prehistoric western Europe: first, the single standing stones, or menhirs, from two Breton words, *maen*, "stone," and *hir*, "long"; second, rows of standing stones, or alignments as they are called in Brittany; third, stone circles, of which Stonehenge is an exalted and elaborate example; fourth, roofed or open temples, such as those in Malta; fifth, the commonest form of prehistoric megalithic monument, the roofed tomb, often called a chamber tomb, because it is a large structure into which one can walk.

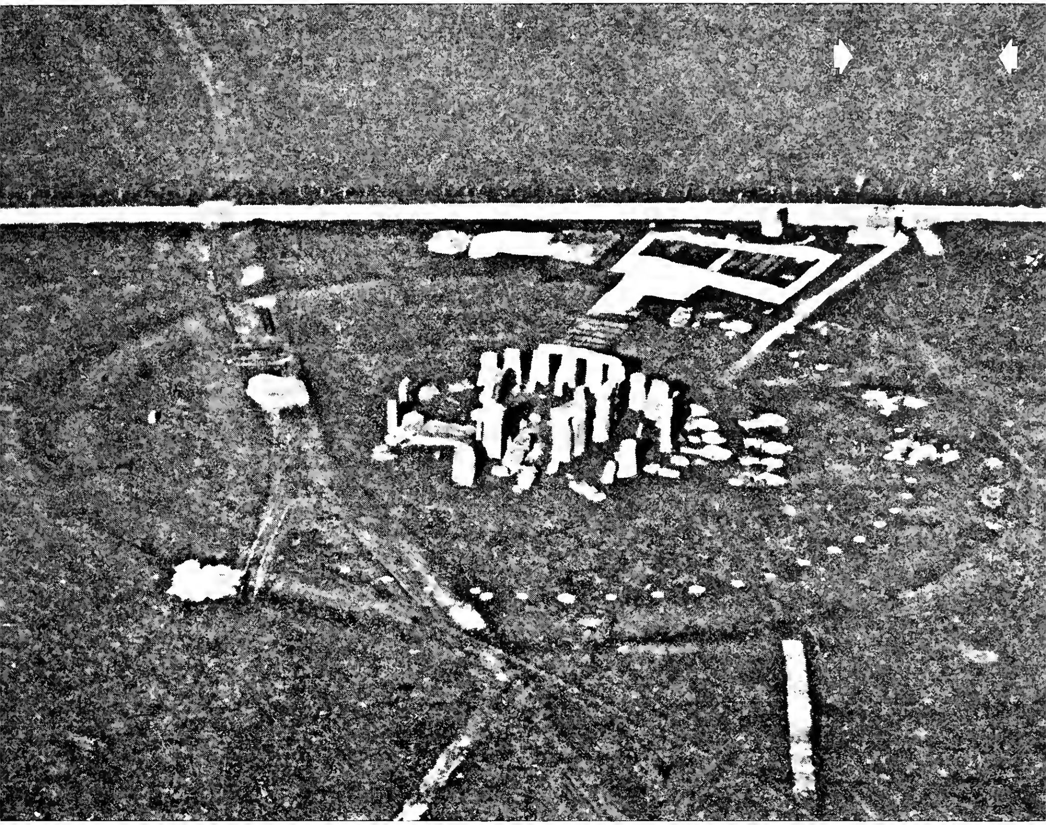
Menhirs, or single standing stones, are common in Brittany: they vary in size from two or three feet up to seventeen or twenty feet. The largest of all is the Grand Menhir Brisé. What the present-day visitor sees at this site in France is three great pieces of stone, the broken remnants of a single giant menhir that once stood 68 feet high and weighed 330 tons. In comparison, Cleopatra's Needle on the Thames Embankment in London (where it was brought from Egypt) is 68 feet 6 inches, and weighs 180 tons.

Because menhirs come to us without inscriptions from the preliterate past, their purpose can only be guessed at. Excavation around and near them does not indicate either that they are the marking stones for graves, or that they evolved on or near a burial site, as did Stonehenge. They may be memorial stones or just stones that were worshiped. It is certain that they were also worshiped into historical times, and that the Church eventually Christianized many of them by carving or erecting crosses on them.

Alignments, or stone rows, the second type of monument, are found in southwestern Britain and in northwestern France, but unquestionably the most famous are those at Carnac in southern Brittany. The main Carnac alignments extend for a distance of several miles and consist of thousands of stones. They fall into three groups: the alignments of Menec, of Kermario and of Kerlescant. The Menec series the largest, is 3,827 feet long and consists of 1,169 single-standing stones arranged in eleven parallel rows with a half-circle erected at the eastern end.

The purpose of these great stone rows is as questionable as that of the menhirs, but surely they were processional ways of some sacred, ritual, or religious nature along which Neolithic peoples passed toward appointed ceremonies in the half-circles. There certainly can be no question that there was a great flourishing of megalithic culture in southern Brittany between 2500 and 1500 B.C.

A prehistoric origin is attributed to the temples of Malta, such as Ha Tarxien, Mnajdra, and Hagiar Kim on the main island, and the Gigantija on the neighboring island of Gozo. These magnificent temples are superb examples of megalithic architecture but unlike the British stone circles, were roofed over. Whatever ceremonies went on inside were connected with the Earth Mother Goddess cult. Representations of the goddess have been found in these temples. Some are smal figurines, but one is the broken part o a large statue that, when whole, mus have stood about twelve feet tall.



ONEHENGE "avenue," indicated by arrows, is seen in 1921
ial photo. As result of air survey, the avenue was found
to reach Avon River, suggesting a pathway to move stones
from boats. The white areas near road are excavation sites.

PORTUGUESE DOLMEN, a place of burial,
is constructed of natural rock slabs.

The most common megalithic monu-
nts are the chamber tombs, which
ill discuss in terms of their exca-
ed contents in Britain. Some twenty
usand of these tombs survive in
tern Europe. We know that many
e been destroyed, but can estimate
original number of perhaps two or
ee times those still extant. Although
ne of them were cut into natural
k, the surface tombs attract most
ntion. Many are covered with great
unds of earth and stones, while
ers are completely free-standing.
nong the latter is the Grand Dol-
n of Bagneux at Saumur, in central
ance. Its interior measures 61 feet
16 feet, and from 8 feet 6 inches to
eet high. And among the most im-
ssive of mounded surface tombs is
v Grange in Ireland. There a pas-

Passageway in Sardinian fortress of first millennium is se
at left. Hypogeum on island of Malta, *above*, is catacomb a

sage 63 feet long leads to a chamber roofed with a corbeled vault, the top of which is nearly 20 feet from the floor. The whole stands in a round mound 265 feet in diameter and 45 feet high, the height of a modern five-story building.

The most significant archeological evidence of the ritual use of these tombs in Britain and Iberia consists of buried human bones. Exhumations from megalithic tombs near Stonehenge indicate that the interred were probably somewhat long-skulled men who averaged between 5 feet 4 inches and 5 feet 8 inches in height. In connection with the skeletons, two curiosities have been remarked generally by prehistorians. First, the number of bones found in many of these tombs during modern excavations indicates a quantity of buried dead that would seem far too large for entombment in one mass burial. Second, many bones are broken in a way that suggests ritual breakage, and perhaps are instances of human sacrifice. There is also evidence that fires were lit in tombs, often simply for lustral or ceremonial purposes, although occasionally cremation was practiced. In some cases, only certain bones in a single skeleton were burned. Most corpses were interred with knees drawn up to the chin or in a squatting or sitting position on the floor of the chamber.

There is little dispute about the interpretation of much of the evidence. Deposits of bones outside the portal in the tomb's forecourts clearly indicate a tomb-closing ritual, and the tools and goods buried with the dead are ritual offerings, perhaps possessions of the dead persons. In the evidence from some communities that practiced collective burial of the dead, such as the prehistoric sites in south Wiltshire, Hampshire, and Dorset, there is little to suggest that tombs were ever reopened to put in fresh corpses. But in many instances, we know that tombs were reopened for such a purpose. Regarding damage to bones, it is thought likely that, in a cold winter, when many of the old perished, their bodies were collected in a common ossuary, where decay of the body was considerable before the corpses were moved. Therefore, during transport from the ossuary to final entombment, inevitable minor accidents would cause the loss or breakage of some bones. The most recent corpses probably were entombed with their skin intact, and decayed in the crypt.

Megalithic tombs for the burial of the dead in prehistoric Europe are not especially mysterious phenomena, b
cause stone vaults and tombs are co
monly employed for the same purpo
today. Cremation and multiple buria
in family tombs are also still commo
place, if modified, practices. Specul
tion, therefore, has been focused
megalithic buildings with significan
not necessarily related to the grave.

Certainly the most discussed of
such megalithic architecture
Stonehenge, on Salisbury Plain, Wi
shire, in southwestern Britain.

At Stonehenge, pillar and bea
architecture was employed to produ
trilithons—two uprights with a lint
across the top—and linteled circles.
is the appearance of these lintels a
parently hanging in the air that seer
to have given the site its name, whi
means hanging stones. Less comp
cated prehistoric stone circles are r
ferred to as henge monuments, a ter
that includes circles with wooden
well as stone posts, and even mon
ments like Woodhenge (in Wiltshi
not far from Stonehenge), which w
a circular structure of wooden pos
and survives to the present day on
as postholes visible on an aerial phot

Recent excavations suggest th
Stonehenge, like a medieval cathedra
was built, modified, and rebuilt sever

ne, which dates back to the third millennium. In tomb at
st Kennet, England, *right,* remains of corpses were found.

es. It was first constructed between
0 and 1700 B.C., and its final recon-
ction took place about 1400 B.C.
se estimates are based on radio-
on dates and on archeological cor-
tions with dated contexts in the
Mediterranean, where many of
artifacts excavated at Stonehenge
ost certainly originated.
lose contact between Britain and
east Mediterranean and Aegean
s from 1500 to 1300 B.C. is at-
ed by the appearance in Britain of
nented faïence beads, made in
pt and traded by Minoan and My-
ean merchants. There is a gold
from Rillaton in Cornwall that is
like one from the shaft graves at
cenae, and a Mycenaean dagger was
nd at Pelynt in Cornwall. More-
r, engravings depicting flat copper
s were discovered recently on some
he stones at Stonehenge. One en-
ving is of a hafted dagger that
bably is Mycenaean. Thus, I have
doubt that the brilliant prehistoric
itect who planned and built Stone-
ge—as a tour de force within the
viously established tradition of
galithic stone circles in Britain—
acquainted with the older cyclo-
n architecture of the Aegean area.
f Stonehenge has been associated
ularly and erroneously with the
Druids, it is because neo-Druids hold celebrations there Midsummer Eve by permission of the British Ministry of Public Buildings and Works, not because there is any archeological evidence that the real Druids built Stonehenge. The real Druids of antiquity were the Celtic philosopher-priests in Gaul and Britain just before the Roman Conquest. They may at one time have used Stonehenge, although we have no evidence even of this. In any case, theirs would have been a re-use after the passing of more than a thousand years.

The origin of the megalithic stone circles—a pattern that seems indigenous to the British Isles—may lie in the wooden circles, which may be mere representations of older circular clearings in woods. The sequence of development might well have been from natural forest clearings to artificial wooden circles, to stone circles, and, finally, to Stonehenge, merging the old earthbound religion of the West with newly arrived celestial religions from the Mediterranean.

According to Gordon Childe, whose influence on the study of European prehistory has been enormous, apostles of a megalithic faith probably arrived in Britain by the Atlantic seaway between 3000 and 2000 B.C., settling in the southwestern part of the island where Stonehenge is located. It is a matter of record that the initial tombs fan out from the west coasts of Britain and around the Irish Sea. In fact, the vast majority of the burial chambers in southern Britain are found within twenty miles of the shore. Proximity to water, which was necessary for transport, and to local stone supplies, were the factors governing the location of these early megalithic sites.

Childe hypothesizes that in Britain megalith builders were not merely fresh contingents of migrating Iberian farmers, but were probably a religious aristocracy of the Iberian Peninsula who first came to Britain as missionaries. Close parallels to the plans of these early British tombs can be found in western Europe, particularly in Iberia. When much later in time the Beaker folk, makers of bell-shaped pottery beakers, invaded Britain, they must have displaced this Iberian missionary aristocracy, whose dead had been inhumed in the megalithic tombs.

In Childe's view, the Beaker folk liberated native British farmers and herdsmen from much of megalithic superstition, but found it provident to patronize native cults, giving them a celestial orientation to replace their obsession with the subterranean graves. As a consequence, the first stage of the great stone circles at Stonehenge, many archeologists believe, was set up by the new Beaker ruling class on or near the sites of sacred megalithic burial grounds. The fact that the final entrance to Stonehenge points to the place where the sun rises on Midsummer Day has been used as an argument for a sun cult; the sun was an early symbol of resurrection.

RECENT findings of Professor G. S. Hawkins, of Boston University and the Harvard-Smithsonian Observatory, have encouraged adherents to the hypothesis that Stonehenge, in its final prehistoric form, was constructed as a celestial observatory. Using a computer, Professor Hawkins has established definite correlations between the position of the stones and the horizon positions of the rising sun and moon at midsummer and midwinter in 1500 B.C. According to an article in *New Scientist*, in October, 1963, the alignment of certain principal stones with the direction of the sun was shown by Hawkins to exist with only one degree of error. Correlations with the moon were demonstrated to within one and a half degrees. The probability that these alignments could have come about, not through the intent of the builders, but from chance, is small.

The main elements of Stonehenge include an outer circle of so-called Aubrey holes, an inner circle of sarsen stones, and within this a horseshoe of bluestone. On the outer circle are two so-called station stones, and two others that once existed have vanished. By joining the positions of the station stones, a rectangle is formed and the point where its diagonals meet is taken to be the center of the monument. The formal entrance is known as the "avenue." The avenue has always been assumed to point roughly to midsummer sunrise. Hawkins has shown that it is substantially correct to say the axis of the avenue did point toward the rising sun on June 21, 1500 B.C.

Archeologists agree that the fantastic communal achievement in Stonehenge and the feat of constructing a huge henge of 1,400 feet diameter at Avebury, in England, are testimony to a high degree of tribal political accord—or perhaps a sacred peace enforced by warrior heirs of the Beaker aristocracy. Certainly work of this complexity and scale—the transport of enormous stone blocks 140 miles from quarry to building site—would require an organized effort by the existing society.

It is possible that archeologists may one day establish worldwide interrelationships between some or all prehistoric structures built with large stones. (Examples also exist in Africa and the Orient, but some were built in very recent times.) But certainly there never was a megalithic master race that spread from Ireland to Easter Island, in the South Pacific, constructing monuments wherever it migrated. With respect to the tombs and megalithic statuary of the Easter Islanders, skeletal evidence excavated from graves shows conclusively that the oldest interred corpses are of the same racial stock as that of the recent inhabitants—Polynesian with Negroid traces. Therefore, these megaliths must represent the efforts of an indigenous South Pacific island population. Moreover, the Easter Island monuments are undoubtedly of more recent origin than the great stone architecture of New Stone and Bronze Age Europe.

From their skeletal remains, the European megalith builders appear to belong to what physical anthropologists describe as the Mediterranean subrace. Probably they spoke a pre-Indo-European language, of which the present-day Berber and Basque tongues may be modified vestiges. If one wished to see peoples like the megalith builders in the Europ world of today, one would go to seacoast villages and seek out the cr of contemporary Basque, Galician, Breton fishing boats.

IT must not be inferred that varieties of megalithic architect in western Europe are all necessa related. The architect of Stonehe need not have belonged to the sa culture as the builders of the Car stone rows or of Spain's Antequ tombs, nor the architect of N Grange to the society that produ the structures at Bagneux. By way comparison, the builders of Christ churches and cathedrals in post-Ron western Europe differed widely in l guage, political loyalty, and cultu

In Europe, megaliths were the h mark of an early, expanding civil tion. Megalithic architecture was characteristic of those times as contemporary, international style i the current, heterogeneous world. megalithic monuments and tombs h seemed remarkable and even myst ous in a human sense, they w spread abroad in a most normal predictable way—through trade, grations, and colonization—in the that much of the world was Weste ized in the past century. All of the W was once in the grip of a nascent, p European civilization, of which m aliths remain as enduring evider

RUINS OF MNAJDRA SHRINE on Malta, *below*, are nearly 4,000 years old and are situated on cliff overlooking sea.

TEMPLE OF HAL TARXIEN, at right, on Malta. Spiral motif on center w symbolizes the Earth Mother Godd

SKY REPORTER

Daylight saving is one result of international time standard

By Thomas D. Nicholson

In last month's "Sky Reporter," we discussed factors that affect an annual chronological event, the beginning of spring. A related event occurs this month—the change from standard to daylight saving time. In most communities, the change is made on the fourth Sunday of April—this year, on April 26. At 2:00 A.M. on this date, clocks will be advanced by one hour and remain so until autumn.

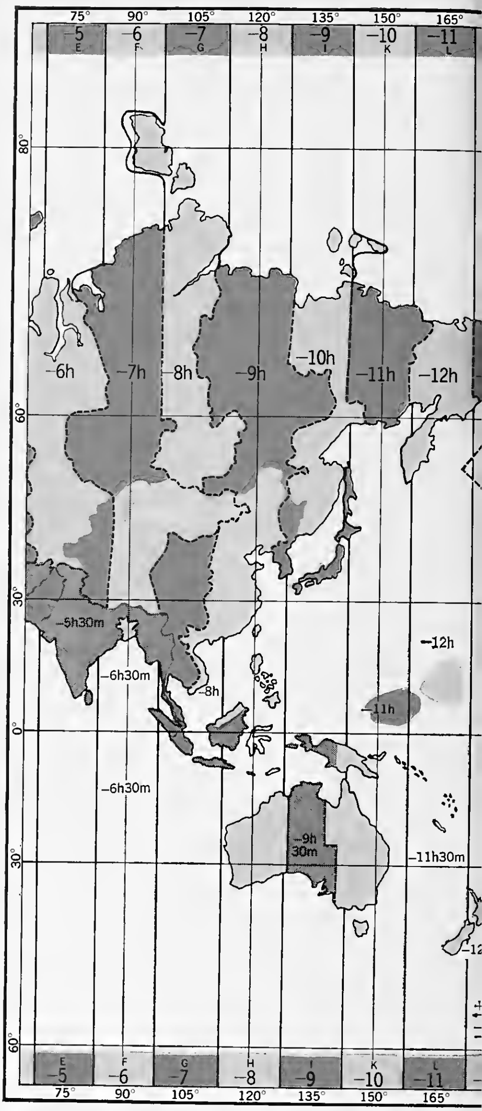
The question of whether or not to go on daylight time each spring is a matter of state and local option in the United States. Even the choice of standard time is left to the states or local communities, for there is no national standard of time. The federal government regulates only the time used by government offices and stations, interstate commerce, the Armed Forces, and districts and territories of the federal government.

With respect to daylight time, there are communities in our country where the issue is still debated annually. Before reviewing the pros and cons of the argument, we should examine daylight time itself and see just what it is and what happens when we adopt it.

Daylight saving time is simply a form of standard time, which was introduced in the United States in the latter part of the nineteenth century. Previously, each community kept time by the sun, setting its clocks to twelve noon when the sun's shadow pointed north. As a result, the time reference at any one instant was different in each community, even in cities quite close to one another. Furthermore, timepieces were continually falling into error. Even a perfect watch set to noon by the sun on January 1 would be ten minutes fast at solar noon on January 31, not because of any malfunction in the watch, but because the solar days in January are longer by about twenty seconds per day than the average for the year.

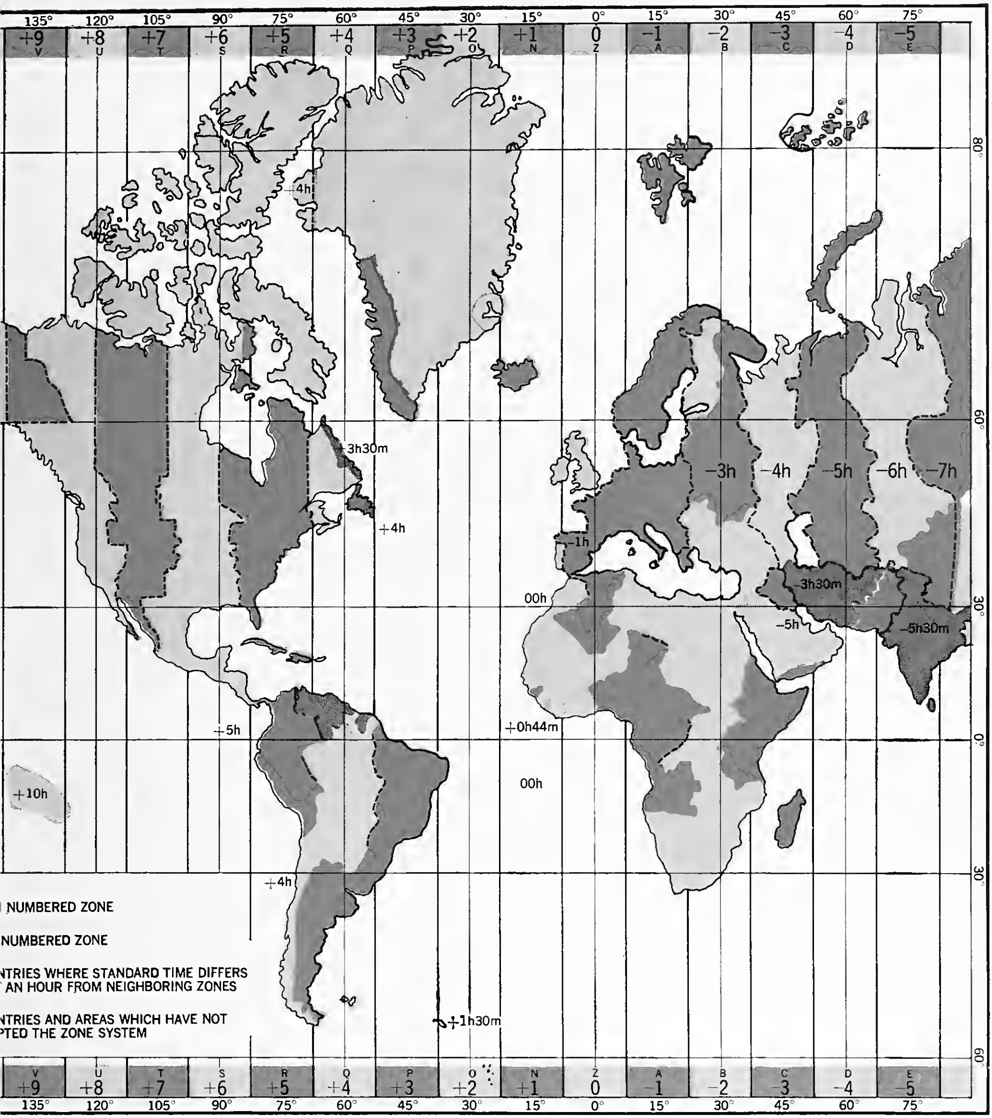
These defects in local solar time—local apparent time is its correct name—became significant with the rapid growth of commerce, transportation, and communications that took place after the Civil War. The problems were particularly troublesome for railroads responsible for setting up and keeping timetables and for the careful scheduling of equipment along tracks and in terminals. Faced with a different standard of time in each community they served, some railroads designated a uniform time to be kept along certain sections of their line. This, however, sometimes led to confusion when several lines used the same terminal. At Pittsburgh, for example, six different kinds of time were maintained in order to conform to the schedules of the many railroads using the station.

Soon after the Civil War, plans for standardizing time within the United States were presented to Congress and to the railroads, but after many years of waiting for Congress to take action, the railroads finally moved independently to introduce a more orderly plan. In 1883 th majority of railroads agreed to adopt a system of standar time similar to the one used in England, based upon th meridian of Greenwich, England, as the origin for th measurement of longitude and time.



International zone time map shows breakdown of worl into 24 standard meridians, each exactly 15 degrees apart

The mean solar time at the meridian of Greenwich ha been used as standard time throughout England, Scotland, and Wales since 1848. This meant that it was noon all ove England at the exact moment when noon occurred a Greenwich. The use of mean solar time, rather than ap-



zone containing longitude 180, the International Date
, is divided into halves that differ from one another
by 24 hours. Numbers in Europe and Asia are time settings of Soviet Union, which remains on daylight time all year.

nt (true) solar time. avoided the confusion of a noon
t (by the true sun), which ran ahead of and behind
clock during certain periods of the year.

INCE the United States had officially adopted the
Greenwich meridian as the basis for longitude
surement in 1850, the plan adopted by the railroads,
ough without government sanction, was at least con-
nt with the policy of the government. The railroad
divided the United States into four zones about 15
ees wide in longitude. At the approximate center of
zone were the meridians 75 west longitude, 90 west,
105 west, and 120 west, designated as the standard meridians for the zones. The time within each zone was to be the local mean time of the standard meridian in the zone. The zone boundaries did not extend directly north and south, but were modified to conform to local political and natural borders. Some states requested, and were granted, uniform railroad time throughout; other states were divided between two zones, but in no case did a city lie in two zones.

The standard time system was put into effect by railroads on Sunday, November 18, 1883, and the more than 70 different kinds of time previously used in railroading were

Royal Observatory at Greenwich, England, built in 1675, was for advancement of navigation and nautical astronomy.

reduced to four—those we now call Eastern, Central, Mountain, and Pacific Standard Time. Since the standard meridians in each zone were exact multiples of 15, the time in each zone differed from adjacent zones by one hour, and from Greenwich Mean Time (at the zero meridian) by 5 hours (at 75° west), 6 hours (at 90° west), 7 hours (at 105° west), and 8 hours (at 120° west).

The extension of the standard time zones into an international system resulted from a series of conferences held at Washington, D. C., in 1884. The nations participating agreed to divide the world into 24 zones, each 15 degrees wide in longitude, in which the central meridian was a multiple of 15 degrees. The time throughout each zone was the local mean time of its central meridian, and differed from the time in adjacent zones by exactly one hour. The Prime Meridian (zero degrees longitude) was the standard meridian in the zone designated as zero. Zones in west longitude were numbered +1, +2, +3, etc., to +12 in the zone adjacent to the 180th meridian. Zones east longitude were designated by negative numbers to —12 in the zone containing the 180th meridian.

There are actually 25 zones in the International Zone Time system, although there are only 24 different standard meridians and watch settings. The zone containing longitude 180 is divided in half: the half in west longitude is 12 hours earlier than Greenwich, the half in east longitude 12 hours later. As a result, the time on either side of longitude 180 differs by exactly 24 hours. Thus the 180th meridian became the International Date Line. On the east longitude side of that meridian the calendar is always one day later than on the west longitude side, although the clocks in the two halves bordering the International Date Line are always set to the same hour.

Today most nations of the world use time standards that are based on the international time system, modified somewhat to political or natural boundaries in order to maintain uniform time throughout a certain area. Thus, for example, Eastern Standard Time is the same as zone +5 time, Central Standard is +6 time, Mountain Standard is +7 time, and Pacific Standard is +8 time.

Daylight saving time is the standard time of the zone directly east of the one in which a region or community actually falls. When a community adopts daylight time, it substitutes for its usual standard meridian the one that is one hour, or 15 degrees in longitude, to the east. For example, Eastern Standard Time is the local mean time of the 75th meridian, but Eastern Daylight Time is the local mean time of the 60th meridian.

Obviously, the important effect of daylight saving time is in transferring the long hours of sunlight in the spring and summer months from the early morning, when most of us prefer to sleep, to the early evening, when we can make more efficient use of them in work and leisure. Hence the "saving" of daylight. The practice was first introduced during World War I in Germany and England as a means of conserving coal and electricity during the late working hours of the day by transferring daylight to those hours. It was adopted nationally in the United States in 1918 as part of the war effort, but it reverted to state or community option after the war.

During World War II, the entire United States was again directed to observe daylight saving time the year round, not just in spring and summer months. During the years 1942-45, some communities adopted a double daylight time during the spring and summer, advancing the standard time meridian an additional 15 degrees to the east, to the 45th meridian in the eastern time zone.

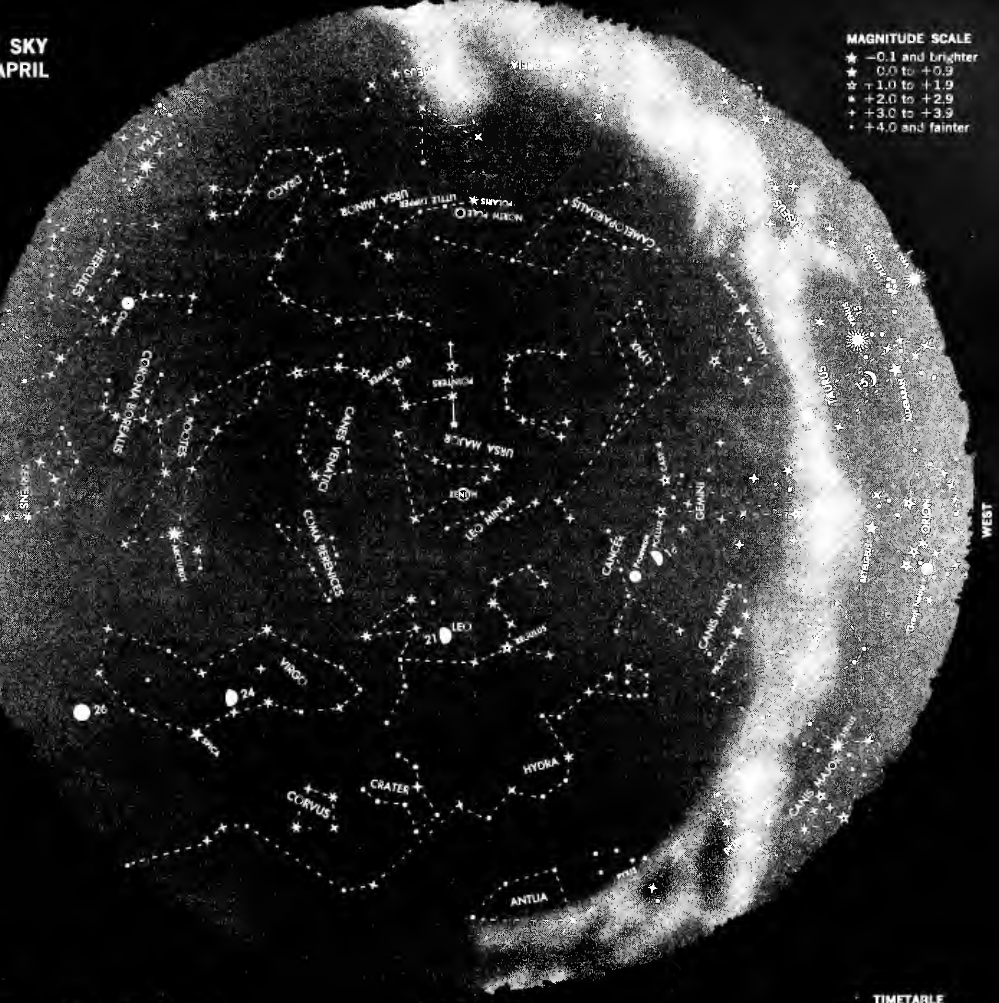
There is still some agitation to adopt daylight saving time as a year-round standard rather than to continue the present, somewhat confusing practice of local option. The entire Soviet Union, for example, which includes ten different time zones, uses daylight time throughout the year. There is some justification for reform in our practice, since even the communities in the United States that use daylight time do not keep the same schedule. Some continue daylight time until the fourth Sunday in September, others until the fourth Sunday in October.

The arguments presented against the use of daylight saving time are also reasonable, however. Some communities in the United States, such as the western portion of Texas, western Oklahoma, parts of North Dakota, and parts of Michigan, are already so far west of their standard meridians that their standard time is practically a daylight saving time. Farming communities are generally opposed to daylight time because many farming activities are closely related to sunlight hours rather than to clock hours. Farm animals are not easily induced to change their schedules by an hour when the community changes from standard to daylight time and back again.

Finally, it is pointed out, the effect of daylight time can be achieved by adjusting our daily schedule to the changes in daylight. Thus we can arise, go to work, and come home an hour earlier during spring and summer months without rearranging our clock time. But somehow it seems less painful to rise an hour earlier during the spring and summer months if the clock still reassures us it is our normal rising time. This, in the long run, may be the only real advantage that daylight saving time has to offer us.

Dr. Nicholson is Assistant Chairman, Astronomer, and a lecturer at The American Museum-Hayden Planetarium.

SKY
APRIL



SOUTH

uarter	April 5, 12:45 A.M., EST
oon	April 12, 7:37 A.M., EST
uarter	April 18, 11:09 P.M., EST
oon	April 26, 12:50 P.M., EST

TIMETABLE

April 1	10:00 P.M.
April 15	9:00 P.M.
April 30	8:00 P.M.

(Local Mean Time)

ril 7: Greatest eastern elongation of Mercury occurs on date. For several evenings before and after, it may be low in the west shortly after sunset.

ril 8: Look for Saturn in the morning sky before sunrise eft of the late crescent moon. In the morning sky of the Saturn is to the right of the moon.

ril 10: Venus reaches greatest distance east of the sun.

ril 12: Venus, in the evening sky tonight, shows us ex- half of its illuminated disk, resembling in appearance rst quarter moon.

ril 15: In the afternoon sky today, the crescent moon es between Venus and Aldebaran. By nightfall, the moon e some distance to the east, but the three objects form teresting triangle in the evening sky.

ril 20-22: The Lyrid meteors, reaching maximum about P.M., EST, on April 21, may be seen in the early morning s. Although not a good shower, the radiant—near the t star Vega—is nearly overhead after moonset. The y rate per observer is about 15.

ril 22: Jupiter is in conjunction with the sun on this date and begins to enter the morning sky for the first time.

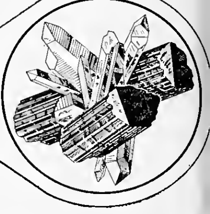
April 27: Mercury is at inferior conjunction, passing between earth and sun at 5:00 P.M., EST, and enters the morning sky.

With the exception of Venus and the opportunity to see Mercury during its favorable elongation, April is not impressive for its planets. Jupiter, which enters the morning sky late in the month, and Mars are too close to the sun. Saturn is beginning to be easily visible in the morning sky (the moon will help in locating it on the 8th and 9th).

Venus dominates the evening sky, appearing in the west shortly after sundown and setting four hours after the sun. Brightening from magnitude —3.9 to —4.1 in April, it passes through Taurus, south of the Pleiades in early April and north of Aldebaran at midmonth.

The elongation of Mercury on the 7th is considered favorable because the planet is east of the sun on the ascending branch of the ecliptic; hence its setting, with respect to sunset, is retarded as much as possible. Mercury's stellar magnitude is —0.1 at elongation, and the planet remains in the sky for a period of about an hour and a half after sundown.

NATURE IN ROCK & MINERAL



By PAUL MASON TILD

Novaculite, often referred to popularly as "oilstone" or "whetstone," is a type of quartz that has proved extremely valuable to artisans and industry in the honing of cutting edges. Before examining this rather enigmatic mineral, it will be helpful to review the properties that characterize quartz.

Quartz—silica to the mineralogist—represents a union of two of the most abundant elements known, the non-metallic element silicon and the ordinarily gaseous element oxygen. Collectively, these two elements account for some 75 per cent of the matter comprising the earth's atmosphere, oceans, and crustal rocks. It is not surprising that their union in the form of the dioxide of silicon should be one of the major constituents of the earth's crust. Nor does it seem unreasonable that the silicate minerals as a class—those minerals that consist of silicon and oxygen in combination with one or even several of the metallic elements—should equal or perhaps outnumber all other minerals.

There are many varieties of sili
most of which are to be found in ev
the most rudimentary of mineral coll
tions. In its coarsely crystallized sta
silica, in the form of common quartz, fu
nishes such basic but nonetheless han
some collectibles as water-clear "ro
crystal"; amethyst in various shades
purple or reddish purple; pale-brown
purplish-brown "smoky quartz"; "ro
quartz" (highly prized when specime
exhibit one or more crystal faces); a
milky-white quartz known to miners
"bull quartz"—often one of the first mi
erals to go into the collections of youn
sters. Less common examples inclu
transparent or translucent yellowish a
greenish quartz.

In addition, there are many whol
opaque varieties of silica, usually of
more somber color and tougher natu
Varieties include agate, carnelian, ja
per, chert, and hard-to-define chert h
brids of unexciting gray or brown colo
tion. All of the minerals in this cla
travel under the general description

Rainbow novaculite shows concentric bands of rose, gray, orange, and white. The patterns in this specimen vary fro
one quarter-inch to two inches in widt

edonic silica." They are com- known as cryptocrystalline, but trographic microscope and X ray that while some are aggregations ute crystalline silica grains, others tually composed of myriad fibers ths of silica, probably not crystal- Jovaculite falls under the granular f quartz classification.

Novaculite Defined

ould be said that the word "novacu- " will be used here in a rather lized way—that is, in reference to articular kind of rock. It is neces- o point this out, because during r days in America the name was only applied to a rather wide of rock types, the only criterion that when a piece was properly r sawed out and shaped—dressed s the saying was—it would serve with or without oil to make a keen g edge on scythes, axes, knives, and tools. Such stones could be sandy shales, gritstones, or even sandy s with sufficient free silica in small, grains to cut the steel of a blade. ock type answered this description likely to be quarried and called ulite, or oilstone. "The goodness of stone," said a New England geolo- n 1844, "depends on its wearing evenly, so as not to glaze, and al- to present new surfaces of fine ous particles which cut . . . steel." must also be said here—not argu- tively, for the time has long since d for that, but merely as an added of interest—that the originator of ord novaculite was guilty of a odd error in terminology. Novacu- ems from the Latin word for razor, *ula*. But to the Romans a razor was strument that served to give the face a new appearance; the root of ord was *nova*, something new. The ness of the instrument was not in Thus the promulgator of the term unded the razor with the stone that ened it. It is late in the day to sug- hat the term "cosite" might have more appropriate, stemming as it from the Latin *cos*—a hone, or a tone. (Such a change might also to confusion with the newly cata- d quartz polymorph coesite, first ed artificially by Loring Coes, Jr. in then discovered as a natural min- at Barringer Crater in Arizona in and subsequently found in other r craters as a polymorph of ordi- quartz created by enormous shock xtreme temperature.)

texture, a sample of pure novaculite ds one of the maple sugar in a e; in color, the mineral ranges snow- and creamy-white through us shades of buff and green; from ue to dark blue; and from light to a dull black. Traces of iron—and perhaps manganese, also—in various states of oxidation may produce rainbow-like halos of color in lighter-hued specimens. The rock is quite brittle in its pure condition, and breaks out in sharp flakes and sherds typical of the silica family of minerals. Held in the hand and struck lightly with a metallic object, a large fragment rings musically like a fine piece of cut glass.

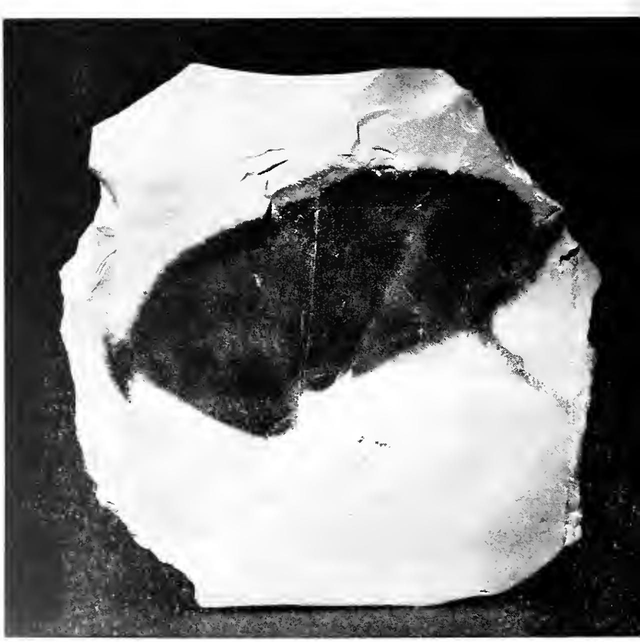
The petrographic microscope reveals the individual grains of silica in novaculite to be of remarkably uniform size and fitted together with few or no open spaces or "pores" around them. In describing this uniform array, one investigator has made the comment that the grains "are not cemented, but seem merely to be jammed together, the tenacity of the stone apparently being due to the interlocking of the edges of the grains." In parts of the novaculite formation there have been found traces of floral and faunal life; sponge spicules, radiolarian capsules, brachiopods, microspores, and other relics—even an occasional piece of petrified wood.

The novaculite discussed in this article is a type of quartz rock that outcrops

Mr. Tilden, author and editor, writes regular columns for this magazine both on rocks and minerals and on current conservation legislation in Washington.

over a wide portion of the 12,000-square-mile province of the Ouachita Mountains of western Arkansas and southeastern Oklahoma. This so-called Arkansas novaculite is a rock formation that varies in thickness from 250 to 900 feet or so, although the beds of novaculite are separated by layers of shale. It has been well established that the formation was laid down during the late Devonian and early Mississippian periods, perhaps some 350 million years ago. Exactly how it was laid down, however, has been one of the challenges
American geology. Since the middle
the past century no fewer than thirte
competent geologists or geological p
ties have investigated the Arkansas
vaculite and the silica-rich rock forn
tions that lie above and below it. T
number of resulting theories as to
mode and circumstances of disposit
almost equals the number of investi
tions. Some sample theories: novacul
is a metamorphosed sandstone; a me
morphosed chert; the result of hot-wa

FOREIGN MINERALS in polished slab of novaculite produced dime-size "sore." The inclusions present in this specir
are deposits of hematite and limor



UNPOLISHED buff specimen is readily identifiable as a "blackheart." Black center is not an inclusion, but a s
probably made by disseminated carl

ts; was originally a limestone, replaced by silica; represents a ea chemical precipitate; was volash that later became silicified.

Practical Uses

ATEVER the antecedents of this unsual and extensive sheet of silica, ck itself has been turned to good it by man. In the vicinity of Hot s, Arkansas, where it outcrops in icularly pure form, quarrying of one, and its fabrication into nsas oilstones" has for many years n industry—not large, but a steady er of hones for all manner of cutdges. These oilstones are used vide for sharpening carpenters' engravers' tools, for surgeons' and for precision cutting instru—even for the pointing of hypo: and other needles.

e of the color variations of novacuave given rise to an interesting man's jargon. For example, a gray slab with a black center is known ackheart." "Rainbow" describes, priately enough, specimens that : bright bands of color in concentterns of rose, orange, gray, and A dark inclusion of some foreign l within a light-colored slab of lite is called a "sore," and dises the piece for commercial pur- The dead-black variety of the is known as "blueberry," and be considered worthless, save for ited and quite unusual purpose—of "blueberry" find a use in the ops of Europe. There, when a er enters with a "gold" item for the proprietor merely rubs it a piece of the black novaculite sts the resulting metallic smear cid—just to be sure that it really l! It is understandable that anname for the black novaculite is ouchstone."

e there is a superabundance of ck variety of novaculite, it was l that the quarrymen should have ted to find some wider market for ne manufacture of table and coun-, for example, since the stone very high polish. It was soon dis1 that this notion was not practihen a hot dish was placed on a lite tabletop, the stone beneath h developed cracks; thus the defor "blueberry" still comes only urope's pawnbrokers.

oite the beauty of these fabricated ones, the serious mineral collector oubtless prefer his novaculite ens "in the rough." This way, they t only furnish his collection with ge variety of one of the earth's nest minerals; they will serve remind him that there is many a in the past history of the earth mains to be unraveled.

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About the Authors

Mr. Arthur Leipzig, author of "Old Africa's 'People of the Village,' " is a wide-ranging photographer whose home is in New York. His article about the Meban people, to be concluded next month, is based on several weeks he spent with Dr. Samuel Rosen's third expedition to investigate Meban health.

The significance of the discovery of an *Iguanodon's* footprints on the island of West Spitsbergen is discussed in "Dinosaurs of the Arctic," by Dr. Edwin H. Colbert. He is Chairman and Curator of the Department of Vertebrate Paleontology at The American Museum, where casts of two *Iguanodon* footprints are scheduled for display. Among Dr. Colbert's special interests is the investigation of past distribution and intercontinental migrations of land vertebrates.

Mr. Paul Villiard, who wrote "Multicolored World of Caterpillars" and took the accompanying photos, is a biophotographer and writer on natural history subjects. Originally a mechanical engineer, Mr. Villiard became interested in Lepidoptera during travels in South America, and he began to concentrate on rearing, identifying, and photographing this group of insects. He is now completing a book on lepidopterous larvae, and is planning one on marine shells.

Dr. Bryan Nelson, who describes the gannetry on the Bass Rock, an isolated islet at the mouth of the Firth of Forth, has concentrated on studies of the gannet for the past three years. Dr. Nelson did his undergraduate work at Saint Andrews University in Scotland, and received a Nature Conservancy scholarship to Oxford. He has been awarded a postdoctoral Senior Carnegie grant to extend his gannet work to boobies, assisted by the Frank M. Chapman Memorial Fund, which is administered by the Department of Ornithology at The American Museum. Dr. Nelson and his wife, who acts as his field assistant, are now pursuing ornithological researches for a year on uninhabited Tower Island, in the Galápagos.

The photographs and description of a bee cross-pollinating an orchid are the work of Mr. H. Lou Gibson, a specialist in scientific and medical photography with the Eastman Kodak Co. His hobby is growing wildflowers, of which he has raised more than 300 species.

Dr. Glyn E. Daniel, author of "Megaliths and Men," is an archeologist who specializes in the study of prehistoric chamber tombs of England and Wales. A Fellow of St. John's College, Cambridge University (England), Dr. Daniel is General Editor of the "Ancient Peoples and Places" series, published in the U. S. by Frederick A. Praeger.

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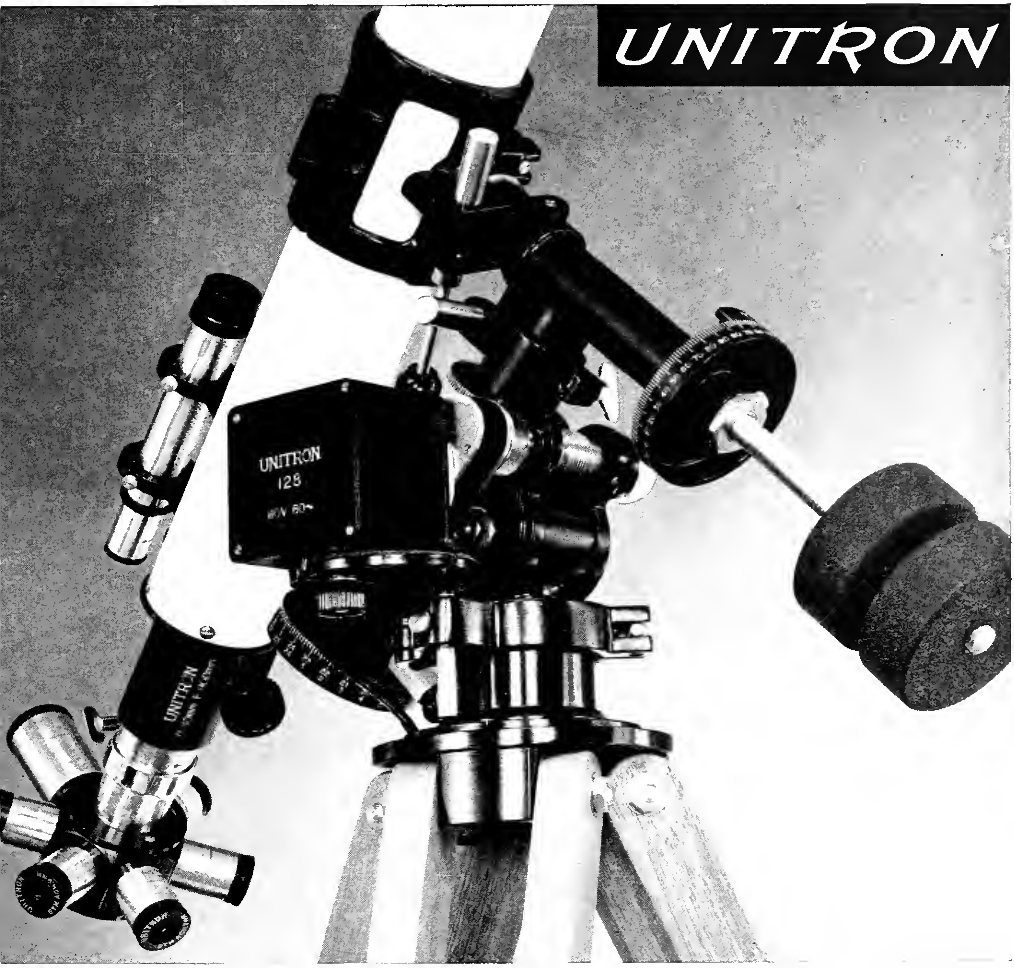

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SCIENCE IN ACTION

Launching an expeditio

By Richard G. Van Gelder

In many ways, basic research could be called "anticipatory research." It is the material from which a new concept may come. It may form the foundation of a new theory when added to other similar bodies of knowledge. It may remain dormant in the literature until just that moment, for instance, when the solution of some medical problem requires that certain bit of information. Basic research anticipates future use of knowledge, but no one can say precisely the *way* it will be used.

An example of this combination of basic research and pragmatism can be found in an expedition now being planned by The American Museum's Department of Mammalogy. But before discussing the program, it might be well to describe some of the thinking that governs a department like this one.

One of the main concerns of any such department is the collecting of specimens—and this involves a sizable proportion of our time. But why collect mammals at all? The museums of North America have about 1,500,000 specimens from all parts of the world, and if all the other collections were added, the total number of study specimens would come close to 2,500,000. As there are only about 5,000 species of mammals recognized today, is there any need to collect any more material? The answer to this lies in the three phases of biology: What is it? How does it work? Why does it exist and function as it does? For a few parts of the world the "what" phase is nearing completion. The mammals of North America are pretty well known, and research on them is now moving into the "how" and even to the "why" stage. But in other areas of the world the mammals have not been studied so thoroughly. Parts of Asia, Africa, New Guinea, and especially South America are still in the "what-is-it?" stage. It is in these places that collecting still goes on and still is needed.

Another question has been asked: Aside from satisfying the intellectual curiosity of a few individuals and aside from adding to the general knowledge of the world, is there any practical application to classification of mammals? The answer is: Unquestionably!

As an example, some years ago a mammalogist did a taxonomic study of the rabbits of California. In addition to telling how to identify California rabbits, the author recorded whatever observations he had made or could find in the literature. A few years later his pr fessor received a letter from some co mercial flower growers in the state, clai ing that they were losing thousands dollars because rabbits were eating many of their plants. The profess wrote back and asked what kind of ra bits were doing the damage. The far ers didn't know. "A rabbit is a rabbit they said. The professor insisted on mo precise information. A rabbit was sh and sent to him. Using his studen published work on the subject, the pr fessor identified the rabbit as a bru rabbit. Under "remarks" the author ha written that brush rabbits are not know to venture more than a few yards fro cover. So the professor told the flow growers to cut the brush back 40 fe from the edges of their fields. The ne year he received a letter saying that th simple method had saved the growe $6,000 during one year.

This is but one simple case of applie taxonomy. Knowing the *kind* of rabb made control possible. No biological r search can be done competently witho the scientists' knowing *what* species, even subspecies, he is dealing with, an something about their widely differin biologies. And here the odd avocatio of flea-picking enters mammal researc

Fleas and the Mammalogist

Although fleas, ticks, mites, and li have always been a part of norm field work in mammalogy, it is only r cently that a great deal of attention being paid to this facet—which brings back to the currently planned expe tion. Recently the Museum's Depar ment of Mammalogy received a gra from the U.S. Army Medical Researc and Development Command to do fie work in South America—collecting ma mals and their ectoparasites. We decide to work in Uruguay, Bolivia, and A gentina. Late in 1962 our field party le and spent six months collecting in Ur guay. At this writing, a year from th time we started the field work, som thousands of specimens are being cat logued in preparation for study an eventual publication. During this peri we also began to make plans for th Bolivian expedition. Then somethin new entered the picture.

In 1959 hemorrhagic fever, a vir disease that is characterized by fev and internal bleeding, broke out in tw places in the Bolivian lowlands. Th human mortality has been at least

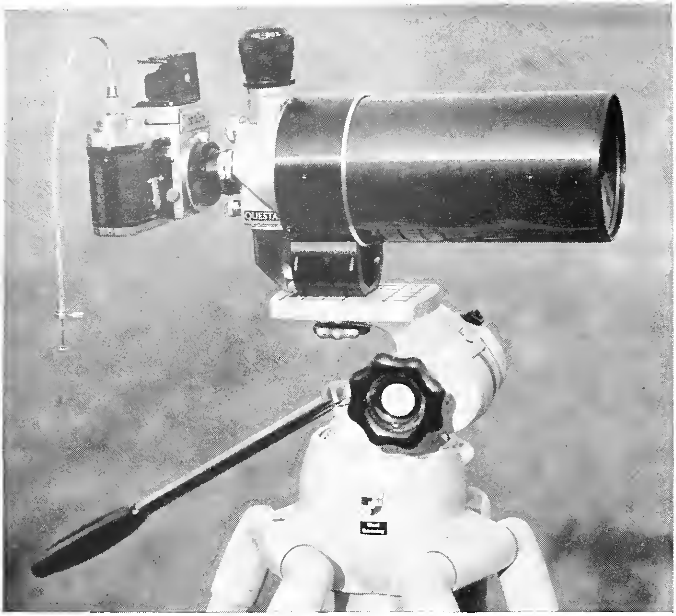
:ent and possibly higher. In 1963 an :miological team from the Middle rica Research Unit began an inten- study in the town of San Joaquin. virus is believed to be transmitted n ectoparasite carried by a mam- but the vectors have never been ed down in the parts of the world e hemorrhagic fevers occur—Argen- Korea, and Tibet, among others. ıe work of the Middle America Re- :h Unit has involved studying the ɔgy of the disease. The animals, sus- :d or not, must be trapped, the ecto- sites removed and preserved, and everything sent to specialists for :ification. The American Museum y will be working in co-operation the M.A.R.U. team, collecting mals and their ectoparasites in the ınds to try to determine the extent e plague in the wild. But if we had in this area five years ago, what dy of knowledge might have been able: mammal specimens identi- habitats recorded in our notes, to- ɜr with information on food and ity, and lists of ectoparasites known ve on certain species. We might not had the answer for the medical re- :hers, but we surely would have had ı information that might have been .e to them. Now, all the time we are :ing, people may be dying for lack little basic research.

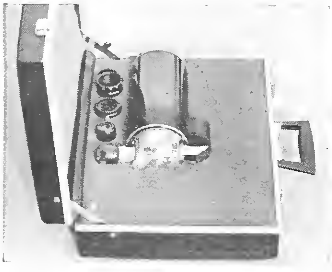
ɔ one could have anticipated hemor- ic fever in Bolivia. No one can ac- tely predict any biological develop- ts, except with long and careful : study. So, when people ask me the Army is supporting mammal ırch in South America, I tell them ıt Bolivia and the basic research we had planned to do—basic re- :h that became applied before we even started.

Expedition work falls into three sections. First, it must be planned; second, it must be done; third, the collected material must be worked up. Each facet is discrete, in which the work may be just as arduous as in any other facet. The planning segment breaks into divisions we might label "where," "when," and "how." We like to choose areas that either have not been studied before, or that still leave promising problems. In deciding to work in South America, we built our plans around the scientists we knew in various countries. The presence of a thoughtful, helpful, enthusiastic colleague who is native to the country is the greatest help one can have in an initial expedition program. Thus far, our colleagues in the South American venture have come through with flying colors—and getting things through some of the governmental red tape in foreign countries can be a real chore. I remember one day in Uruguay signing seven long documents—nine copies of each—that granted us duty-free import and export. But it was thanks to the weeks of groundwork by our mammalogist associates in Montevideo and the people at the American Embassy there that the papers were ready when needed.

Once the selection of the expedition site has been made, the next decision is when to go. In some countries the choice is made for you. We are going to Bolivia this year during the six-month dry season, which begins in April. In Uruguay we did not face the problem of rainy and dry seasons, and so we went as soon as we could. We started ordering our materials on October 1 and were in the field on December 3—which may have set some sort of a record. Among the considerations that must be borne in mind in the "when" stage are the length of time it takes for supplies to be or-

The *Exploradora* will soon house fifteen scientists and crew members.





dered and received; shipping meth
and steamer schedules; and the t
lapses occasioned by the need for
cial collecting permits—which have b
known to take years.

Before the "when" phase is comple
though, a good deal of the "how" as
must be considered. How many pe
are going to be in the field party? F
are you going to travel? How are
going to live? For the Bolivia trip
faced multiple problems of how.
will be traveling in an area with
roads, with few people, and with no
tain local sources of food, fuel, or o
supplies. Because the area has m
rivers, we decided on a houseboat.
has involved a whole new phase of
pedition learning for us, but the
ploradora, 63 feet long and 13½
wide, is almost complete, and sh
house, carry, and serve as a labora
for our staff and crew of fifteen.

Finally comes the job of meshing
where, when, and how. Will all of
personnel be available when you w
to leave? Will the length of the trip
terfere with the school year and af
the work period of your student as
ants? Can you buy formaldehyde
Bolivia or will you have to ship it do

No Room for Tyros

EACH person in the party is caref
selected—first for his specialty,
second for his other abilities. Every
must wear two or three hats. On
Bolivian trip, for example, the mam
ogist will be photographer and admi
trative leader of the expedition
year he also was cook and interpr
for a couple of months). The herpet
gist will also be required to handle
any and ecology in the study area,
will be in charge of liaison with Boli
personnel. An assistant with a med
degree will be charged with our hea
keeping the engine of the house
running, and taking serum sam
from the animals.

As personnel is selected, the orde
of equipment begins. Over the years
have maintained a card file of exp
tion equipment used on trips. As
material is ordered, the cards ge
colored tab, and as it comes in they
another tab. When the boxes are pac
for shipment the tabs are removed
this way we can see immediately w
has to be ordered, what is on its
and what is at hand. On the Urug
trip the only thing that somehow w
astray was some of our special noteb
paper—a minor loss.

Gradually, the pieces of the exp
tion begin to fit together. Working b
from the date we want to leave for
field, we set a shipping date. Work
back from that we set an ordering
for equipment. When the equipment
been sent to the operation site, ther

VAN GELDER, who in this column
cribes the problems of planning
expedition, is Chairman of the
seum's Department of Mammalogy.

riod of slightly less hectic activity,
other needs arise. It is the time for
ng shots, renewing passports, mak-
plane reservations, worrying about
rompt arrival of equipment in the
dition area. This is where a good
ague on the receiving end comes in
y; he usually sees the materials
ıgh so that we can sometimes be in
eld a day or two after our arrival.
the trip we try to accomplish as
as possible in the limited time
able. In even the most carefully
ted group there will be personality
ences, but this has posed no serious
ems on previous expeditions. There
be accidents and sickness, but
we have been fortunate. There will
sappointing days, and there will be
arating ones. The adventure is in
rip itself. The last thing a good ex-
ion leader wants is "excitement"—
ing the unexpected. All of our
ning has gone toward trying to an-
ite hindrances to our work, and
the unforeseen is bound to happen,
n only hope that it will not seri-
deter us from our objectives.
ter the trip has ended, after all of
quipment and specimens have been
ed back, after everyone has re-
d, the long task of scientific book-
ng must be done. Specimens are
gued; skins tanned; skulls cleaned
numbered; notebooks rearranged
filed; maps collated. Then the
of the materials can begin. This
ake months and years, and often
Too many collections are not
ed up, but generally we feel that
ould gather specimens while the
g is good. Once in the Museum,
rly catalogued and housed, they
be available to anyone for study,
s we are working up one kind of
nal, other scientists from other in-
ions may be working on a different
from the same collection.
en as this goes on, another oppor-
for field work may arise, and
the process begins. Where will we
When will we leave? How will we
the area?

list details the photographer, artist,
ner source of illustrations, by page.

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ph Sedacca
Arthur Leipzig
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e Boltin
urtesy of Natascha

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tthew Kalmenoff
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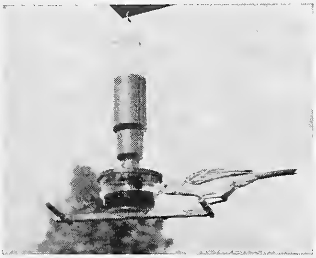

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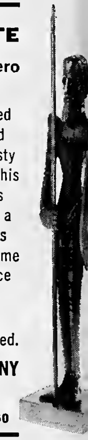

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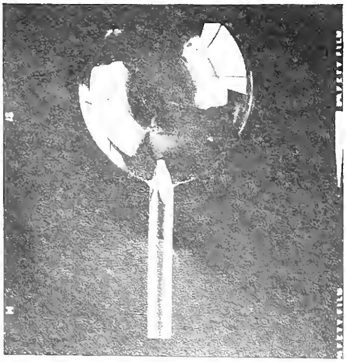

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ARTICLES

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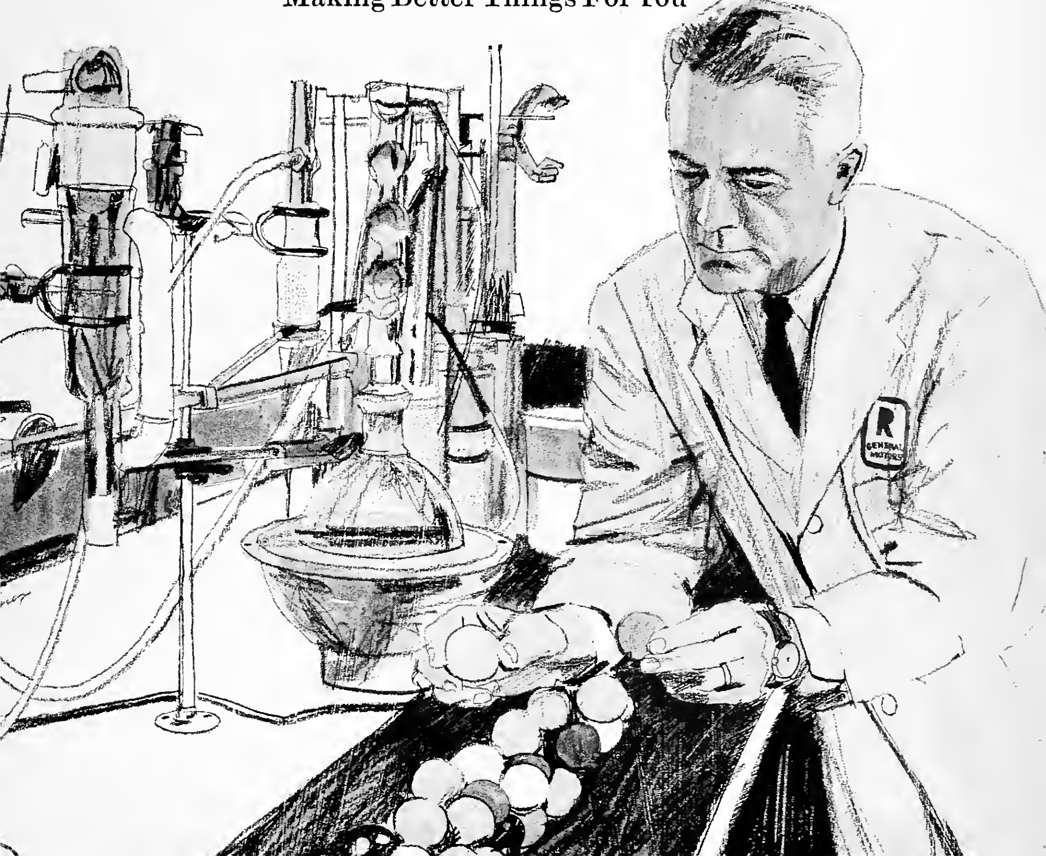
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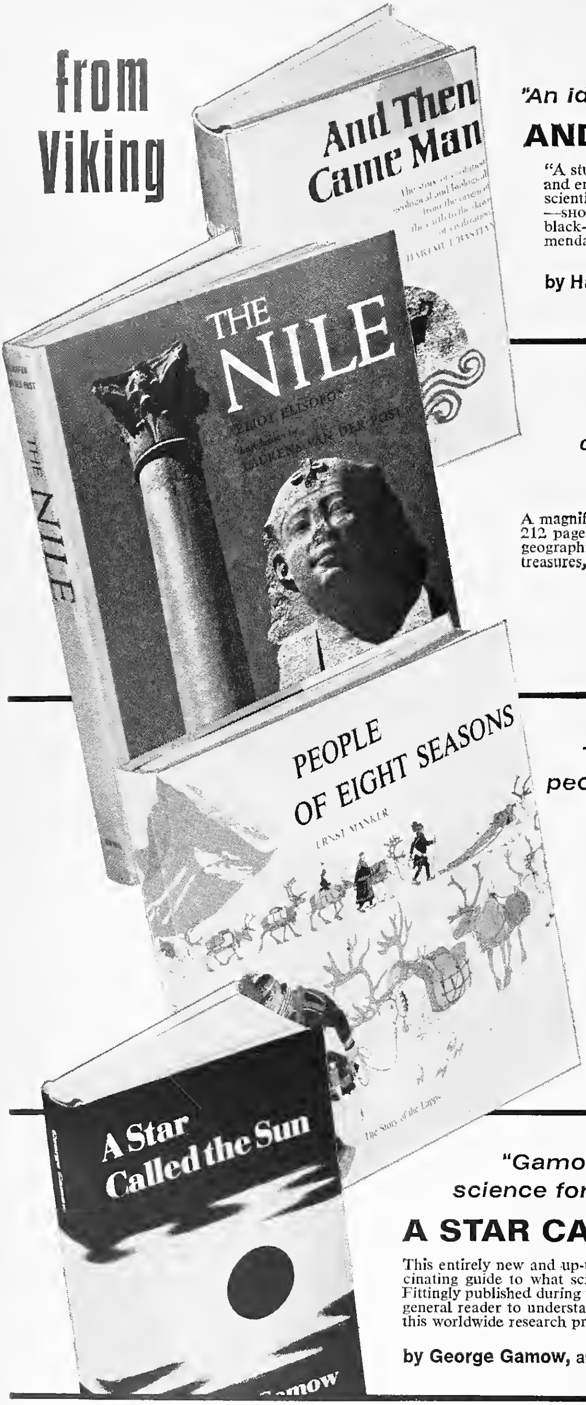
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Reviews

Women, witchery, and rebellion color the African scene

By Colin M. Turnbull

ic, Divination and Witchcraft ng the Barotse of Northern desia, by Barrie Reynolds. *Univer- of California Press, $6.00; 181 pp.,* . Women of Tropical Africa, ed- by Denise Paulme. *University of fornia Press, $6.50; 308 pp., illus.* er and Rebellion in Tribal Africa, Max Gluckman. *The Free Press of coe, $6.00; 273 pp.*

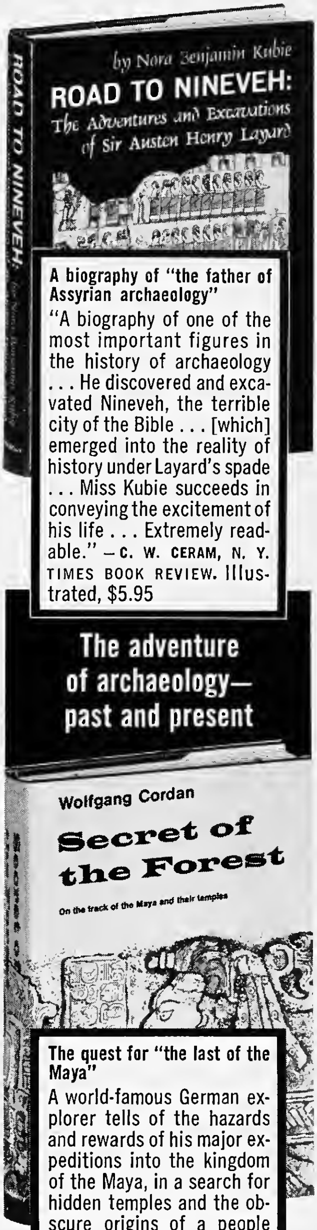
hat women are tricky creatures is, of course, beyond dispute, and in ca they are frequently regarded by menfolk with a jaundiced eye. ir power to create life indicates an nate and, to some, an almost sinister ciation with the supernatural. In- many societies, not only African, gnize a female propensity for witch- t. It is not surprising, then, to find en playing an important part in ie Reynold's book, *Magic, Divina- and Witchcraft among the Barotse orthern Rhodesia.* There is even a ewhat faded photograph of four d-looking ladies who had been ac- d of necrophagy.

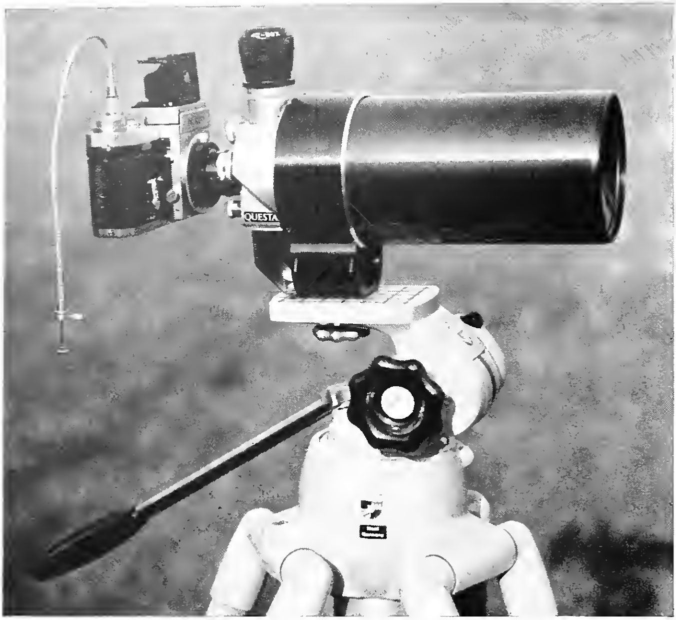
ollowing the introduction, we are n examples of the versatility of can women in the fine art of be- hment, and the section "Equipment Methods," with illustrations of hcraft kits, almost puts this book in each yourself" category.

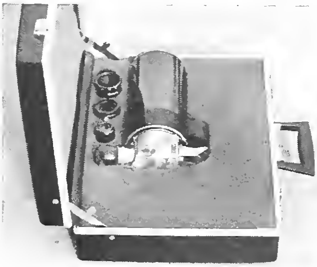
r. Reynolds sets out to describe hcraft and its allied practices and efs in Central Africa's Barotseland. depicts the principal actors—the h and the sorcerer, the doctor, and diviner—and then describes his in- gations of the sudden glut of witch- cases that occurred in Barotseland he late nineteen-fifties. The picture resents through case histories rep- nts a special and abnormal situation. nolds himself recognizes this and s the reader to Dr. V. Turner's ad- ble *Schism and Continuity in an can Society* for a more balanced unt. Even so, I wish that the author given us more general background ing witchcraft in relation to society whole. In isolation, it cannot help earing quaint, senseless, or even aric; in reality it serves a perfectly social function. The concept is one of the major mechanisms by which order is maintained in many African societies. It is a great pity the point is not clearly made in this book.

However, descriptive ethnography is of value to all of us because, eschewing theory as it does, it presents all the information that could possibly be considered relevant in an impartial manner. While having some doubts about the effect of this book on the non-anthropological reader, I can appreciate the wonderful miscellany that is presented with clarity and moments of humor. Who would not be interested by instructions on how to raise a body from the grave without getting your hands dirty, so that after you have sliced off those sections required for a banquet, the remains return of their own accord, leaving you suitably unsullied? We are even told of an unfortunate old lady who slipped up in her calculations and, on raising a body in expectation of a glorious feast, found it to be so decomposed that she had to rebury it without further ado. As ethnographic description such items have their own value and are a pleasure to read if one can preserve the air of detachment that is necessary.

Women of Tropical Africa is an excellent, much-needed book that appeared in a French edition in 1960 and has only now been translated into English. It makes no attempt to beguile the general reader with a fancy format; on the contrary, it is severely academic. (The faint print, in my copy at least, and close type may further discourage the weak in purpose.) However, anyone initially drawn by the title will find the book engrossing. It consists of an introduction by Denise Paulme and six studies by different authors (all women) concerning the role of women in various areas of Africa. The analytical bibliography is of immense value to the serious student and is a fair measure of the book itself. Instead of listing works by alphabetizing the authors, it considers various significant aspects of womanhood and subdivides each according to region, then lists selected works dealing primarily with that topic. Thus we have works cited that deal with the social and legal status of women, their family life, initiation, and associations, as well as the economic,







political, and ritual activity of wome their education, and emancipation.

Each chapter deals similarly in sp cifics rather than generalities, and if, the end, we do not arrive at an over-a picture of "the African woman," it only because she does not exist. One the many virtues of this book is that indirectly accentuates the diversity social phenomena in Africa. At the san time, the information provided enabl the reader to make comparisons ar form certain valid. limited generaliz tions of his own. For the layman th book goes a long way toward dispellin that unhappy misconception of Africa women as beasts of burden. For th scholar it marks a break in the strea of anthropological articles and mon graphs of Africa written primarily fro a male point of view.

Women get twenty-one references i their own right in the index to Ma Gluckman's *Order and Rebellion* i *Tribal Africa*, and also appear und other headings—one of them, naturall "witchcraft." The two books reviewe above had very specific topics, but Pr fessor Gluckman's excellent book mea ders like a placid stream flowin serenely between the opposed banks academic controversy, carrying the u resisting reader with it.

Basically this is a collection of th author's own essays from journals th are not easily accessible to many st dents. But instead of being conte merely to compile his works, he unde took the difficult but immensely valuab task of using these essays to assess h own contribution to the body of anthr pological knowledge and theory. H presumably did this task in the hope clarifying his own arguments and sti ulating further thought and discussio

Although one of the leading figur in British social anthropology, Profess Gluckman has not always been full understood. The forty-nine pages of i troduction are devoted to a clarificatio of his position and might be heavy goi for the untrained reader, but they affo an exciting glimpse of an exact, fort right academic mind at work. The autho unlike some of his colleagues, does n wear academic blinkers. If he conclud that his work had made a valid contr bution, this is no more than a mode statement of fact. In pointing to th danger of concentrating too heavily the lineage structure of society he n only helped to divert a great deal of e deavor from a dead end but also opene up new fields of investigation.

Following the introduction are te essays that deal with the problem order and disorder. Sometimes this broa subject is tackled directly, as in th author's analysis of the concept of th "reasonable man" in Barotse law, an sometimes indirectly, as in his essa

Malinowski. Other discussions in-
de “Succession and Civil War among
Bemba,” “Rituals of Rebellion in
th-East Africa,” “The Magic of De-
ir” (which in itself is an admirable
on in the value of detached observa-
.), “The Village Headman in British
tral Africa,” and others.
'o have reprinted these essays in book
n would have been contribution
ugh, but to couple them with the
oductory clarification of the author's
uments has made it a major contribu-
to anthropology, and a book of prime
ortance in African studies.

istant Curator of African Ethnology
'he American Museum, Mr. Turnbull
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Aztecs,” as the publisher's blurb of
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ı, can hardly be considered all that
ure today.
ıe field of ancient Mexican art is
y complex and is not really suscep-
to the simplified historical treat-
t it gets in many books. It is also
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ecs, and their ilk must soon lose its
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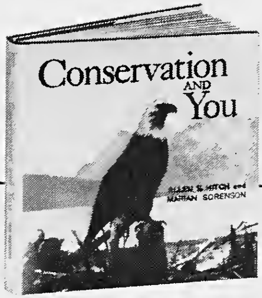
cious of this. His book, like others,
ivided schematically into separate
ters on the various cultures, each
ed almost as a watertight compart-
. The resulting condensation of in-
ation produces very vivid pictures of
ultures, indeed; if not exactly tech-
ored, they are at least hand-tinted.
not sure that Mr. Emmerich does
go rather too far in this. I am sure
the result is not a history of pre-
mbian art; so much space is de-
l to the setting that his discussion
ıe art itself becomes almost inci-
al. There is a certain amount of
gorization of the art objects, but
exposition of the development of
ric interplay of the styles.
ıe photographs by Lee Boltin, who
properly shares the honors as co-
or, are largely in his familiar, care-
brilliant manner. The drama this



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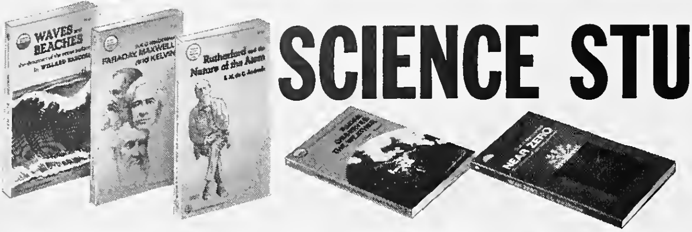

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nders is occasionally distracting if bject does not warrant it, as in some e present cases. Then the technique nes a sort of Russian roulette with otlight. More often, fortunately, it ly illuminating. The choice of pic- subjects is presumably Mr. Em- ch's. Over two-thirds of about 168 umbered) photos show well-known , monuments, and museum pieces; emainder, from private collections, only a few surprises to offer. On hole, they are typical of the things have been coming on the market g the last few years, but this in it- nakes them a welcome addition.

me intelligently used devices assist eader: small maps at the chapter ngs indicate the areas described, corresponding photos appear in the ins on the pages where particular ts are described. Soundly produced her respects, it is altogether an at- vely unsensational book. Taking its nts and appearance—lucidly writ- text and fine photographs—as a , *Art Before Columbus* adds up to good value. A beginner in the lit- re could go a deal further and fare orse than with this book.

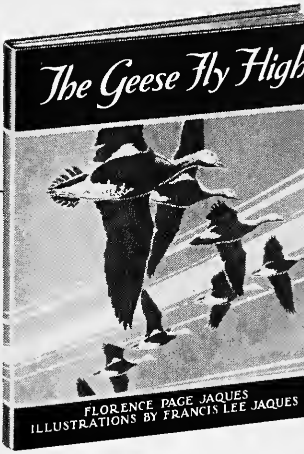
DOUGLAS NEWTON
The Museum of Primitive Art

OTICS: NATURE'S DANGEROUS GIFT, orman Taylor. *Dell Publishing Co.,* *; 212 pp.*

949 Norman Taylor wrote *Flight om Reality,* which was widely ed and enjoyed great popularity. is a revised edition of that volume. story of man's use and misuse of us narcotic drug plants in every n part of the world is told in an ging manner.

vegetable kingdom produces different kinds of plants, and a er of them contain certain alka- the effects of which are primarily odify the normal activities in the r brain centers. The modifications several different forms, depending the amount and kind of alkaloid Some are habit-forming, some are some have aftereffects, others do ll will be used by mankind in spite ery law or restriction put upon All were found by primitive man, lmost all have been "refined" or fied" to extract the active principle. r strict, medically controlled appli- n, some have proved to be of great it in the treatment of mental ills, esthetics for surgery, as relief from pains of terminal cancer, and in ways that all society applauds.

t society's main problem with these is that they are sometimes mis- Misuse takes two forms, and the r of these, in Dr. Taylor's eyes, is at vicious group that makes huge nes playing upon the weak addicts



who will go to any length to get eve increasing doses of their narcotic. Mis use by the second group, the addicts, i begun to satisfy some weakness, or perhaps to reduce pain from a long-lasting pain-producing disease, and then continued beyond this need.

In 1949, *Flight from Reality* told wha had been done to help relieve th problems—the restrictive measures o government action and the ameliorativ treatments recommended by medica groups. In 1963, *Narcotics* present more evidence of the efforts of bot groups. The added information in th revised edition documents the more recent findings of various groups on th danger of cigarette smoking as the caus of lung cancer and some heart diseases

This is a thoughtful book on a topi of importance to society. It cannot b too strongly recommended.

DAVID J. ROGER
N. Y. Botanical Garde

BIRDS OF WISCONSIN, by Owen Gromme. *University of Wisconsin Pres* *$22.50; 214 pp., illus.*

HERE is a lavish collection of painting by the Curator of the Division Birds and Mammals at the Milwauke Public Museum depicting over thre hundred species of birds of the nortl central states. Facing each color plat is a small map and calendar that ind cates the general range and season status of each species illustrated. Ther is no text or bibliography. Gromme paintings, executed over a twenty-yea period, exhibit a considerable disparit in quality, ranging from superb to ver poor. In general, the game species ar birds of prey are well done, wherea many of the songbirds are not at all co vincingly portrayed. The composition the plates and the postures of a numb of individual birds are reminiscent of t better-known works of Fuertes.

There is no comprehensive publicati on Wisconsin birds that includes a hi tory of ornithological work in the stat a discussion of physiography and ec ogy of distribution, and a bibliograp of state records. An annotated list l Kumlien and Hollister (1903) revised l Schorger (1951) remains the princip reference work available. There is critical need for a thorough analysis ar updating of distribution records for t state and for a systematic appraisal the avian populations represented. It encouraging to note that Gromme working on a text, "which eventually w be published as a technical suppleme to this volume of plates." Hopefully, t appearance of the technical suppleme will not be contingent upon a large sa of this prohibitively expensive collecti of bird portraits.

WESLEY E. LANYO
The American Museu

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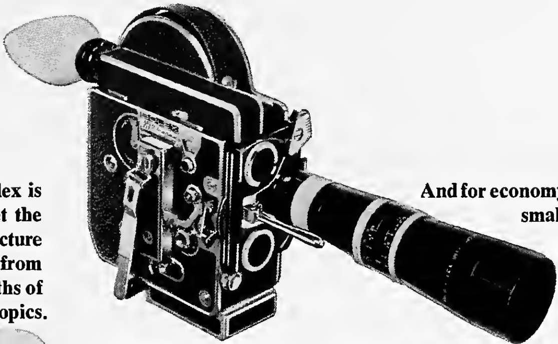

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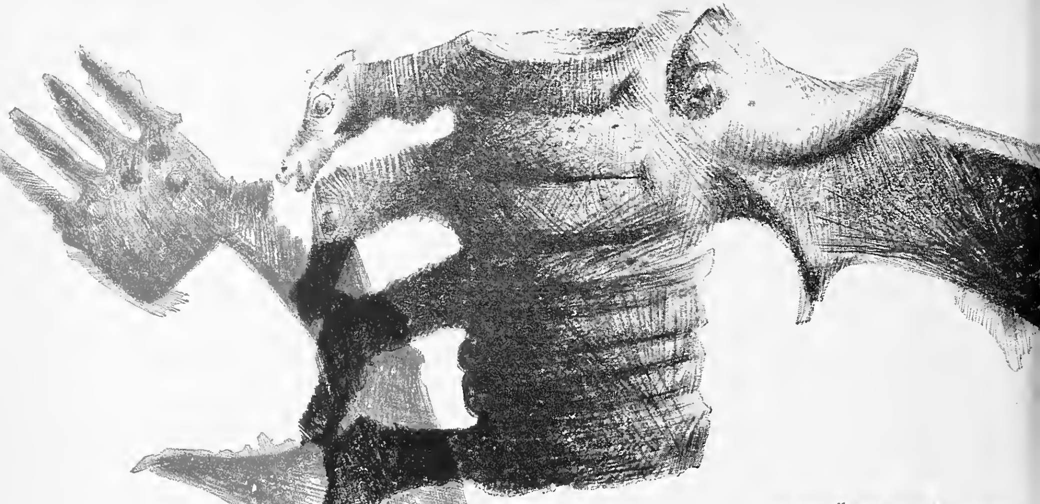


Bronzes of Luristan

Art of little-known nomads influenced Near East cultur

By BERNARD GOLDMAN Drawings by ROBERT J. LEE

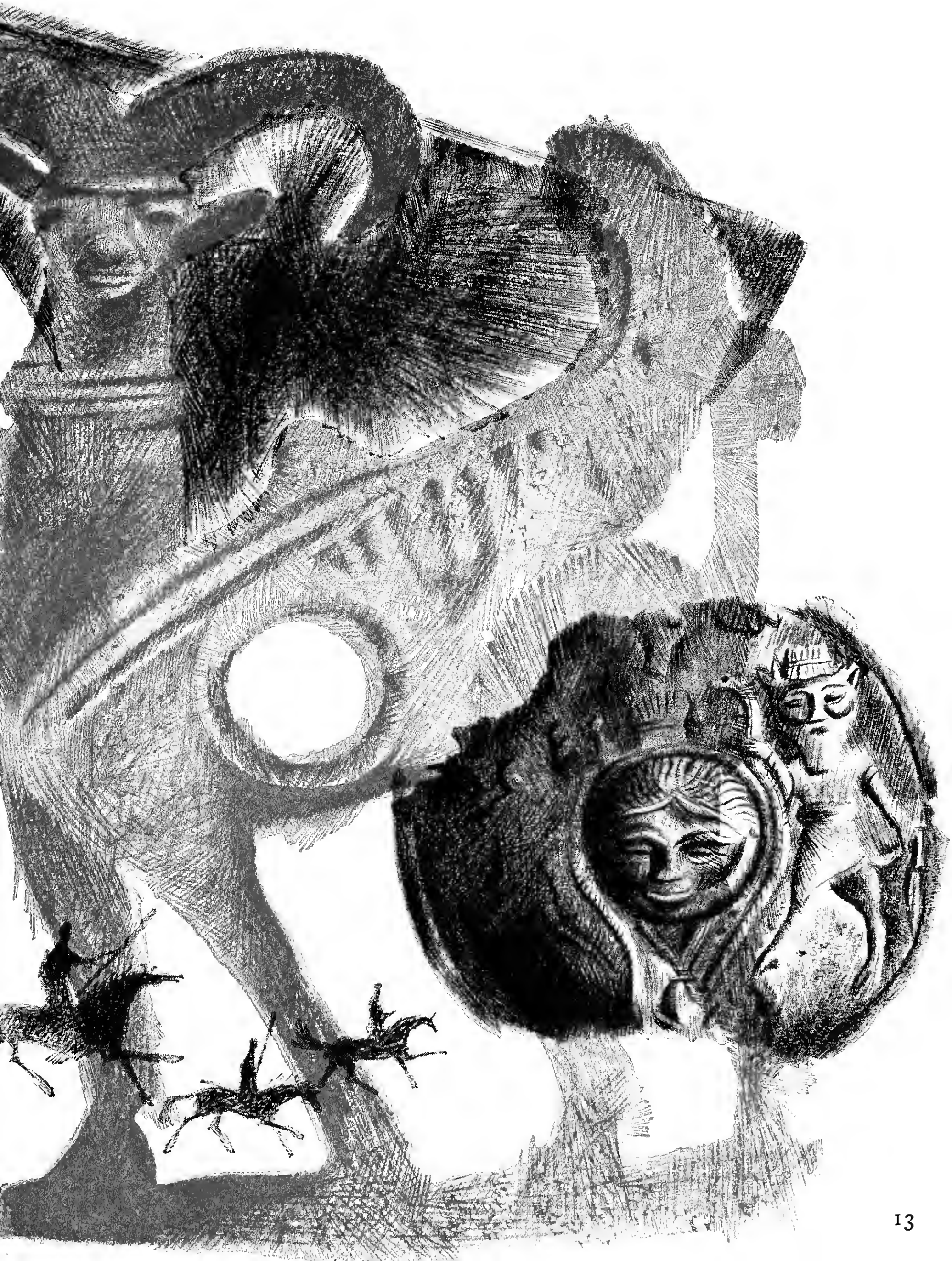
THE ZAGROS MOUNTAINS are a formidable range that rises as a precipitous barrier between the river valleys of Iraq and the Iranian plateau. Mile-high peaks tower over broad, parallel valleys that run in a northwest to southeast direction along the 620-mile length of the chain. An arm of this range stretches westward into the ancient Mesopotamian plain from modern northwest Iran, and forms the highland home of the Lurs. In 1927 a peasant of this region, known as Luristan, accidentally uncovered an ancient grave, the lonely resting place of one of his ancestors who, like his modern counterpart, had roamed the Zagros valleys.

The shallow grave was unpretentious, a stone-lined rectangle capped with large, flat stones as protection against nature and prowling animals. An enclosing circle of rocks marked out the area—probably in the tumulus tradition—indicating it was consecrated ground. The bronze contents of the grave proved far more interesting to its discoverer and, subsequently, to the merchant who bought the curiously worked pieces. Word quickly spread through the upland valleys that these bronzes were magic "antiquities" that could be exchanged for gold in the markets of Kermanshah.

The treasure hunt was on in Luristan. The Lur methodically prodded the sloping hillsides with pointe sticks until they struck the telltale stone slabs. The covering scrub and thin layer of soil were shoveled aside, the cover stones pried up, and the small bronzes, scattere among the bones of man and horse, were collected. B the early 1930's vast cemeteries had been plundered an thousands of these exotic objects—decorated with hawk-nosed, wiry men, owl-eyed women, savage lions, an fantastic beasts—were funneled through the Irania markets to the dealers of Berlin, Paris, London, and Ne York. Within the last thirty years they have entered almost every public and private collection of antiquities. It is the rare museum that does not boast at least on "Luristan bronze." The measure of their popularity ca be found not only in the inflated prices they now brin in the antique shops, but also in the appearance o modern forgeries that are difficult—and frequently are totally impossible—to detect.

The typical Luristan bronze has a lively charm and spirited sense of design that guarantees it a place in the world of ancient art. But these bronzes are important for a number of reasons. They raise perplexing problems:

Inventive imagination characterized the work of Luristan artisans. From left are two ceremonial axes, a "pin," a horse bit plate, and a repoussé disk, all made of bronze.



made them, when were they made, who owned
n, what does their fantastic ornamentation mean?
se are questions for the archeologist, but he can an-
r them only with suggestions of possibilities.

HE archeologist works by carefully recording the
exact details and condition of each find recovered
spade and brush. However, a number of factors all
excluded the archeologist from making precise inven-
es of excavations in Luristan until the cemeteries had
plundered beyond reconstruction. The wildness of
mountain terrain, the dangers of moving about in
e unsettled hills in the 1930's, and the desire of the
dish tribesmen and their dealers to keep the source
heir lucrative grave digging to themselves kept the
ntist at a safe distance. At best, an untrained observer
asionally was allowed to accompany one of the well-
anized plundering expeditions.

lence, the exacting techniques of the archeologist
ld not be brought to bear on the Luristan bronzes.
by piecing together fragmentary evidence, by sort-
out the rumors and hearsay concerning the graves,
by comparing the bronzes with the material remains
ther ancient Near Eastern people, a satisfactory, if
culative, picture begins to take shape.

he bronzes must have belonged to a vigorous, horse-
ng people, for they carried with them into their tombs
only elaborate horse equipment but also, sometimes,
r horses. Snaffle and bar bits, ornate bit plates, bridle
s and bells, and martingale plaques are found by the
dreds. Apparently the ancient Lur prized his fine
lions not only for their swiftness and endurance but
as symbols of his social status. Only thus can we
lain why he lavished so much attention on the horse's
pings, why he so often depicted the beast in his art,
why even in death he kept his favorite horse close
de him. This horse burial tradition is well known in
regions occupied by the nomadic people of south
ssia and Siberia. But, like the American cowboy, the
was not sentimentally attached to his mount. The
cal bit and cheek plate are studded with metal spikes
t must have assured instant obedience.

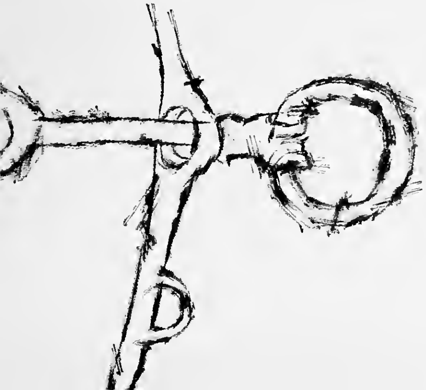
hese ancient Lurs lived a seminomadic existence, as
many of their modern Kurdish counterparts. The in-
se heat of the summer months drove the Lurs and
r flocks up into the high valleys that offered good
turage, while the bitter alpine winters forced them
n onto the lower slopes.

The tribes had a regular circuit, returning to the same locale each year; the extensive cemeteries indicate a pattern of regular habitation rather than a wandering people. They pitched their goatskin tents near a mountain stream where there was ample pasturage. Hard woods were available on the upper slopes, while lower down grape, fig, barley, and wheat could be grown. Some bronze adzes indicate at least a modest planting. As would befit a mobile people, their furnishings and equipment were probably sturdy, small, and light; hence, a minimum of delicate, fragile pottery has been found. Their more settled neighbors (and probably relatives) in some of the ancient Iranian cities—Tepe Giyan, Tepe Sialk, Susa—developed, on the other hand, a fine, painted ceramicware. However, the Lurs preferred hardier metalware: embossed vases and beakers, cast bronze pails, beaten and riveted pots. This table service was augmented with thick clay jugs and pitchers that are hardly a tribute to the potter's craft.

The Luristan mountain encampments were not isolated from the mainstreams of Near Eastern culture. Two principal arteries, along which caravans inched their ways, threaded through the region. One route followed over the tortuous passes from Baghdad to Hamadan and Teheran, and from there went on to distant India and China. (For historical records of long-distance travel by the Chinese during the Han period, see NATURAL HISTORY, February, 1963.) A second route went from Shushtar to Isfahan, Persepolis, and Shiraz. The ruins of many settlements from different periods, now reduced to low mounds (called *tepes*), dot the valleys. Skins, wool, and horses were probably traded by the Lurs to the passing merchants for manufactured goods, the products of the plains. But our interest here is in the itinerant metalsmith who went from camp to camp, sometimes attaching himself to a caravan for protection, and sometimes making his solitary way across high passes and broad meadows to lonely communities.

THERE is evidence indicating that these smiths may even have been formed into loose "brotherhoods," or guilds. As the seminomad encampments were small and unable to support metalsmiths of their own, the itinerant's pack animal was burdened with cast bronzes, beatenware, heavy jewelry, votive pieces, horse-trappings, and fine weapons. He was also a tinker who patched up old vessels with sheet metal and rivets. The smith belonged to the same mountain stock as his customers. His forebears must have had their roots in the Caucasus, which had an ancient metal-working tradition. That mountainous region between the Black and Caspian seas has rich lodes that were exploited at least as far back as the fourth millennium B.C. The smith who sold to the Lurs certainly did not come up from the Mesopotamian plain, for his products were far different from those of his fellow smiths in the lowlands.

For the mounted warriors of Luristan, the smith cast in molds not only their harness equipment but also the light weapons they used in their lightning raids, the



Elaborate, enigmatic pieces show humans with bulging eyes in totem pole effect or, sometimes, snarling lions facing each other. Hands on a horse bit, below, grip rein rings.

razzias, organized for booty or for settling blood feuds. On their belts the Lurs carried long, straight swords with iron blades, the hilts and pommels decorated with ferocious lions and bearded heads. They thrust short bronze daggers into their robes, in the Assyrian fashion, or wore them at their waist in wooden scabbards plated with embossed silver and gold. Wood and bone inlays, long since crumbled to dust, also once decorated these weapons. Skull-cracking blows were aimed by the sweeping riders with solid bronze maces, spiked and knobbed.

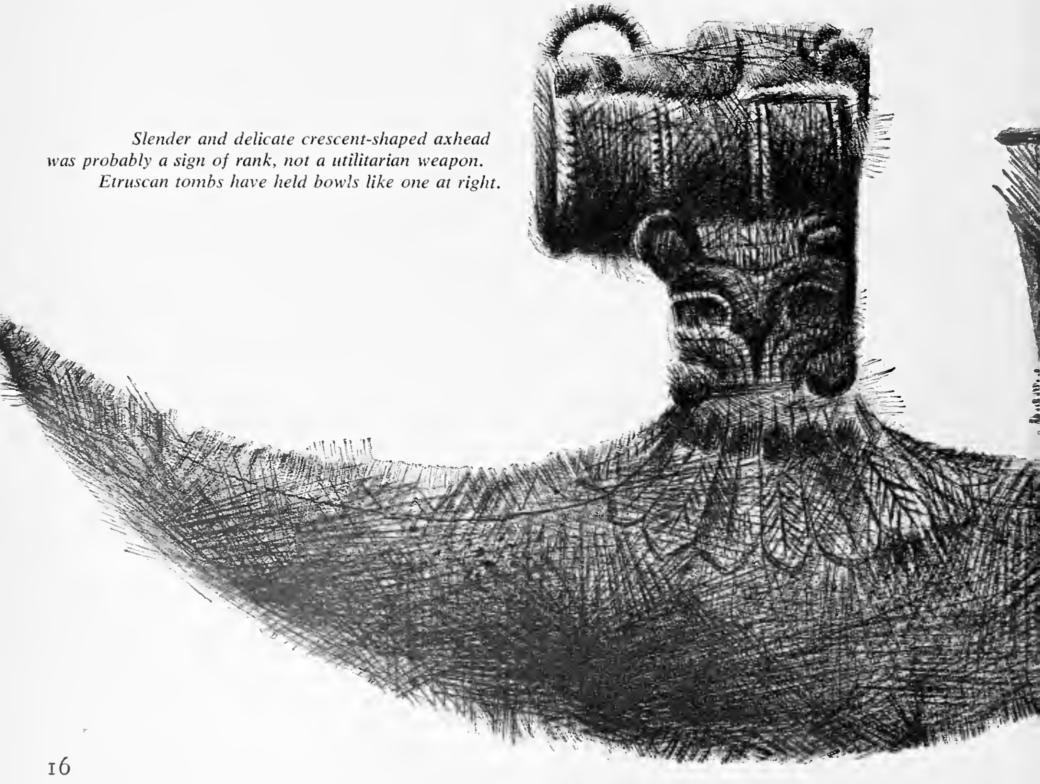
A primary symbol of authority, however, must have been the fancifully decorated "tomahawk," or light ax. Some of these small, bronze axheads are so delicately formed that they are almost useless as weapons. Rather, they must have been signs of rank, of ceremonial use, carried by the leaders. Some blades are slender crescents being disgorged by lions; others are long and curving, and the hafted end is elaborately decorated with animal heads or rows of spikes.

Warriors may have carried small leather shields decorated with bosses and roundheaded rivets. The bow and arrow—weapon par excellence of the later Iranians (Persians, Parthians, and Sasanians)—were part of this light cavalry equipment, as is evidenced by leaf-shaped arrowheads, bronze rings of special design that were used to string the bow, and embossed metal sheathing from quivers, all of bronze. Some chariot fittings have been found, and a two-wheeled light chariot is represented on a horse cheek plate. But the char could not have been very popular in this mountainc terrain, and must have had no more than a ceremon function in Luristan.

The metalsmith also catered to the domestic needs the Lurs. He made straight pins with elegantly decorat heads, ornate safety pins (fibulae), heavily model bracelets and anklets, twisted wire torques, tiny pendan and polished bronze mirrors set in ornamental handl Animals are ubiquitous in the decoration. Also amo these goods are some enigmatic bronze pieces that av age seven to eight inches in height; they are elaborat worked compositions of facing animals and humans the shape of slender tubes. A rod was inserted throu the tube, fixing it to a heavy bronze base shaped like miniature bottle. Snarling lions with protruding tongu may face each other, or a grinning human with bulgi eyes and pointed or bearded chin may stand betwe them. Sometimes the different bodies merge and gi rise to fantastic combinations, grotesque monsters. T earlier Lur compositions are fairly realistic, while t later ones exhibit increasing use of combined forms a stylized designs. These are not simply household bric-brac, but rather emerge from the spiritual life of the Lu We shall return to this matter of religion in a moment.

When did these proud mountaineers race their hors over the grassy slopes of the Zagros? At first, when t bronzes had just come to the attention of the Weste world, they were dated as far back as the third mille

Slender and delicate crescent-shaped axhead was probably a sign of rank, not a utilitarian weapon. Etruscan tombs have held bowls like one at right.



ım B.C. and were thought to have continued on to out 1000 B.C. when the country was overrun by one the great migrations from the north that disrupted and placed many oriental states. Perhaps, it was speculated, group of these intruders, speaking an Indo-Iranian diat and, more important, adept at working iron, eclipsed Bronze Age culture of Luristan. These people introced into Iran new designs in pottery and new customs, ch as a different manner of burying the dead. They ne from the Caucasus, skirted the arid Iranian plateau, d entered India. But who, then, were the Lurs? They re first identified and dated on the basis of some nze daggers, swords, and hemispherical bowls that re found in the Luristan hills and that carried names kings and nobles in cuneiform. The people mentioned the inscriptions belonged to the second millennium . Given this time period for the bronzes as a whole, it s then reasonable to suspect that Luristan art beged to a known historical group, the Cassites. This d mountain people had broken down into the Mesoamian plain and ruled that rich land for over four ndred years in the second half of the second millenm. But there is strong contrary evidence that quesns such an assumption.

Some of the bronzes looked to be Assyrian (first milnium), some Neo-Babylonian, and some seemed to Persian. Hence, it was equally reasonable to suspect t the Luristan bronzes were also made in the ninth to n centuries B.C. It quickly became apparent that dating and attributions needed to be seriously re-evaluated. First, the introduction of iron did not ring the death knell for Luristan; the Lurs used iron, in swords for example, when a stronger metal was needed. Second, none of the bronze objects that carried inscriptions, and hence are datable, displayed any of the typical Luristan decoration. And, conversely, none of the objects clearly within the Luristan style is inscribed. The reason for this discrepancy is clear: the inscribed material is centuries older than the Luristan bronzes and originated, not in Luristan, but in Mesopotamia. As mentioned earlier, Luristan was crossed by two major highways, and the Lurs themselves were mobile. It is only to be expected that manufactured products of the river valleys should have infiltrated the mountains at all times. And so the inscribed material cannot be used as a basis for dating the typical Luristan bronze of the style here illustrated. The reason that some so-called Luristan bronzes look Assyrian, Neo-Babylonian, and Achaemenian is, simply, because they belong to these different people and are not of Luristan origin or manufacture at all. Once the excitement of finding a heretofore unsuspected art style had diminished, it required little practice to distinguish between bronzes made and found in Luristan and ones only found there.

THE style of the bronze pieces, the mode of burial, the pottery types, and the form of the decorative motifs combined to indicate that the Luristan bronzes and their horse-riding owners date well within the first half of the first millennium B.C. This animal style of art is a later descendant of a style known earlier in Anatolia (Turkey) and Talysh (south Russia). The culture is related to that of the broad nomadic band that stretches from south Russia to the Ordos, but with significant differences that indicate that it is far removed from its more northern and very distant relatives. Certain clues, and some obvious borrowings, relate the Luristan bronzes to the metalwork of the Assyrians and late Hittite kingdoms. All in all, the Luristan bronzes seem to be a highland art style of around 800-700 B.C. There are many minor but very important details that confirm the probability of this dating. A few examples of the type of evidence used may be mentioned. A pitcher of a distinctive Luristan type was found in an archeological context of 750-600 B.C. by the German Archeological Institute on the island of Samos, while the English uncovered an eighth-century tomb on Crete that contained a typical Luristan bronze ring. Late eighth- and early seventh-century B.C. Etruscan tombs disclose bowls, weapons, and ornaments that, while not of Luristan manufacture, imitate Luristan models. Two graves found by the French at the Iranian site of Tepe Giyan are Luristan burials. The cemetery in which they were found was in use for a long time both before and after 1000 B.C. Luristan fibulae are of a type that does not antedate the ninth century. Some motifs used by the Lurs, particularly on the embossed plaques, can be dated by their Assyrian counterparts to between the eighth and sixth centuries B.C.

Without the help of written records from Luristan, the prehistorian must try to decipher this language of art forms to learn the culture of these mountain folk. The bronzes certainly speak a highly articulate language, but it is still very foreign to our ears. The basic religious grammar is succinct and standardized. A design that recurs frequently is that of a human flanked by animals. The man wears a small cap and about his waist a tight girdle. The woman has bull-like "horns" over her curling side locks, and she is usually nude except for a belt and bracelets. Both man and woman are represented holding the legs or necks of mountain lions and ibex on either side of them. They do not subdue the beasts, and the animals do not attack them. Their pose is formal, almost dancelike, as if they were performing a stately pavan. This design is not peculiar to Luristan, but it has some unique features there, such as the fantastic composite animals with their elongated bodies.

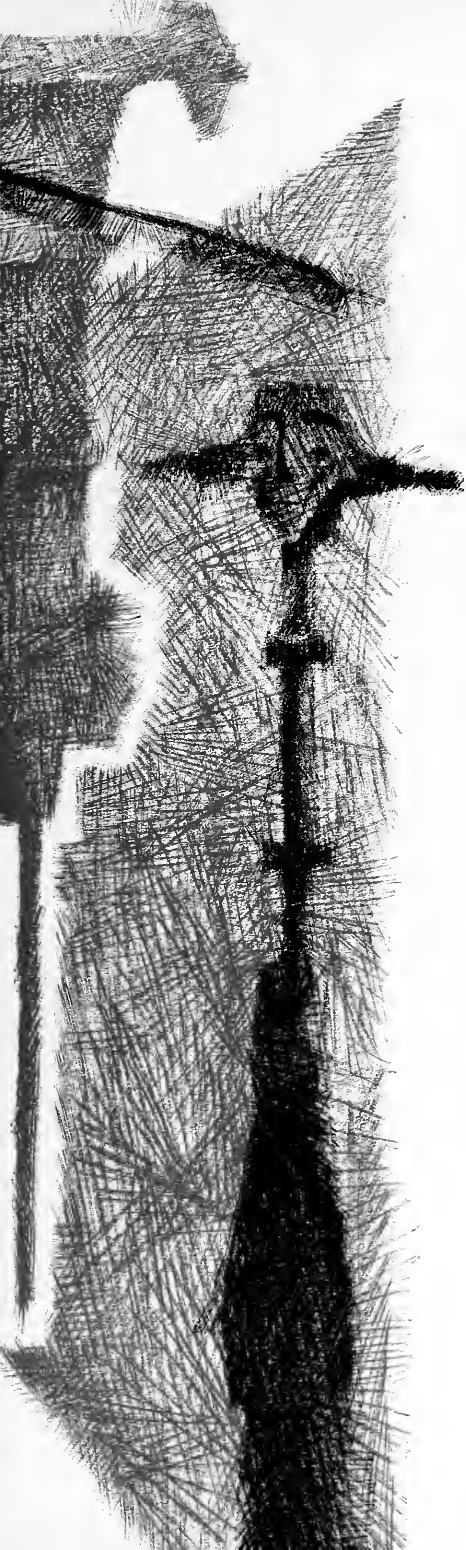
The variety of animals represented can be listed in descending order of frequency of appearance: mountain lion, ibex, horse, bull, rooster, water bird, rabbit, fox (?), swine, tortoise, fish, frog, eagle. The animals of the northern steppes and forestlands are missing: elk, reindeer, bear. The southern and eastern animals, camel and elephant, are also not represented. These omissions are important, for while the Luristan seminomads may be distantly related to the northern nomads, the link is very weak. The northern nomads who wandered up into the forest belt of Russia and Siberia and over the steppes into modern-day China had an animal style art that was as lively and imaginative as that of Luristan. In the seventh and sixth centuries B.C. it flourished in the skillful hands of the Scythians who passed it on to the Sarmatians. (NATURAL HISTORY, October, 1960.) The tradition was still vital in the first centuries of the Christian Era when the nomadic migrations carried it deep into east Europe. The hallmark of the northern nomad style is the bird of prey and the northern members of the deer family. Surely, had the northern nomads and the Lurs a strong common background, they would have shared these significant designs, but they do not.

Bucket is an interesting example of the elabor
vessels used by Lurs. If metal stronger than bronze
was needed, they used iron, as in swords at right.

The camel, domesticated by the end of the seco
millennium B.C., indicates by its absence from the Lu
stan fauna that the nomads of the eastern deserts a
Arabia are not important to our understanding of
Zagros tribes. An ax with a camel on its butt has be
called Luristan, but it fits much better into Persian a
The Persian Empire of the second half of the first mill
nium B.C. knew the Bactrian camel; its likeness is carv
on the walls of the royal Persian citadel at Persepolis.

What key remains, then, with which to unlock th
extraordinary bronzes? The field of comparative religi
may offer some insight. Wings and plant forms spri
from the animals; human heads are put on animal bodi
the bodies of mountain cats are elongated, while smal
animals perch on their backs or emerge from their bodi
Lions and humans share common features. Grinni
heads are piled on top of each other to form miniatu
totem poles. Hence, despite the limited range of elemen
the bronzes burst with animal energy; they seem to spe
of an uncompromising outdoor life spent in the toweri
icy passes and also under the burning sun in the a
lowlands. We would not be far wrong if we see in th
bronzes the images of a religion based on elemental na
ral forces. The male figure may, like the later Iranian g
Mithra, have been associated with the sun. Of course
do not know his Luristan name; in Mesopotamia he w
Shamash. In the Semitic world one of the powerful natu
gods was simply called *El*, that is, "Lord." Perhaps,
the time being, Lord may be used as the most conveni
designation for this Luristan hero, and his compani
may be titled Lady.

Religions and mythologies commonly use animals
personifications of various natural forces, and som
times they serve as symbols of the divine, as emblems



holy authority. So, for example, Jesus is the Lamb, and in Revelation the Evangelists are the Four Beasts. The Lurs knew well the cunning, ferocity, and explosive power of the mountain lion. They must have looked at the ibex with equal respect. What other beast could cling to impossible crags and move with such agility as that majestic creature? And its broad, curling horns were a formidable weapon. The horse, as already mentioned, held a special place in Luristan iconography. The bull was probably borrowed from the lowlands where, since most ancient times, it served as a symbol of strength and generative force. Thus, the bull stands as majestic guardian on Assyrian doorways; in Near Eastern literature, the chief gods are often called "bull."

In trying to understand the religion behind the Luristan bronzes, we find several possibilities. The association of the Lord and Lady with the beasts may be an expression of the power of these deities. The animals may be purely extensions—symbols of the incalculable strength of the gods. It is in this sense that in India the gods and goddesses had their animal forms, or avatars. Or, perhaps, the Lord and Lady are sky gods, and the animals are representative of earth powers. The Lord holding the animals who, in turn, rest their paws on his hips and shoulders, could symbolize the dynamic equilibrium of nature, the check and balance system found in many mythologies. Such a system of opposing forces is found in the Indo-Iranian myths, in the dichotomy of light opposed to dark, of good opposed to evil, of time finite opposed to eternity.

The bronzes are suggestive of yet another proposition. It should be noted that the Lord and Lady not only hold the flanking beasts but also seem to rise out of or to be carried by the converging animal bodies. Are the animals cosmic vehicles that support the gods? In the classical world the sun god was borne aloft by a horse-drawn chariot; the throne of the Israelite Yahweh in the Temple of Solomon was carried by winged cherubim. Perhaps, then, the circle of the beasts' bodies represents the heavens in which the god resides.

THESE suggestions are not mutually exclusive, but it is probable that the truth lies somewhere in-between, for religions and their symbols are highly complex, with a variety of meanings and concepts expressed in simple terms. The Lady, for example, may be a late representation of Derceto, the Great Mother goddess of Asia, the personification of life-giving forces. As such, she would be a sister to those other great fertility goddesses whose many names we know: Innina, Ishtar, Astarte, Ashtoreth, Aphrodite, Venus, and so on. It is proper that she, like Diana, the Huntress—her later classical counterpart —be associated with animals. The moon became the astral symbol for the Great Goddess, and so it may be the crescent moon, and not horns at all, that rests on the Lady's head. One Luristan bronze in a Swiss collection shows the Lady with her body terminating in a fishtail. This is a very strange combination, indeed, until we remember that the Asiatic Great Mother was part fish, part woman—a true mermaid.

We may ask whether these people had temples for their Lord and Lady, whether they erected altars where sacrifice could be made. As is to be expected with seminomadic people, architectural remains are almost non-existent. Summer and winter encampments do not leave behind stone foundations that the archeologist can reconstruct. However, a building has been found at Surk Dum above the plain of Kuh-i-Dasht, in western Iran, that contained some Luristan bronzes, and it has tentatively been designated a shrine. The building should have much to tell about Iranian religion; it is currently under study by its excavator, the renowned archeologist Erich Schmidt of the Oriental Institute in Chicago.

Concerning the ethnic stock of the ancient Lurs there are, once again, suggestions but no definitive answers. As mentioned before, the Luristan bronzes were once thought to have been made by the Cassites who overran the Mesopotamian plain. This attribution is not only unlikely because of the time factor, but also because no Luristan bronzes have been found in Mesopotamia. Surely if the Cassites had been the owners, they would have brought their precious bronzes down with them into the Tigris and Euphrates valleys. However, if the bronzes flourished about 700 B.C., then they may belong to an Iranian people who were soon to become one of the constituent elements of the great Persian Empire—the confederation of Medes and Persians. There is evidence to support the theory that the Medes were moving down from the region of the Caucasus into Iran at about this time. Another, perhaps related group, the Cimmerians, were also pushing down through these mountains out of south Russia. One of the great French scholars of prehistoric Iran, Roman Ghirshman, suspects that the Luristan bronzes belong to a Medo-Cimmerian people. This theory of origin would explain why the Luristan bronzes disappear with the confederation of Medes and Persians: Luristan art developed into that of the Persian Achaemenians. Unfortunately, we know little about these Cimmerians and Medians during their formative period, and we know even less about their art.

One of the apparent mysteries connected with the Luristan bronze pieces has already been mentioned: although the metalwork of Mesopotamia has been fou
in Luristan, no Luristan bronzes have been discove
in the extensive excavations carried on in the plains. T
key to this mystery is socio-political. Mesopotamia h
a long and fabulous heritage that seemed in the eyes
ancient man to stretch back to the very beginning of ti
Its textiles, for example, were sought after on the wo
market, as even the proud Greeks turned envious eyes
the opulent treasures of the East. The cultural emine
of Assyria and Babylonia was enhanced by the politi
expansions of these wealthy states in the eighth and s
enth centuries B.C. The arts and crafts of the Assy
Babylonian world must have formed the last word
refined style for the provincial Oriental. Why, inde
should the metropolitan centers of antiquity—Ninev
Babylon, Assur—import the rude bronzes of the ha
civilized mountain folk to the East? Do the style cent
of New York turn to the prairie, those of London to t
Welsh hills, or of Paris to the provinces? On the oth
hand, the mountaineers of Luristan would be eager
own works from the treasure houses of Mesopotam

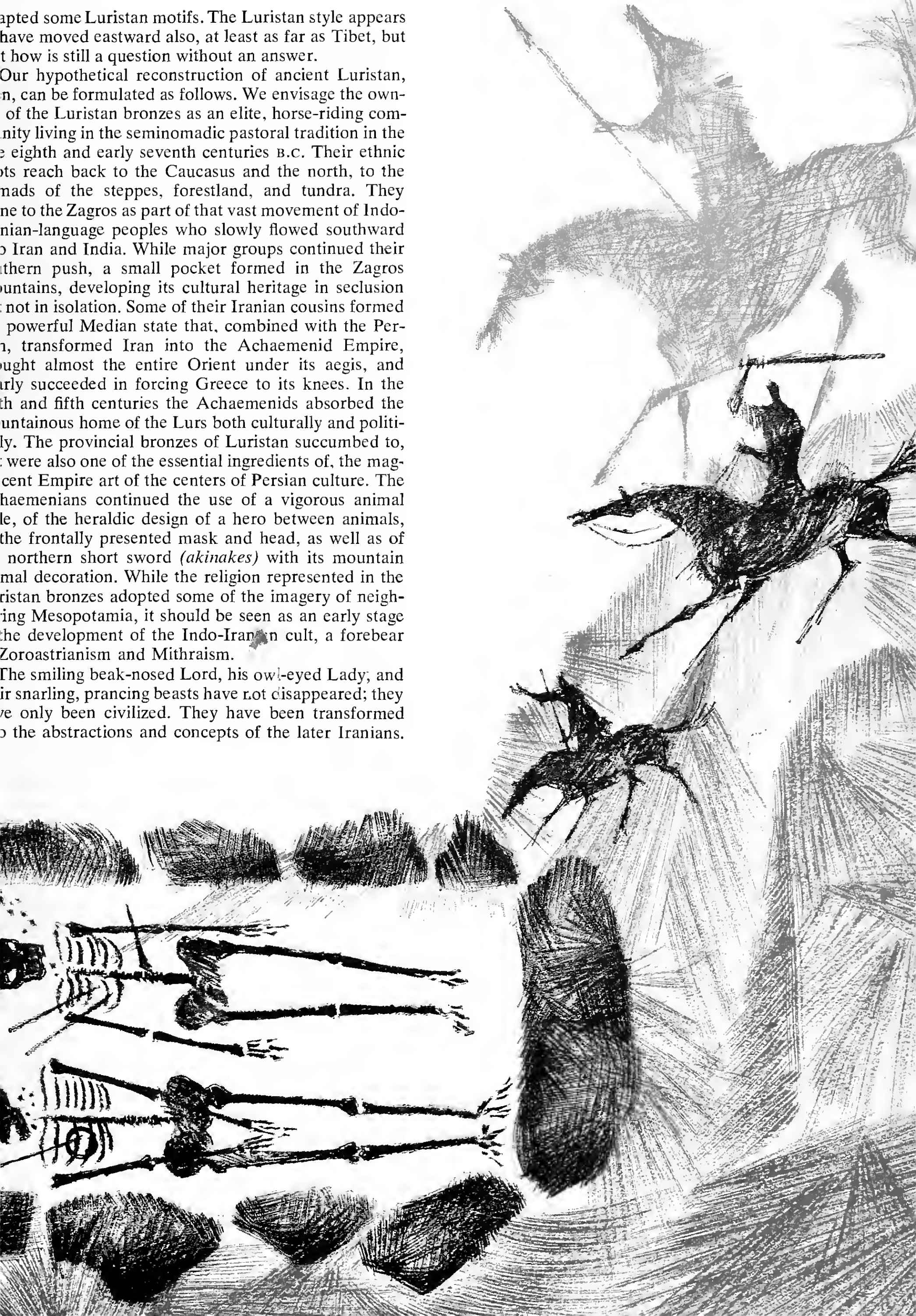
SOME bronzes that were thought to be from Lurist
have been found in Arabia and in Greece. Th
have some Luristan traits, but are sufficiently differe
to place them as originating elsewhere in the Near Ea
Yet there is no question of the authenticity of the Lu
istan pitcher found on Samos or the bronze ring decorat
with the Lady and her feline companions excavated
Crete. We can speculate that these are ancient souven
brought out of the East by Greek or Phoenician trade
The chief importance of the two pieces, however, is th
they were found in an archeological context of *ca.* 7
B.C. But if Luristan bronzes were not exported as tra
items, they still had their influence on other cultur
Many characteristics of their vital animal style filte
westward to the coast and out into the Aegean. Even a
cient Etruria, on the Italian peninsula, adopted a

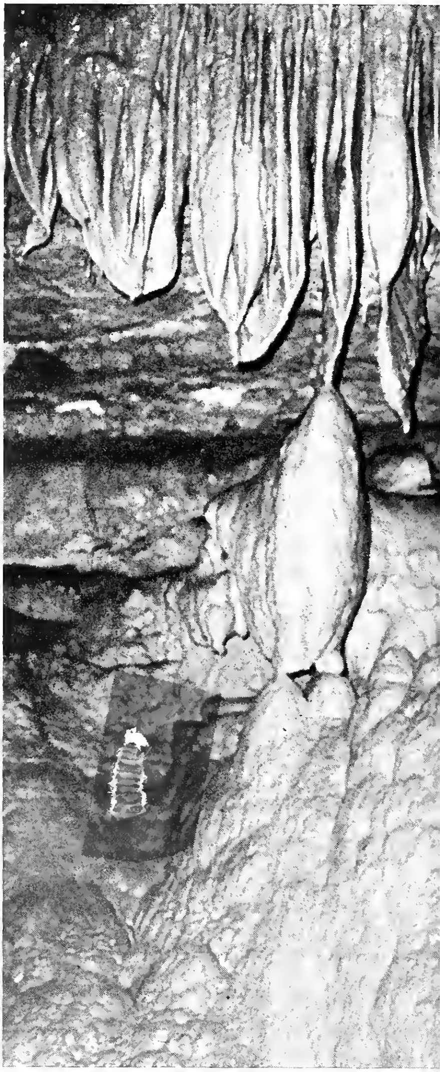
Mode of burial, as well as style of bronze pieces and types of pottery, helps to assign the horse-riding Lurs to the first half of the first millennium B.C.

apted some Luristan motifs. The Luristan style appears have moved eastward also, at least as far as Tibet, but t how is still a question without an answer.

Our hypothetical reconstruction of ancient Luristan, n, can be formulated as follows. We envisage the own- of the Luristan bronzes as an elite, horse-riding comnity living in the seminomadic pastoral tradition in the e eighth and early seventh centuries B.C. Their ethnic ots reach back to the Caucasus and the north, to the mads of the steppes, forestland, and tundra. They ne to the Zagros as part of that vast movement of Indonian-language peoples who slowly flowed southward o Iran and India. While major groups continued their ithern push, a small pocket formed in the Zagros ountains, developing its cultural heritage in seclusion : not in isolation. Some of their Iranian cousins formed powerful Median state that, combined with the Per-1, transformed Iran into the Achaemenid Empire, ought almost the entire Orient under its aegis, and arly succeeded in forcing Greece to its knees. In the th and fifth centuries the Achaemenids absorbed the untainous home of the Lurs both culturally and politily. The provincial bronzes of Luristan succumbed to, : were also one of the essential ingredients of, the magcent Empire art of the centers of Persian culture. The haemenians continued the use of a vigorous animal le, of the heraldic design of a hero between animals, the frontally presented mask and head, as well as of northern short sword *(akinakes)* with its mountain mal decoration. While the religion represented in the ristan bronzes adopted some of the imagery of neigh-ing Mesopotamia, it should be seen as an early stage he development of the Indo-Iranian cult, a forebear Zoroastrianism and Mithraism.

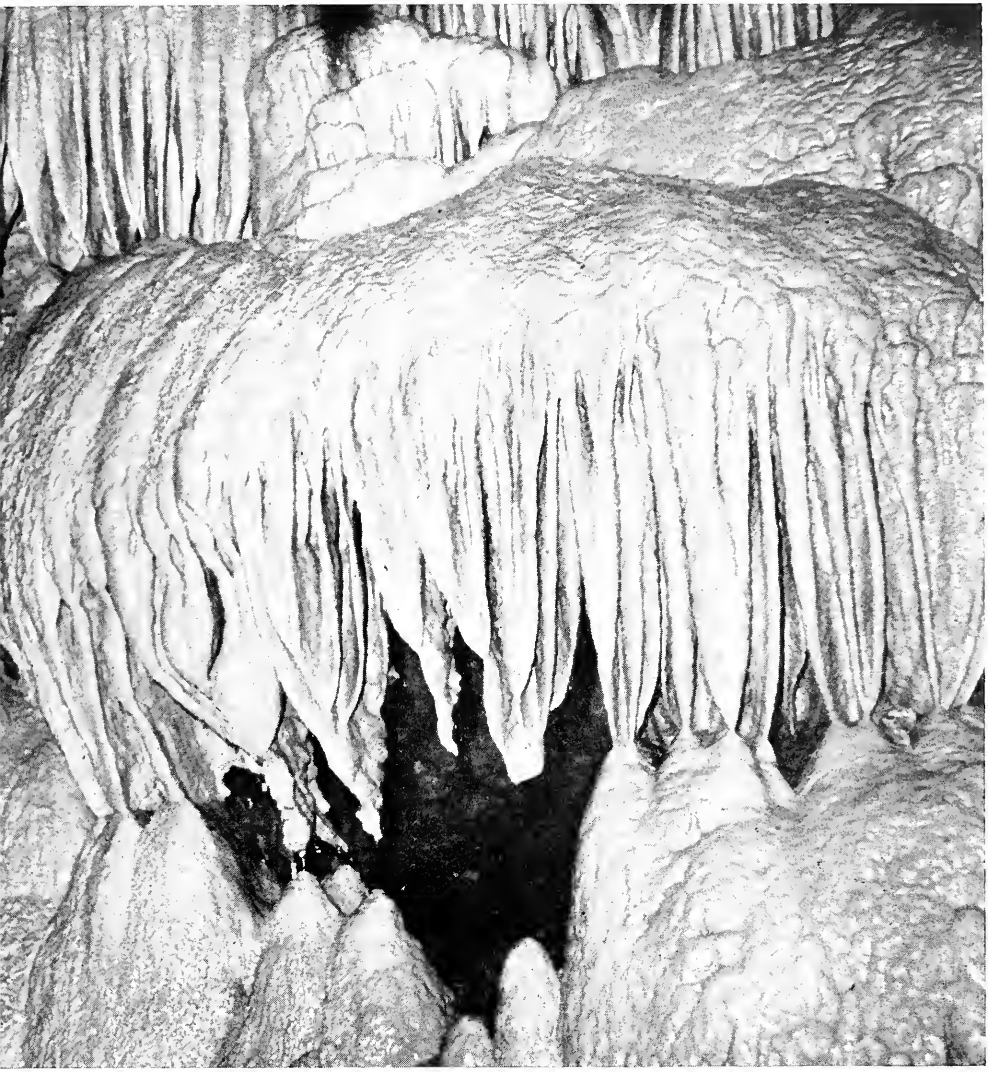
The smiling beak-nosed Lord, his owl-eyed Lady; and ir snarling, prancing beasts have not disappeared; they e only been civilized. They have been transformed o the abstractions and concepts of the later Iranians.





Stalactites hang from ceiling of Diamond Cave, near Harrison, Arkansas, where subsequent photos were made. Rounded masses on cave floor are stalagmites.

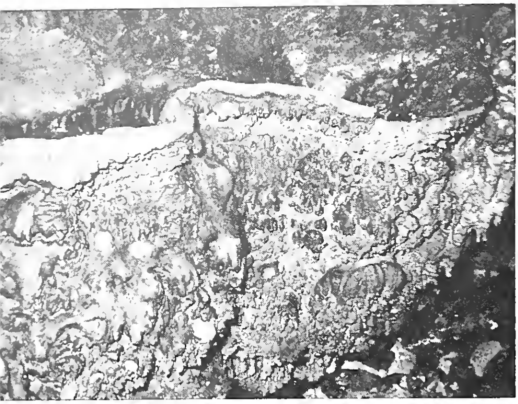
Splash patterns of fast-dripping, carbonate-laden water produced tiered, columnar stalagmite. The flow of water over sides of layers made small stalactites.



Stalagmites and Stalactites

Slow growth marks precipitate deposits

By Edward O'Donnell



Carbonate rock, deposited by flowing or dripping water, is known variously as dripstone, flowstone, or travertine.

STALACTITES are icicle-like structures most commonly found hanging from the ceilings of caves in limestone-rich areas, and stalagmites are complementary masses that develop on cave floors. Both result from slow precipitation of material from ground water. Most stalactites and stalagmites are made up of two forms of calcium carbonate—calcite and aragonite—although some small stalactites are composed of gypsum, gibbsite, opal, and chalcedony.

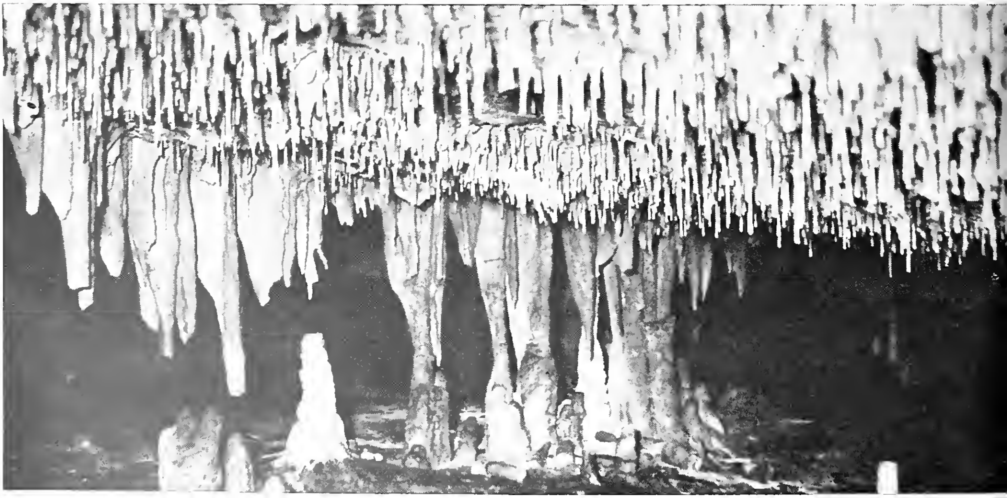
Limestone is the most soluble of the common rocks, and nearly all great caves are in limestone areas. Pure limestone is composed of calcium carbonate derived mainly from shells of marine organisms. In an alkaline environment, limestones are chemically stable, but they are subject to slow leaching when exposed to rain water and subsurface ground water, which are acidic.

If several small pieces of limestone are placed in distille water they will show no noticeable changes, even during period of several years. Should the water be charged wit carbon dioxide, however, carbonic acid is formed and th limestone will show a measurable weight loss in only a fe days because some of the calcium carbonate of the lim stone is converted to calcium bicarbonate, which is solub in water. If this solution is allowed to evaporate, it wi become supersaturated with calcium carbonate, which, i turn, will be precipitated as calcite or aragonite.

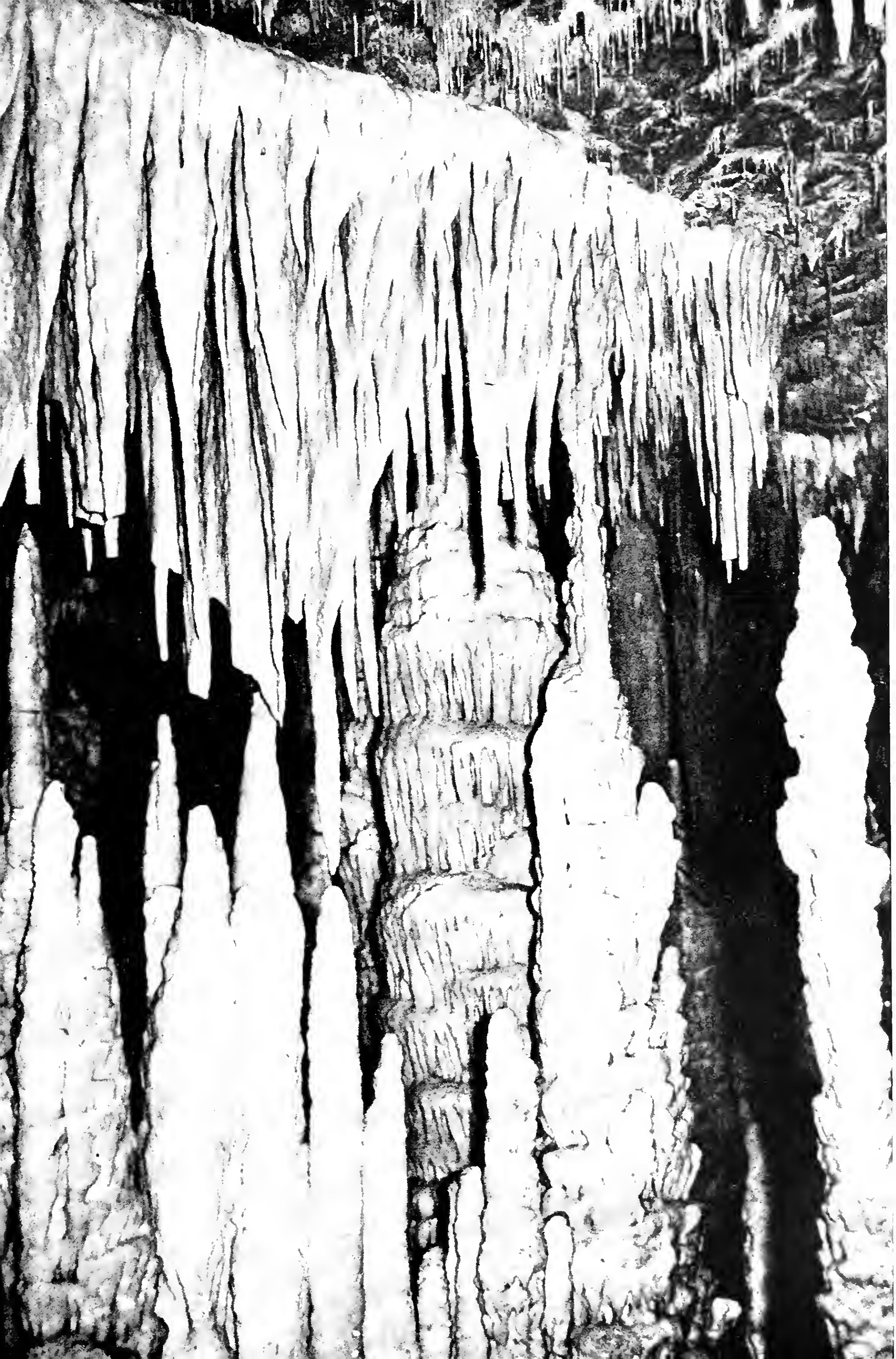
In nature, rain water falling to the earth becom charged with carbon dioxide from the atmosphere. Aft it hits the earth it comes in contact with organic acids the soil. The water percolates through the soil until reaches bedrock, where it follows fractures and beddi planes. If the rock is a limestone, solution occurs, and aft a long period of time, perhaps several thousand years, pa sages are formed that range in size from small channels great caverns. Size depends on how long the process h worked, the volume of water involved, and its acidity.

Stalactites form when carbonate-enriched ground wat reaches a cavern. The water drips slowly from the ceilin but before each drop falls, a small amount of evaporati takes place. The drop becomes saturated with calcium ca bonate and an infinitesimal amount is precipitated. Whe the drop falls to the cave floor, the same thing happe again, and a stalagmite begins to develop.

The rate at which stalactites grow is not definitely know Certainly the speed of formation will depend on the amou of water that is available and how much calcium carbona is in solution. Sir Archibald Geikie, the great Scottish g ologist of the late nineteenth century, recorded stalactit one and a half inches in diameter beneath a one hundre year-old bridge in Edinburgh. They had grown from lim leached out of the cement in the bridge. All evidence poin to a slow rate of formation, and it is estimated that stala tites grow approximately one cubic inch in every centur



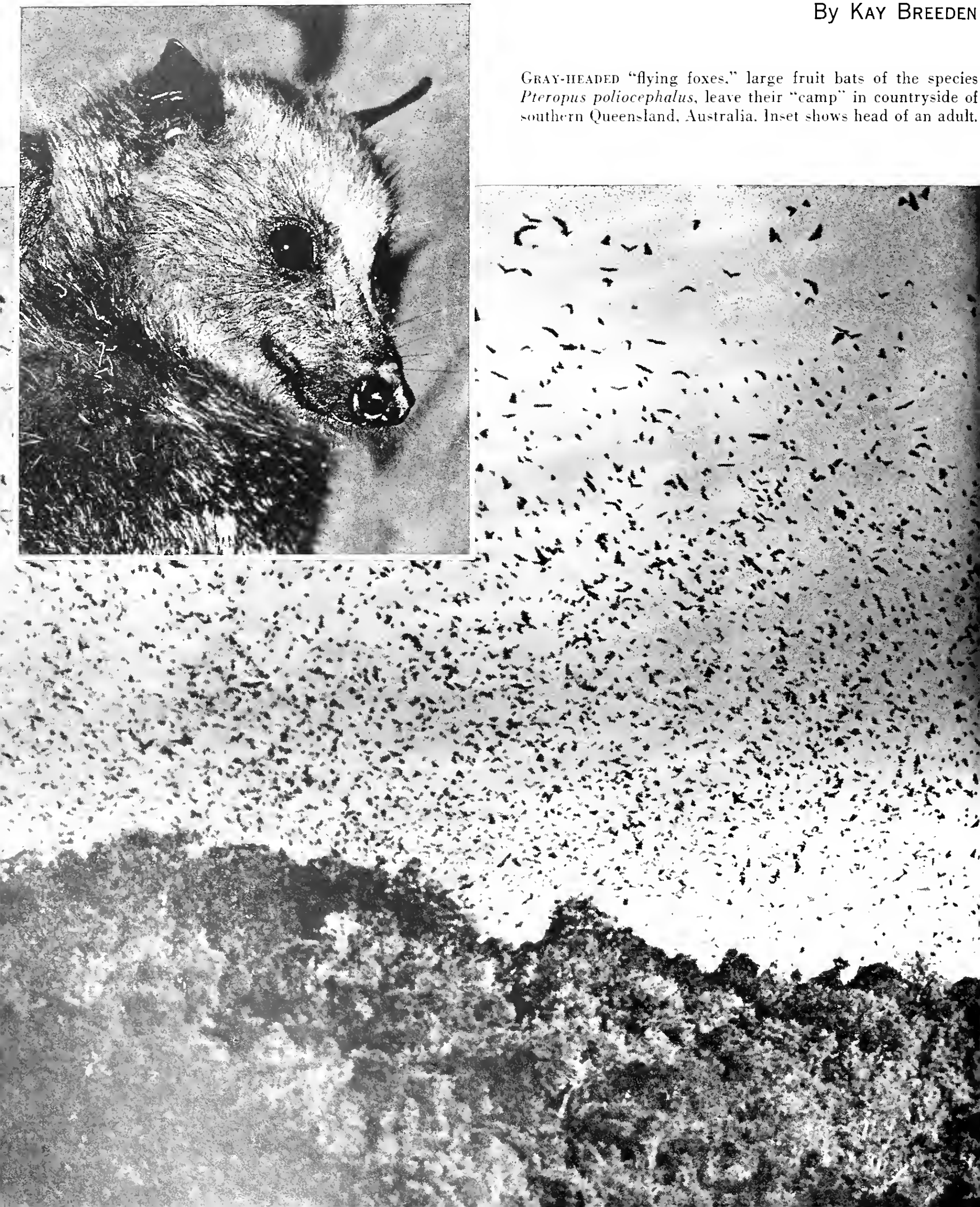
Meeting of twain occurs when stalactite and stalagmite form opposite each other. As growth continues, such unions produce floor-to-ceiling pillars, examples of which may be seen above, at center. Alignment of stalactites on ceilin of the cave at right is probably attributable to joint c fracture in the rock that permitted a rapid flow of wate



Fructivorous Fliers

Australian fruit bats take wing at dusk in sorties after food

By Kay Breeden



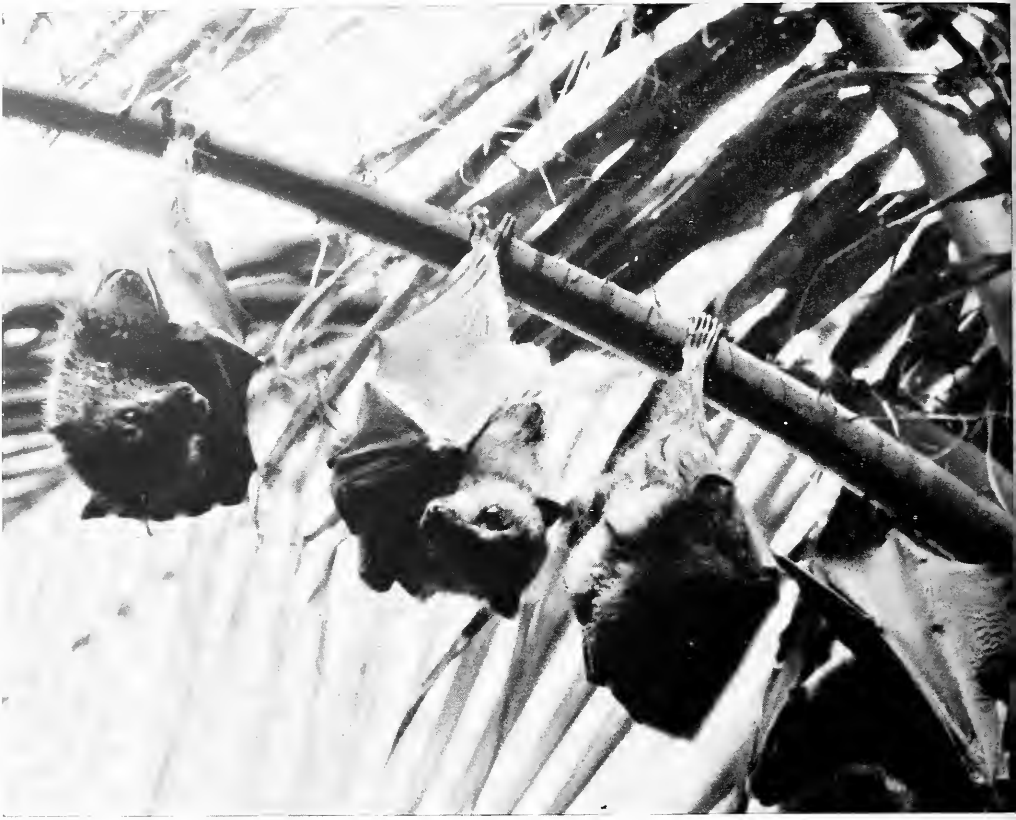
Gray-headed "flying foxes," large fruit bats of the species *Pteropus poliocephalus*, leave their "camp" in countryside of southern Queensland, Australia. Inset shows head of an adult.

UST BEFORE DUSK one winter afternoon in subtropical eensland, Australia, we witnessed the impressive spec- le of thousands of large, gray-headed fruit bats, or ying foxes," leaving the trees of their "camp" to feed in surrounding countryside. They had been situated in a ural amphitheater in a rain forest, and we were fore- rned of their departure by the increasing tumult.

The first sign of mass movement away from the camp was in, upward spiral of "foxes" barely visible in the slowly kening night. Soon, the bats blackened the sky as far as could see. Their shrieks and the whispering *woosh osh* of their wings filled the air, and all the while the ise in their camp grew more intense, announcing that n larger numbers were about to take to the air. Although night became too dark for us to see, we stayed and listened to the foxes continue their incredible exodus. It went on for another quarter of an hour before the stream diminished and finally stopped.

Three species of fruit bats of the genus *Pteropus* occur in southern Queensland, within a hundred-mile radius of Brisbane. Of the three, the gray-headed flying fox, *P. poliocephalus*, is the most common, and this article is concerned mainly with this species. The "black fox," *P. gouldi*, which is the largest Australian fruit bat, and the "little red fox," *P. scapulatus*, are the other two species; much that will be said about the gray-headed flying foxes holds true for the black and red bats, particularly with respect to their various behavior patterns.

Bats form the order of mammals known as Chiroptera, which means "hand-winged," and they are the only true



RESTING "foxes" are seen in camp, hanging by one foot from a palm branch. They envelop themselves in flying membranes.

BAT RETAINS FOOTHOLD on branch, *right*, and flaps wing raise itself into a horizontal plane for the take-off, *lower pa*

flying mammals. There are two suborders, Megachiroptera and Microchiroptera. The flying foxes and all other fruit bats of the Eastern Hemisphere are Megachiroptera, while almost all insectivorous bats are Microchiroptera. One difference between the suborders is that the Megachiroptera are usually large bats and the Microchiroptera are generally small, although some species of the former are actually smaller than many species of the latter. With one possible exception, none of the Megachiroptera employs ultrasound in echolocation, but all Microchiroptera that have been studied do. Most Microchiroptera are insectivorous or carnivorous; more often than not they have poor eyesight and employ ultrasonic echolocation to detect and capture their insect prey. Members of the family Phyllostomatidae, the tropical and subtropical leaf-nosed bats of the Western Hemisphere, are the only Microchiroptera that feed on fruits and blossoms (NATURAL HISTORY, October, 1962). Members of this group generally have a tail, complicated ears, and often nose-leaves. Megachiroptera, on the other hand, frequently lack tails, have keen eyesight, possess simple ears, and usually simple noses. Their most common foods are fruits and blossoms. The Microchiroptera are cosmopolitan in distribution; Megachiroptera do not occur in the Americas.

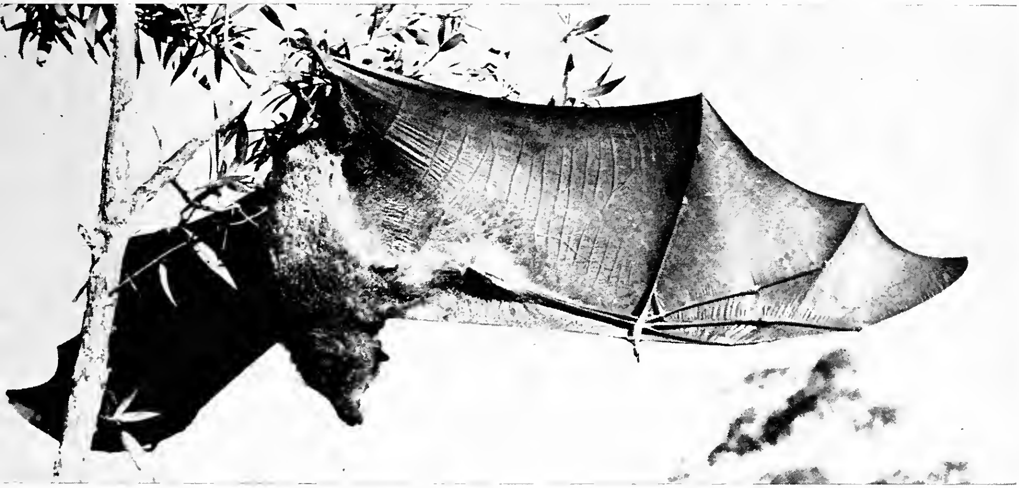
The gray-headed flying fox is a magnificent animal with a wing span that averages about four feet, a shaggy head, large brown eyes, and black ears. Its body coat is of silky, silver-gray fur, and a mantle of burnished amber or orange fur extends around the neck and shoulders. The flying membranes are soft and black. Large males may weigh as much as two pounds. By facial expressions, movements of their ears, and seemingly always-active noses, the bats convey an impression of inquisitive intelligence.

AFTER an exodus at dusk, such as the one described, the bats disperse for many miles in all directions to seek food and water. They drink by lapping while flying over the surface of a pond or stream. Should they fly too low and accidentally pitch into the water, they are easily able to swim to shore. Their diet consists chiefly of nectar, which they extract from the blossoms of flowering trees. They feed on wild and, also occasionally, on cultivated fruits.

The little red flying foxes feed exclusively on flowering trees, including species of *Eucalyptus* and *Melaleuca*, and their migrations coincide with the flowering seasons of their various food trees. Gray-headed bats will eat fruit only when blossoms are not available. The black flying foxes are fruit-eaters, and have a decided appetite for cultivated citrus and other orchard-raised fruit. Because of such depredations. all species of fruit bats have become unpopular with local farmers, who regularly shoot many of them as they rest in their day camps. The local unpopularity of the animals is out of proportion to the damage they do, however, as modern harvesting methods entail the picking of green fruit, which is then ripened indoors. Only a very small percentage of any of the species of bats eat cultivated fruit, and the extensive damage that sometimes does occur s usually the result of the same few bats returning nightly o the same orchard. When such a group was poisoned in one orchard near Brisbane, there were no further raids on the crop that season from the same or any other camp.

To reach their food trees, the flying foxes sometimes ravel as far as forty miles. The method by which they irst locate feeding grounds and subsequently return to them night after night is not yet completely known. It has been suggested that rivers may be the chief landmarks in their visually oriented navigation. But no matter how they come and go, they are certainly efficient; a characteristic sound of night in the Australian bush is the screaming of the bats.

FLYING FOXES return to camp just before dawn. We witnessed their homecoming one morning while standing ankle deep in a swamp with some other researchers at the edge of a camp of *Pteropus poliocephalus.* It was still pitch dark when we arrived, but already the sounds from the camp and the rustling of wings overhead indicated that the return was under way. As the morning sky brightened, we could see a number of the bats flying low over the trees. Soon they were returning from every point of the compass. The first arrivals had been feeding close by. We heard occasional squawks from individuals that experienced near collisions.



Simple ears and nose of this bat give it doglike appearance. Males may weigh two pounds and have a four-foot wingspread.

Bat-festooned tree in a "flying fox" camp is seen below. The camps, each with thousands of "foxes," are in moist regions.

For some time we had also heard a periodic, loud, flapping noise, which we finally identified as the wingbeats of bats returning from farther away. These were flying at a great height, and as they neared the camp they pulled their wings in slightly, zigzagged down in fast dives, and then leveled off into glides just above the treetops. The amazingly loud flapping noise was produced by air rushing past their wings as they dove down out of the morning mist.

The swamp was a typical refuge for the bats. The gray-headed species spends the day in large, communal camps. Fifteen to twenty such settlements, with intervals of about forty miles between them, are known in the Brisbane area. They are usually situated in wet, relatively cool areas, such as the mangrove forests of river estuaries, palm groves and adjacent rain forest, *Melaleuca* swamps, and, less commonly, in gullies with mixed rain forest and eucalyptus. These locations are nearly always remote from civilization, and the flying foxes return to them year after year. In a few cases, a growing suburb or township has expanded right to the end of a large, well-established camp. In such instances, if the bats are not molested they become accustomed to man and appear to be undisturbed if people enter camp. The number in a camp fluctuates considerably, but is greatest in the Australian summer, from October to February. The population of a settlement may then be in excess of ten thousand. Occasionally, from several hundred to tens of thousands of the more nomadic little red foxes will invade the camp of gray-headed foxes, at which time the population of a camp may be swelled to as much as 250,000 for a few weeks. Usually, however, the little red bats go to camps of their own species.

As the Australian autumn advances, the population of the camps in the Brisbane area dwindles rapidly, until by the beginning of June most camps are deserted. Where the bats migrate, and exactly for what reason, are questions that remain to be answered. It has been suggested that their movements are made largely in response to the shifting availability of food supplies. Around Brisbane, in the winter of 1962, there were unusually large numbers of blossoming eucalyptus trees. Although the bat camps in this vicinity are usually deserted in winter, one camp situated twenty miles outside the city then contained the largest population of gray-headed flying foxes ever recorded in the area—probably more than 100,000 individuals.

One researcher has remarked that visiting a flying fox camp is like skin diving, in that it is a visit to a totally foreign realm. But unlike the underwater world, where all is quiet, where the movements of flora and fauna are graceful and flowing, the daytime habitat of the flying fox is chaotic—a noisy place of erratic motion. The first indications that one is nearing a camp are a distant, high-pitched squabbling and a distinct, musky odor. A sudden rush of beating wings accompanied by startling shrieks tell the observer that he has reached the edge of the camp itself, and that the scouts, usually old males, have raised the alarm. If the site is not often disturbed by hunting parties with firearms, these alarm calls will have little effect. The visitor is soon in the midst of the pandemonium that is normal among flying foxes in camp. The branches of the trees are festooned with thousands of the animals hanging upside down in tight clusters, truly one of the amazing sights in the world of mammals. The trees often look as though a hurricane recently had passed through, for the masses of foxes hanging close together tend to strip off the leaves and small twigs. The camp is alive with the creatures' wingbeats and their continuous wrangling.

As an intruder walks farther into the camp, the bats react by climbing higher in the trees—moving along the trunks and branches with the aid of the long, curved claws on their thumbs and toes. When they have climbed to the highest point they can reach, they lean forward to observe the human interloper. Their noses twitch, their ears switch rapidly back and forth, and their large brown eyes perceive one's every move. The more "nervous" animals may take fright at this stage and fly away emitting shrieks. With care, however, it is possible to reach the center of a camp

Fruit bat climbs a tree trunk by pulling itself up with its clawed thumb, which is at first joint of the wing structure.

Female hangs from branch by one foot and scratches with the other. A nursing young is obscured by her right wing and fur.

vithout creating too much disturbance. If one then remains till, the bats that earlier took flight will return and resume heir normal daytime behavior.

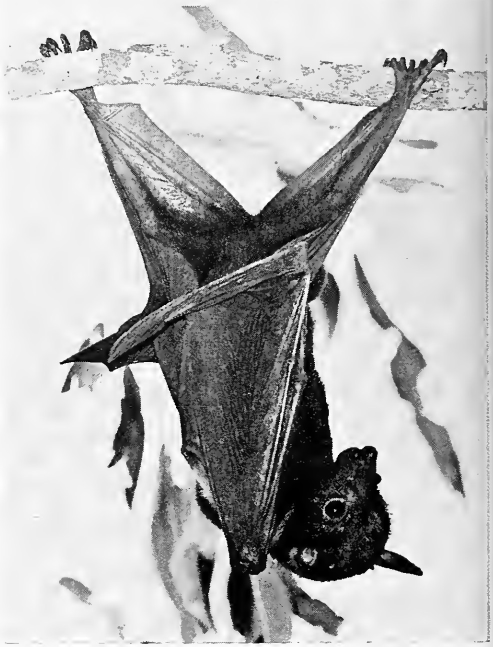
Although these mammals are assumed to rest during the lay, their activity is tremendous. There are always a few n the wing, and there is always a scramble in some corner f the camp. Such action usually has a simple cause—a alling branch or one bat alighting too close to another. Battles look and sound most ferocious. Fighting animals tter loud screams, while they lash out with the sharp, ooked claws on their thumbs, and snap at each other with heir equally formidable teeth. But I have never seen any ur fly, nor have I observed any other bodily damage as he result of these displays. "Fights" usually end when one r both foxes take flight and go elsewhere in the camp, vhere a similar display may be repeated. Sometimes a particularly pugnacious animal will chase another along a ranch, disturbing every other bat resting there. This may ouch off a chain reaction throughout the camp, and such vents are the principal reason for the continuous uproar.

Flying foxes have a number of ectoparasites that cause hem to scratch frequently and energetically; now and then oxes hang by one foot and comb themselves thoroughly vith the claws of the free foot. On a hot day, they use their vings as fans. Despite the daytime fighting, scratching, and anning, many bats are asleep. If the weather is not too ot, a sleeping bat adopts a most interesting posture, wrapping its wings tightly around itself. During rain, the animals lo not seek the protection of thick foliage; instead they employ their wings to enfold the body, one leg, and the head. The flying membrane extends to the ankles and, because it is oily, gives perfect protection against rain.

Two of the feet seen at left belong to a young nursing bat under mother's wing. Young are independent at three months.

Characteristic alertness shows on face of bat, *right*, whic grips branch with claw. Species prospers despite predation

Little red "flying fox." *Pteropus scapulatus*, seen below, is smaller than gray-headed bat, and migrates more erratically.



The take-offs and landings of the foxes in camp are intricate operations. A gray-headed flying fox cannot simply release its hold on a branch and flap away, as can a microchiropteran, because its body must first be brought into a horizontal position for take-off. This the flying fox accomplishes by beating its wings vigorously, while keeping its grip on the branch until its body has been raised into the proper plane. Landings vary from the very rough to the very adept. A bat may fly into leafy branches or a tree trunk with considerable impact, and then clamber to a limb to hang. Or it might fly low over a horizontal branch, brake, grip the branch with the claws on its feet, and then hang down. Another variation in landing entails the bat flying to a point beneath a horizontal limb, where it brakes, does a half-roll, then grips the branch with its feet, and subsequently hangs head down.

Male flying foxes carry sperm in the epididymis all year round, and will attempt copulation during any season. The females only respond during a period of about a month (usually April) in the Australian autumn. The young are born when the foxes reinhabit their summer camps in October. Even though offspring are well developed when born, they are incapable of immediate flight. Their first month is spent tucked under the mother's wing. Extra-curved tips on the claws of their thumbs and feet, and recurved milk teeth allow the young to keep a strong grip on the mother's fur and on the teats, one of which is located under each wing. After their first month, the young are left behind in the camp at night, although they remain with the mother during the day. Young foxes are able to fly at about two months, but it is not until they are approximately three months old that they venture from the camp to forage for themselves. The progenies of fruit bats are fully independent at four to six months, and sexually mature at about eighteen months. On occasion, though, we have seen six-month-old young carried by a flying female. In these cases, the young equaled about half the adult's body weight. Probably the adult female is better built for the task of carrying young during flight than is the male, for she has a longer forearm and therefore a greater wing area than a male of the same weight. In the wild, flying foxes sometimes may live to the age of four or five years.

Predators on the flying fox include the Wedge-tailed Eagle *(Uroaëtus audax)*, White-breasted Sea Eagle *(Haliaeetus leucogaster)*, Powerful Owl *(Ninox stenera)*, Lace Monitor, or Goanna, a large lizard *(Varanus varius)*, and the Carpet Snake *(Morelia argus)*. But none of these brings as much pressure to bear on the animals as does man, who kills great numbers each year. The species that suffers most is probably the little red flying fox, which, because of its erratic migratory habits, often settles close to human habitation. This is usually followed by an organized "shoot," with the result that thousands are regularly killed. Fortunately, many flying fox camps are situated within national parks, or in remote and inaccessible areas. So these mammals, in contrast to many of Australia's dwindling marsupials, are not now actually threatened with extinction.

Panax Schin-seng.

Man Plant's Return

inseng roots, once dug for export, grow again in forest

By H. Lea Lawrence

INSENG—*Panax quinquefolium*—a
r natural gold of the woodlands
e much sought and highly prized,
now drifted away from public
nory, just as have the trappers
hunters and mountain men who
med the forests in search of it. And
ess this herb, like some of its
nterparts around the world, should
ve valuable to modern medical sci-
e, it is likely that it will again
rish and multiply just as it did
rly 250 years ago when it was noth-
more than another woodland plant
nose who observed it.

is paradoxical, in a sense, that
should be the case, for seldom has
price of ginseng been higher than
today. Nor has the demand for
eng lessened; it is easily as market-
today as it has ever been. But the
ory and circumstances surround-
the plant in this country explain all
effectively.

or centuries the Chinese, who have
and still are the world's leading
s of ginseng, have valued this herb
medicinal, an aphrodisiac, and a
m. The Asian species—and it is
d only in two portions of the
d—is *Panax ginseng*, but it re-
bles the North American species
losely that it is difficult for a lay-
to distinguish the differences.
orians believe that ginseng's chief
ction for the Chinese lay in the
form, which is branched or bifur-
d, and bears a superficial resem-
ce to the human figure. Indeed, the
ginseng stems from two Chinese
ds that mean "man" and "plant."
any flower enthusiasts possibly
never seen ginseng in the wild,
with its comeback apparently as-
d, it may again become a common
dland plant. Ginseng, in the family
iaceae, is found in shaded, damp woodlands, often in valleys and under stands of big timber. It is a perennial, growing from eight to fifteen inches high and bearing three branches, on each of which are five ovate leaflets, pointed at the apex and rounded at the base. From six to twenty flowers are produced in a cluster on the fertile branch from June to July. Later in the season bright crimson berries appear. The first-year plant produces only three leaves, which sprout directly from the root. The second year the stalk generally bears four leaves, and may attain the height of eight inches. The third year the plant has the mature arrangement of three branches with five leaves on each, plus the fertile branch in the center.

After the first year, the plant sends up a stalk from the bud stem, which grows from the main root. At the end of the year, when the plant is killed by frost, a scar is left on the bud stem. The next year the stalk grows from the opposite side of the stem, and the scars show the plant's approximate age.

The story of ginseng in North America dates to 1714 when a missionary to China sent back a description of the "miraculous" root in the hope that a similar plant might be located in the northern woodlands. A search was instituted among fellow missionaries, and in 1716 Father Lafitau, a missionary with the Indians, found ginseng growing near Montreal. The roots were dried and prepared as specified and the herb was sent back to China. Not long afterward the word was received that the Chinese would readily accept *Panax quinquefolium.*

Following the missionary's discovery, the gathering and marketing of ginseng began in a small way, but it slowly gathered momentum and began to arouse more interest when it was found that the range of the plant extended from the southern part of Canada throughout the eastern United States as far south as Georgia and Alabama. Hunters and trappers, who spent all their time in the woods, began to dig ginseng as a seasonal enterprise, since its market value almost immediately surpassed the prices paid for other herbs, barks, and leaves then purchased for medicinal purposes. In the early days, it was no trouble at all to find ginseng in great quantities. A man could dig all he could carry out of the forest in less than half a day's time.

The first dealers in ginseng were the Chinese merchants located on the West Coast, and buyers throughout the nation purchased the herb from local collectors and marketed it through these exporters. Two reasons governed the Chinese control: first, it had to be properly prepared and dried before it would be accepted on the market in China; second, at that time the Chinese were somewhat prejudiced against doing business with foreigners, and the Chinese merchants in America were the only persons with whom the mainland Chinese would deal.

It is not unusual, either, that during this same period ginseng was employed rather extensively in American herb medicines. Two of the most widely known during the 1800's—"Seng" and "Ginseng Tone"—were highly recommended, even by many physicians of the time, although claims for their virtues never approached those that were made for some of the other botanical medicines of that day.

One physician, a Dr. McMaster of Michigan, described the plant as follows: "Ginseng is a mild, non-poisonous plant, well adapted to domestic as well as professional uses. In this respect it may be classed with such herbs as boneset, oxbalm, rhubarb and dandelion. The medical qualities are known to be a mild tonic, stimulant, nervine and stomachic. It is especially a remedy for ills incident to old age."

In referring to the Chinese faith in the herb, a *Materia Medica of the Confederate States* quotes a Dr. Healde who alludes to "their confidence in it

**TEENTH-CENTURY plate in German
of medicinal plants includes root,
that looks like a human body.**

as a restorative after great fatigue, an antispasmotic in nervous affections, in coma, and as an aphrodisiac. One hundred and twenty grains of the sliced root are boiled in a quart of water, and two ounces of the decoction, or twenty grains of the root in substance is employed."

ACTUALLY, there is no scientific proof that there is any medical benefit derived from the use of ginseng root, green or dried, or from the leaves or any other part of the plant. The best that can be said is that it can be used to make a licorice-like tea that is pleasant to the taste—if one likes licorice.

However, ginseng, along with other herbs and plants all over the world, has already been subjected to a certain amount of research in the constant quest for new and improved medicines. It is possible, although not probable, that ginseng might prove to have some beneficial qualities, after all, because in recent years other seemingly worthless remedies have come to play an important part in medical progress.

For instance, reserpine, a derivative of the plant *Rauwolfia serpentina,* or snakeroot, has been for several years a valuable aid in the treatment of high blood pressure and emotional disturbances. Strangely enough, the native medicine men of Asia had for centuries employed the roots of this plant to achieve similar purposes.

Digitalis, isolated from an old Shropshire brew that contained foxglove *(Digitalis purpurea)*, has long been a remedy for heart ailments—a use to which herbwomen also put it.

Mahuang, a Chinese herbal drug made from *Ephedra* spp., gave us the clue to ephedrine; colchicine, a gout medicine, is derived from the seeds and corms of autumn crocus *(Colchicum autumnale)* and is a medicine, legend tells us, that was used by the witch Medea; false-hellebore *(Veratrum* sp.*)* is the source of a root remedy for high blood pressure that was used by the American Indians; curare, long known to South American Indians, is a "miracle drug" used as an anesthetic, muscle relaxer, and in some cases as a drug for certain types of mental disorders; South American Indians' use of hallucinatory mushrooms led to the discovery of psilacybine; quinine, codeine, morphine, thebaine, and many others are examples of medical discoveries that were based upon research into herbal medicines and native "cures" from various countries.

Today, contemporary research into botanicals is moving ahead at a rapid pace, and drug companies and various scientific interests have teams of plant hunters probing all parts of the globe, and even under the sea, in search of new plants and concoctions that may lend clues to discoveries such as those already mentioned.

Should ginseng not become a "miracle medicine," the future of the plant seems secure. Ginseng hunting has declined tremendously since the 1930's, when it was often the mountaineers' only "cash crop," and locations formerly stripped bare of the plant are now showing new growth. The trappers and hunters are gone, and the mountain people have lost interest in the hunting of herbs since industries have moved into the foothills and provided employment and an economic stability that they have never previously known. The older people, many of whom were once the best herb hunters, now enjoy old-age pensions and welfare benefits that make work unnecessary in their declining years.

Dealers who have long purchased ginseng and other herbs say that traffic in these items is almost non-existent today, and even dried ginseng, which still commands a price as high as $21 per pound on the market, comes in, in lessening quantities each year. One buyer said that during the peak years, from 1920 through 1945, he bought from 1,200 to 1,500 pounds annually at one store. Today, however, only slightly over 100 pounds a year is purchased.

ONCE ginseng was an important enough export item to be listed separately by the Department of Commerce and Labor. Beginning with 1858, the first available listing, at which time the market price was $.58 per pound, some 366,000 pounds were exported. In 1868 the price had jumped to $1.02 per pound and the poundage to 370,000. By 1889 it was up to $2.33 per pound, with 271,000 pounds exported. Figures for 1902 show the price at $5.55 and the export total at 154,000 pounds. The last listed figure was in 1913, when the price was $7.50 and 221,000 pounds were exported.

Today the Department of Commerce groups ginseng with other herbs and does not classify it separately, but it can be safely assumed that under 100,000 pounds are exported annually,
and that some of this total comes f
commercial growers. Actually, c
mercially grown ginseng did not s
up on the market until the late 18
when the secret of successfully g
ing it in cultivation was discove
Once something was learned a
raising the plant, the ginseng indu
sprang up, and for many years w
stable enterprise. Like the huntin
wild ginseng, this industry bega
decline in the late thirties or e
forties, and now it has all but
appeared. Part of this was bec
cultivated ginseng brought a m
lower price on the market than
wild ginseng. The root grows m
more rapidly when cultivated u
optimum conditions. This, the Chi
felt, lessened the quality, and they
less eager to use it. (As to exactly
rapid growth was thought to be
eterious to the root is not known
cisely. However, there is no ques
that when roots of wild ginseng
sectioned, they show consider
more density and color than do
cultivated plants. In addition, the
plant is more fibrous than the c
vated variety.) Presently, cultiv
ginseng brings about a third the
of the wild root on the market.

THE herb hunters dug ginseng f
the time of its appearance in sp
through the fall, although autumn
conceded to be the best time, for
the root was larger. However,
hunting was competitive busines
one time, and leaving a patch of
seng in the woods was an open in
tion to the next herb hunter to d
up. Thus most "sang," as the m
taineers termed it, was dug wh
was first discovered. The green
was rinsed in water to take off th
cess dirt and then dried, either by
ing it in a stove or by tying it on s
and hanging it outside in the sun.
a season's collection was suffic
dried, it was taken to the neares
lage or town and sold to a deale
ually to the same person who bo
furs and hides and other produc
the forest from the woodsmen.

Nowadays the signs that adve
for "Furs, hides, roots and herbs
a rare sight, for the individuals
made their living from the forests
all but disappeared. While the an
they hunted and trapped for th
trade may not have made a come
in all instances, the plants they s
have begun to show recovery s

OOTS like one above were hunted by woodsmen, dried and ocessed, then shipped to the Orient by Chinese merchants.

MATURE PLANT has three branches, each with five leaves, *below*. Fertile, flower-bearing branch is in center, *above*.

PART II:

Old Africa's

"People of the Village"

MILIEU MAY ALTER HEALTH

by ARTHUR LEIPZIG

A FEW MILES from the Ethiopian border, in the bush country of southeastern Sudan, the Meban have long lived in near isolation from the rest of Africa and the world. Vehicles can reach this region only during the dry season, from November to May; throughout the rest of the year the surrounding swamps of the White Nile are impassable. Part I of this article (NATURAL HISTORY, April, 1964) introduced the work of Dr. Samuel Rosen, of New York City, who led three study expeditions into this country. I accompanied his most recent expedition in March, 1963, as photographer and observer.

Dr. Rosen's study of the Meban was begun in the hope of answering a question about the effect of aging on hearing—namely, to what degree is the progressive loss of hearing with aging a result of noise damage accumulated over a lifetime? If the Meban were found to live in a nearly noise-free environment, and if they preserved their normal hearing from youth into old age, this presumably could be important evidence to make a case for noise as the critical factor responsible for hearing deterioration.

The Rosen expeditions found that the Meban did indeed live in an almost noise-free environment—noise-free, that is, in relation to most contemporary situations. Measurements taken on noise-level meters in several Meban villages near Boing showed a mean level that was far lower than the noise of the average home refrigerator in the United States. There is, of course, virtually no automobile traffic in Meban country. There is no manufacturing and no metal industry. The sounds that one expects to hear in pastoral or agricultural settings are limited here because the tribe has few cattle and little other domesticated livestock. Cocks crow, certainly, but this and all other sound is damped by earth and foliage, whereas on and around many American farms the presence of reflecting surfaces, such as concrete, tends to multiply the noise of livestock, traffic, and machinery. The loudest sound we heard in the bush country came during the harvest dance, when there was considerable shouting, singing and playing of instruments.

Smudgepot smoke keeps mosquitoes from cattle near Meban village. Meban's hat and long shirt came from missionary.

Once the low level of noise in the environment was determined, the next steps were to select individuals to form a sample population, estimate ages, and conduct hearing tests that would permit comparisons with tested individuals in several cities in the United States, Europe, and Egypt. The test group included males and females, from prepuberty to advanced old age. They were gathered in the village of Boing by interpreters and other assistants, then transported by lorry to the test area outside the village.

In initial physical examinatio
expedition members found a few ca
of total deafness and some of hear
impairment, but all of these had
sulted from head injuries, diseases
congenital defects. Except in perh
five of the more than five hund
people in the study group, the teeth
the Meban were without caries.
many of them, the spleen and l
were slightly enlarged. However, so
disorders familiar in Europe and
United States, such as high blood p
sure, heart disease, duodenal ul
ulcerative colitis, acute appendic
and bronchial asthma were not fo
in the test group and apparently do
occur in the tribe. Judging by the
sence of heart disease and high bl
pressure, there probably is only sl
incidence of hardening of the arte
in the Meban population. Meban in
study were also examined by a p
chiatrist, Dr. T. Baasher, who ca
with the expedition from Kharto
the large, busy capital in the Sudan
north, where he had worked w
members of that city's growing po

Dr. Rosen's wife distributes gifts to the Meban examined by her husband.

Women, seen below with youngsters, are usually married by the age of 17.

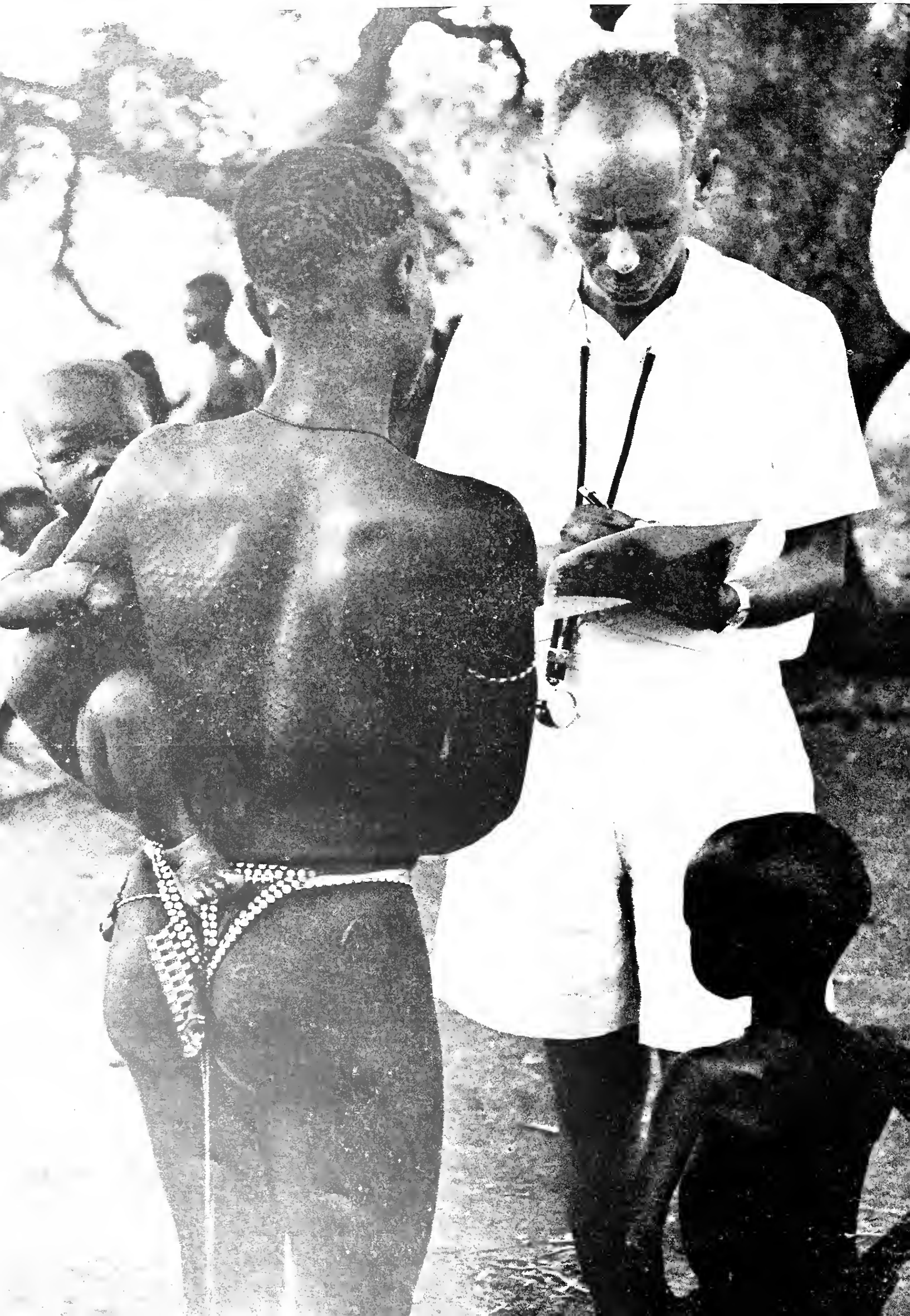
tion of Africans who had recently
ft their tribal lands. Dr. Baasher
und no evidence of maladjustment,
d noted no serious psychological
ress, which is in contrast to the condi-
on of those of the Meban who have
oved to Khartoum.

Despite what seemed to us a monot-
ous and unsatisfactory diet, the
ysical examinations revealed no
gns of malnutrition, or of vitamin or
otein deficiency. Meban are lean,
th well-developed muscles. And most
gnificant with respect to diet, electro-
rdiograms showed that the choles-
rol levels of these people are low. The
incipal food of the Meban is a fer-
ented gruel made of a locally grown
llet seed known as *dura*. Several
her products are made from this
ain, including bread and beer. *Dura*
ntains carbohydrates, very little fat,
d a small amount of protein. But the
eban diet is almost totally free of *ani-*
al protein. They rarely slaughter any
their few domesticated animals and
e limited in hunting by their prim-
ve equipment — handmade, curved throwing sticks and wooden spears.

Their common endemic diseases are malaria, dysentery, pneumonia, and pulmonary tuberculosis. There is a small incidence of venereal disease, occasional cerebrospinal meningitis, both yellow and typhoid fever, and ordinary childhood diseases, such as measles and chicken pox. For treatment of their ills, Meban rely heavily on witch doctors, although modern medicines and medical care are available through missions and the government.

SINCE the Meban have no written birth records, Dr. Rosen and his colleagues had to employ many devices to assess their ages. The tribal chief was present at all physical examinations and often provided information that helped with this problem. Besides the chief, the headmaster of the school was on hand and was able to assist with the children; in some cases, people could make comparisons with the known ages of offspring of Arab merchants who kept birth records. Dr. Rosen's team relied, when none of the above means was effective, on physical signs of age, such as the changes that take place at puberty, and the growth of teeth. In estimating the ages of adults the team's method was complicated, but probably accurate to within about ten years. Shortly after puberty, Meban boys begin courtship, which entails two or three years of working for the prospective father-in-law before marriage. Dr. Rosen and his colleagues estimated that the average boy married at about the age of nineteen, and the average girl perhaps at seventeen. The team assessed a Meban as forty years old by counting as nineteen the age at which he married, adding seventeen for the age when his eldest daughter married, and adding four for her three-year-old child. This system admits of error, of course, and any error would be considerably multiplied in estimating the age of the very old.

All subjects were classed according to age, then given the hearing tests. Researchers conducted the tests both outdoors and in a "rest house" pro-



fficer of the government mobile health
iit takes blood pressure measurement.

ded by the Ministry of Health.
und-level meters, placed near the test
sitions, registered continuous sur-
unding noise levels below 40 decibels
the C scale, which is approximately
e level of a barely audible whisper.
casionally, there was a noise-intru-
on made by a domestic animal in the
cinity. An interpreter gave instruc-
ons to each subject in the Meban
nguage, asking him or her to raise
hand on hearing a tone, keep it
ised, then to lower the hand when
e tone became inaudible.

HE results of these tests were signifi-
nt. They have shown that, compared
th recently studied groups in New
ork, Düsseldorf, Cairo, and a large
oup tested at the Wisconsin State
ir in 1954, the Meban do not suffer
drastic decline in their hearing abil-
during the process of aging. In
ch of the comparisons made, Meban
aring was especially superior in the
er years with respect to high-fre-
ency sound. As age increases, the
rcentage of Meban who hear tones
12 to 24 kilocycles per second grows
gher in relation to other study
oups of the same age, until in the 70-
79-year-old age bracket, 53 per cent
spond to tones of 14 kc., compared
2 per cent of those in New York,
isseldorf, and Cairo.

Since the inception of the Meban
idy in 1961, information on the per-
ption of high-frequency sound has
en gathered by Dr. Rosen's team in
rious places around the world, in-

ore examination, a young mother is
rviewed by Dr. Halim of Khartoum.

Dr. Rosen gives high-frequency ear test. Meban listens through headset to tone that is regulated by doctor and raises hand when sound is audible.

Cardiologists perform one of many heart tests given to the study group. Doctors discovered that heart disease is nearly non-existent among Meban.

cluding the above-mentioned three cities. Research on the Meban at first seemed to emphasize the importance of the quiet environment to their hearing retention. But there subsequently emerged a much more complex picture of the critical factors affecting the tribe's hearing. For instance, the blood pressure readings of the Meban were compared with the same type of data, compiled by insurance companies as well as medical institutions, on healthy adults in the United States and Europe. The differences were striking. The blood pressures of the Meban remain almost constantly low from childhood to old age, an ideal circumstance. In United States and European urban populations, blood pressure increases progressively with advancing age, especially after forty.

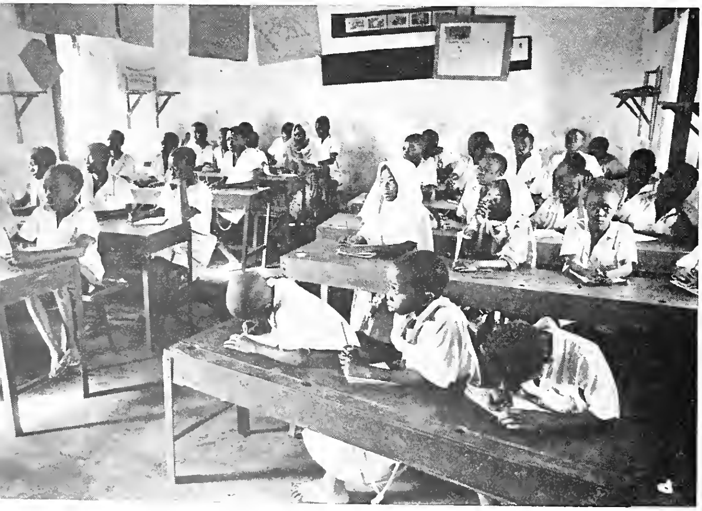
Another interesting contrast is that blood pressure readings were found to be consistently lower in Meban men than in women. Dr. Rosen believes, on the basis of estimated ages, that the men of the tribe generally outlive the women. Insurance company statistics show that the opposite is the average in the United States, where the blood pressures of men are higher than those of women up to about age forty-five, after which the pressures of the women become greater. In the New York test group, a correlation between a rise in blood pressure and decreases in high-frequency sound perceptions has been conclusively demonstrated. And, significantly, this contrasts sharply with the constancy of both blood pressure and high-tone hearing in the aging Meban.

As a result of the work with the Meban and follow-up studies conducted by Dr. Rosen's team in New York, Düsseldorf, Cairo, in a remote region of Finland, and on the Dalmation coast of Yugoslavia, a correlation linking high-frequency tone perception to blood pressure and heart ills now seems almost definitely established. Moreover, the work to assemble this picture seems to have led to a possible major medical breakthrough entailing the use of high-frequency hearing tests to diagnose incipient heart disease.

As recently as the fall of 1963, Dr. Rosen conducted studies of the aforementioned two sample populations in Finland and Yugoslavia. The Finnish group has long been known to have a very high coronary rate, while the tested Yugoslavs have one of the lowest rates of heart disease in the world, nearly comparable to that of the Meban. The ear tests showed that the Yugoslavian test group had far better hearing in the high frequencies than the Finnish test group.

With the information from these recent studies, Dr. Rosen and the members of his expeditions have conclud
that noise damage is doubtless a pro
inent factor in explaining poor hig
frequency perception among the agi
but that other influences probably pl
an even more significant role. The
more critical factors would appear
be such things as vascular hardeni
as well as diet, nutrition, tissue chang
in the middle ear and, in many
stances, the irritations of city life.

But all these variables, Dr. Ros
believes, are undoubtedly interrelate
For according to Dr. Abdul Moham
Halim, the Chief Internist of the Kha
toum Civil Hospital, the Meban
come prone to high blood pressure a
coronary thrombosis if they emigra
to Khartoum. There they are expos
to a new diet, in addition to the te



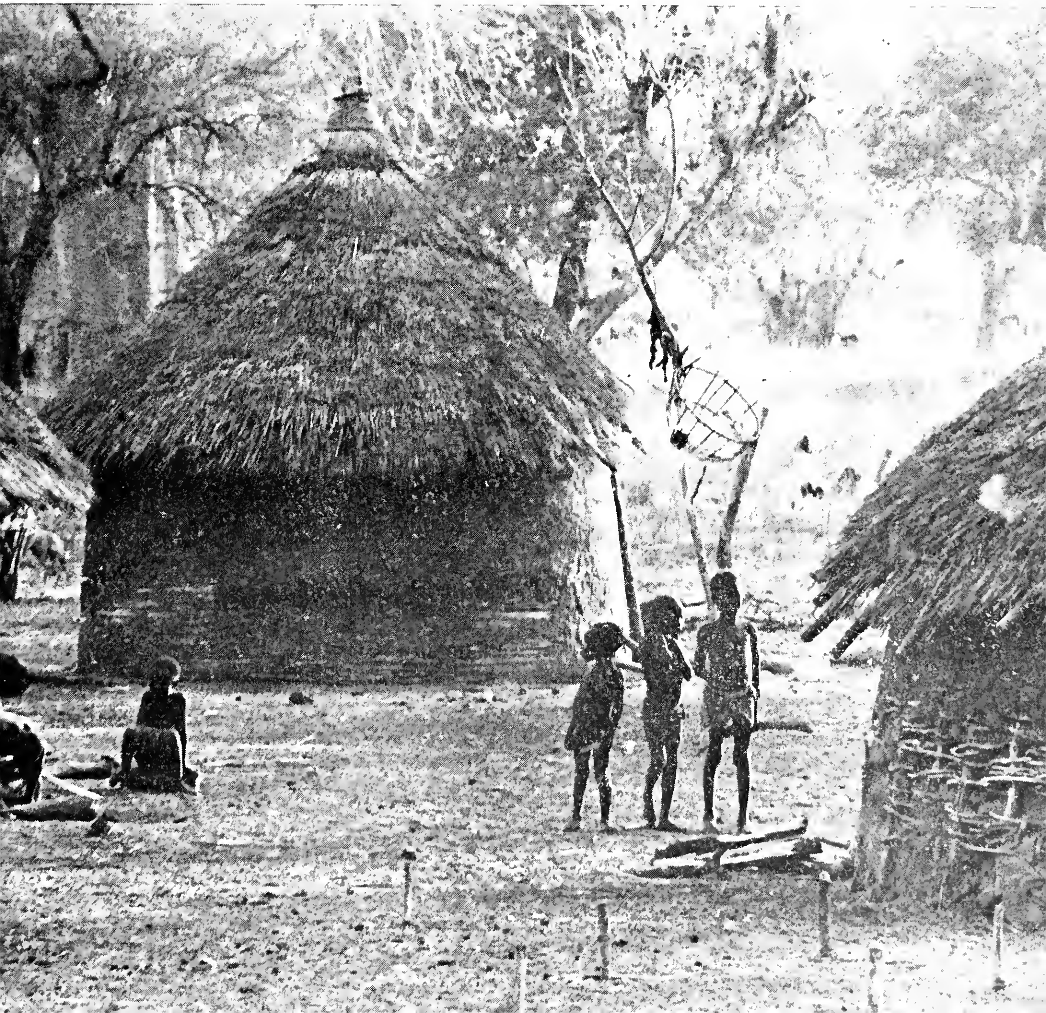
Both boys and girls convene in this classroom. Entrance to higher grades is limited to boys who show a high I.Q.

If the village children, *right*, stay with tribe, they escape the illnesses of the Meban who go to dwell in Khartoum.

ons of urban life, and, according to r. Baasher, they often experience ychological problems. When the eban also develop high blood pres- re, concomitant hardening of the nall blood vessels to the internal ear ay cause high-frequency hearing de- iencies that are normal to the aged European and American cities.

HE picture that finally emerges from e work with the Meban and related udies is a broadly interesting one. is, according to Dr. Rosen and his lleagues, a picture of delicate inter- lationships that exist among the ibe's physiology, its culture, and its tural environment. It may seem sur- ising that even psychological aspects of the Meban way of life—the absence of stress, for example—contribute to their general condition in such a way as to influence indirectly the ability to perceive high-frequency sound. Nonetheless the Meban study, at first viewed only as a study of the human ear, did eventually require the help of Dr. Baasher and other men trained in the behavioral sciences, with perspectives other than those of ear specialists, physiologists, and cardiologists.

In a recent summary of his Meban study, Dr. Rosen has written: "Might not the stress and strain that afflicts modern civilized man somehow affect all his senses? It obviously does affect his hearing. The relatively slight decrease of Meban perception in the high tones in old age, the constantly low blood pressure from childhood to old age, the almost total absence of tooth caries, the virtual absence of hypertension, coronary thrombosis, ulcerative colitis, duodenal ulcer, and bronchial asthma, all too common in our country, would suggest that these afflictions result in good part from the diet and tension-ridden mode of life in modern civilization." And, indeed, to reinforce this conclusion we have the experience of Drs. Baasher and Halim in Khartoum that the Meban lose their marvelous "immunity" to these ills when they go north to the cities. At present, a scientist remains with the Meban in their villages, making a study of their diet, and in the future, more men will go there and elsewhere to expand the scope of the inquiry.



CRESCENT VENUS, top right, is seen with the crescent moo

SKY REPORTER

With a simple telescope Galileo mapped the true orbit of Venu

By THOMAS D. NICHOLSON

THIS YEAR, the 400th anniversary of Galileo's birth (February 15, 1561), Venus goes through some changes in our sky similar to the ones that convinced Galileo that the sun, and not the earth, was the center of planetary motion. Anyone with a small telescope can easily repeat Galileo's observations by following the changes Venus goes through in the months ahead.

When Galileo looked at Venus through a telescope for the first time, in the year 1610, he was surprised to see that it did not appear disk-shaped, as did the other planets. Instead, Venus appeared in the form of a crescent. As he watched the planet over the months, however, its appearance changed gradually. The crescent reversed itself, then changed to a quarter-phase, a gibbous phase, and eventually the planet entered its final phase—round and bright, lik the full moon. As it changed its shape, the planet als changed its apparent size and brightness. Venus, Galile noted, was brightest in its crescent phase, when it appeare six times larger than when it resembled the full moon.

Galileo easily deduced from these changes that Ven had to revolve around the sun, rather than around th earth as astronomers had believed since ancient time Only if Venus revolved around the sun, he pointed ou could it change its shape, size, and brightness precisely i the manner that he had observed.

An interesting story is told by the historian Arthu Koestler in his book *The Sleepwalkers*, relating to Galileo announcement of his discovery of Venus' phases. Co.

ed lest the priority of his discovery be questioned, yet
vishing to reveal it himself as yet, the great astronomer
lated an anagram in which his real message was
en. The anagram read, in Latin, "Haec immatura a
am frustra leguntur oy," which Koestler translates as
se immature things I am searching for now in vain."
, of course, was not Galileo's true message. The letters
e anagram, when suitably rearranged, also form the
ls "Cynthiae figuras aemulatur mater amorum," or
mother of love [the planet Venus] emulates the shapes
ynthia [the moon]." This explanation was later re-
d by Galileo himself.

IE anagram reached, among other persons, the great
German astronomer Johannes Kepler, discoverer of the
of planetary motion. Kepler, according to Koestler,
several rearrangements of the letters of the anagram
attempt to discover Galileo's true meaning. Among
er's solutions was "Macula rufa in Jove est gyratur
em, etc." This is translated by Koestler to read "There
red spot in Jupiter which rotates mathematically."
a marking—the Great Red Spot—was actually dis-
red on the planet Jupiter in 1878, and has been ob-
d up to the present time, rotating with the planet.
this was over two centuries after Kepler's suggestion.
e was no way in which Kepler could have known
t it, or for that matter, even that Jupiter itself rotates.
coincidence, for it must be that, is most remarkable.
small telescope would be superior to the simple instru-
ts Galileo used. Venus is bright enough so that large
s or mirrors are not needed. Great magnifying power
so unnecessary; the most powerful telescope Galileo
had a magnifying power of no more than thirty
eters. Small terrestrial telescopes, such as those used
ature observers, are sufficient. In fact, the crescent
e of Venus can be seen with binoculars, if they are
died against a wall or on some sort of rigid support.
he table on page 48 gives useful information for those
might like to follow the changes in Venus this year,
ther by casually observing the planet with their eyes
e or by observing it more formally with some optical
stance. The table gives the date and hour (EST) for
of the planet's configurations this year, and certain
sical data concerning the planet at each of those times.

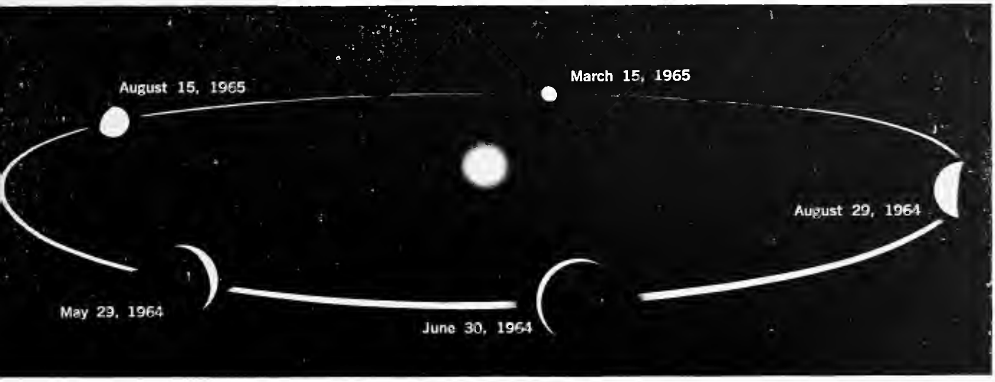
The elongation given in the third column is the angular distance from the sun to Venus as seen from earth, measured from the sun toward the eastern horizon. After inferior conjunction on June 19 it is measured toward the western horizon. While the elongation is easterly, Venus will be an evening star, setting after sunset (the relationship "easterly-evening" makes this easy to remember). When the elongation is westerly, Venus will rise before the sun and be a morning star in the twilight before sunrise.

The fourth column gives the distance from the earth to Venus, showing that the planet is closest to earth at the time of inferior conjunction, when it passes very nearly between the earth and the sun. The apparent diameter of Venus, as seen from earth, is given in the fifth column and clearly reflects the changing distance between Venus and the earth. The greatest angular diameter of the planet, near the time of inferior conjunction, is almost one minute of arc, or very nearly one-thirtieth of the apparent diameter of the moon and sun.

Column six gives the phase of Venus. This is the percentage of the planet's illuminated disk that is visible from earth. From April 11 until inferior conjunction, the crescent phase of Venus resembles the phases of the moon from new to first quarter. In going through these phases, the moon, of course, waxes from the earliest crescent to first quarter, but Venus wanes from the quarter-phase on April 11 to the smallest crescent at conjunction.

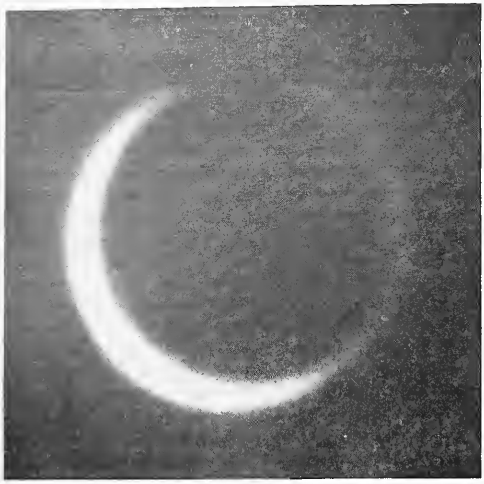
The phase at conjunction is given as zero, but a small part of the illuminated disk of Venus is actually visible even at conjunction because of the inclination of Venus' orbit to the plane of the earth's orbit. Because of the inclination (3.4°), Venus can be separated from the sun at inferior conjunction by as much as four degrees, and part of the sunlit portion of the planet can be seen at the upper or lower limb of the planet. At inferior conjunction this year, Venus is located nearly two degrees below the sun. The actual phase of the planet at conjunction this year is 0.1 per cent, not quite zero.

It is interesting to note, however, that Venus is always brighter at inferior conjunction than would be indicated by the phase alone. The bright cusps (horns) of the crescent extend much farther around the planet than is indicated by geometry alone. At times a complete halo of light can be seen around the dark side. This is caused by the refraction



GRAM SHOWS configurations of Venus in 1964 and 1965. observing similar changes in the brightness, size, and shape of the planet, Galileo reached the conclusion that Venus must revolve around the sun, rather than the earth.

Dr. Nicholson is Assistant Chairman, Astronomer, and a lecturer at The American Museum-Hayden Planetarium.



As venus lies in inferior conjunction, the faint ring visible around it is twilight in the planet's atmosphere.

of sunlight through its atmosphere and provided astronomers with the first evidence that Venus, like the earth, has a rather dense atmosphere.

The last column in the table indicates the brightness of Venus, expressed as its stellar magnitude ("Sky Reporter," January and February, 1964). Notice that the times of greatest brilliancy do not occur when Venus is nearest the earth (inferior conjunction) or when the greatest phase occurs (superior conjunction—which will occur next in April, 1965). These two factors, distance and phase, are both involved in the brightness of Venus. The closer Venus is to the earth, the brighter it is. But also, the closer it is, the more the illuminated surface is turned away from the earth, reducing the observed brightness of the planet.

Because the apparent brightness of Venus is the combined result of distance and phase, two points of greatest brilliancy are observed during the period Venus goes through its configurations. One of these points occurs about five weeks before inferior conjunction (when the planet is approaching earth but the phase is diminishing), and the other occurs about five weeks after inferior conjunction (when Venus is receding from earth but is growing rounder).

The table shows that Venus is at greatest brilliancy on May 13 and again on July 26 of this year. Note that the brightness on April 10 (—4.0) is the same as on May 29, although on the former date Venus is nearly twice as far away. According to the inverse square law of radiatio Venus should be four times brighter when its distance reduced by one-half. But note also that on May 29 see just 13 per cent of the illuminated surface of the plan —about one-fourth of the illuminated portion visible April 10. Thus the brightness of the planet is very near the same on the two dates.

When Venus is at its greatest brilliancy, the planet c be seen in the daytime even without the assistance of opti This, of course, is known to most navigators, who regula depend on daytime observations of Venus. It helps a gre deal to know where to look; one way is to use the cresce moon as a guide. On May 14, at 11:00 A.M., EST, the mo and Venus are in conjunction, and Venus is about fo degrees (or eight lunar diameters) north of the moon. T searching for the planet in the vicinity above the moon that day—with binoculars, if available, to make it easi Then, after locating it try looking with your eyes alone.

Another aid in finding the daytime position of the pla is to know the exact time of meridian passage—the ti when the planet is bearing due south. The local civil ti of meridian passage for Venus is 3:00 P.M. on May 2:50 P.M. on May 10, 2:30 P.M. on May 20, and 2:00 P. on May 30. Look high up in the skies about those tim toward the south and about five-sixths of the way up fro the horizon to the point overhead. Again, binoculars he

Venus will fade rapidly in early June as conjuncti with the sun approaches. It will also be disappearing fr the evening sky, since its retrograde (westerly) motion w take it rapidly toward the sun, thus causing it to set earli each evening. At conjunction, on June 19, Venus and t sun will set together. Then Venus moves west of the s and becomes a morning star.

By early July, it should be easy to observe Venus the morning sky shortly before sunrise. It will gr brighter once again as more of its illuminated porti becomes visible from earth. The phases of Venus in t morning sky resemble the phases of the waning mo although again the order of the phases is reversed. In Ju Venus will resemble the late crescent moon. By August the crescent will have grown to resemble the last quart moon, and in September Venus will appear like the wani gibbous moon. For about two weeks before July 26 (wh Venus reaches greatest brilliancy in the morning sky) a for at least a month afterward, it will again be possible see the planet during daylight hours with binoculars—ev with the unaided eye—as it precedes the sun across the sk

CONFIGURATIONS OF VENUS — 1964

DATE (EST)	CONFIGURATION	ELONGATION (degrees of arc)	DISTANCE FROM EARTH (miles)	APPARENT DIAMETER (seconds of arc)	PHASE (per cent of disk area)	BRIGHTNESS (magnitude)
April 10, 4:00 a.m.	Greatest elongation	46° E	65,400,000	23.6"	51%	—4.0
May 13, 2:00 p.m.	Greatest brilliancy	40° E	42,200,000	37.0"	27%	—4.2
May 29, 1:00 a.m.	Stationary	29°E	32,600,000	47.4"	13%	—4.0
June 19, 6:00 p.m.	Inferior conjunction	0	26,000,000	58.1"	0	—2.7
July 11, 6:00 a.m.	Stationary	29° W	32,500,000	47.5"	13%	—4.0
July 26, 11:00 a.m.	Greatest brilliancy	39° W	41,400,000	37.3"	27%	—4.2
August 29, 5:00 a.m.	Greatest elongation	46° W	64,800,000	23.8"	50%	—4.0

HE SKY
MAY

Quarter	May 4,	5:20 P.M., EST
Moon	May 11,	4:02 P.M., EST
Quarter	May 18,	7:42 A.M., EST
Moon	May 25,	4:29 A.M., EST

TIMETABLE

May 1	10:00 P.M.
May 15	9:00 P.M.
May 31	8:00 P.M.

(Local Standard Time)

ay 4: The Eta Aquarid shower of meteors reaches maxi-
n this evening. The radiant is well up in the southeast by
0 A.M. on the 5th, but the bright last quarter moon will
rfere with observations.

lay 6: Saturn should be easy to find this morning. It is
onjunction with the moon at 3:00 A.M., EST, and it rises
ut a half hour earlier into the predawn eastern sky slightly
ve and left of the crescent moon.

lay 9: Mercury is stationary in right ascension and re-
es direct motion.

lay 13: Venus reaches greatest brilliancy (—4.2 magni-
e) in the evening sky.

lay 14: Venus and the early crescent moon are in con-
tion at 11:00 A.M., EST. This evening, the brilliant Venus
ears to the left of the three-day-old moon.

lay 19: Mars and Jupiter are in conjunction at 2:00 P.M.,
. They are quite close in the morning sky for a few days,
they rise rather late to be visible easily.

lay 24: Mercury is at greatest westerly elongation from
sun (25°). The planet may be seen in the morning sky,
not easily, for this is an unfavorable conjunction.

May 25: Mercury and Jupiter are in conjunction at 9:00 A.M., EST. Both planets are quite close to the sun, barely above the horizon at sunrise.

May 29: Venus is stationary in right ascension and begins retrograde (westerly) motion. It is now moving rapidly toward its conjunction with the sun in mid-June.

Venus is the only planet very brilliant in the west for about three hours after sunset until midmonth. Toward the end of May, it is approaching the sun rapidly and setting earlier by about four minutes each evening.

The other naked-eye planets are morning stars this month, but only Saturn is easily observed. It can be seen in the east for about three hours before sunrise.

For several mornings about the 25th, when Mercury is at greatest westerly elongation, Jupiter, Mars, and Mercury are very close to one another above the eastern horizon for about an hour before sunrise. Observers should see Jupiter (—1.6 magnitude) first. A first-magnitude object to the right and lower than Jupiter (on the 25th) is Mercury, and another—slightly orange in appearance—to the left and below Jupiter is Mars. Binoculars will help in finding the two fainter planets.

The Monarch's Emergence

Each step vital as butterfly sheds pupa

By Alexander B. Klots

Newly hatched caterpillar feed on the underside of a milkweed lea

We in North America are extremely fortunate in having among us one of the world's most interesting butterflies. Primarily known as the world's champion long-distance migratory butterfly, the monarch (*Danaus plexippus* Linnaeus) is also notable for its ability to defend itself against enemies by employing a poison chemical, a process not yet fully understood. In addition, the monarch is the chief partner with the viceroy *(Limenitis archippus* Cramer*)* in a classical case of mimicry, and presents an especially interesting life history and development.

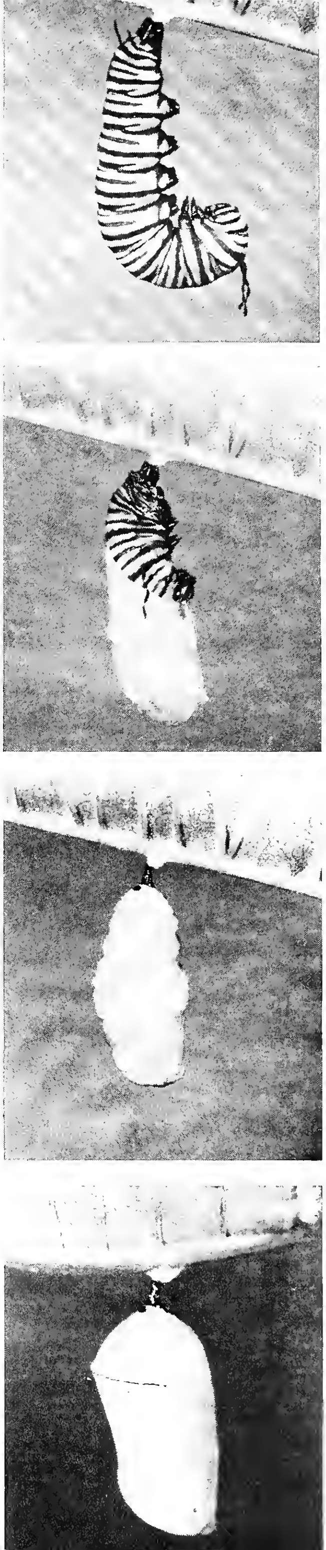
After wintering in Florida, Texas, or perhaps Mexico, the female monarch flies northward in spring to lay her eggs singly on the underside of milkweed leaves. In turn, females whose mothers were such migrants, may very well fly farther north to lay their eggs, so that the migration may extend far into Canada. In a few days of warm weather, the eggs hatch and the tiny caterpillars begin feeding, at first merely gouging out the lower surface of the milkweed leaf, then biting through it. These feeding holes are helpful in locating the caterpillars, which at this stage are boldly marked with black crossbands and have a pair of short, black, threadlike filaments near either end. By the time the caterpillars have reached a length of about two inches, their color has become considerably brighter. The crossbands now are black and yellow and white, and the filaments have become proportionately longer.

While it would seem that their conspicuousness would make them easy prey for birds and other predators, it in fact provides added protection for the young caterpillars. Since, at this stage they apparently are extremely bad tasting or even poisonous, their bold colors undoubtedly serve as warning signs of their inedibility, thus giving them a high degree of immunity from predation. This, however, does not prevent "parasitic" flies and wasps from laying eggs inside the caterpillars, causing untold thousands of deaths.

If it escapes such hazards, the monarch caterpillar will molt four times and attain full size in about two weeks. It then prepares for its metamorphosis into a pupa, or chrysalis (as the pupa of a butterfly is called). First, it spins a thick silk pad that adheres to the lower surface of a leaf or twig. The caterpillar grasps this firmly with the last pair of its abdominal prolegs, then swings from it, head downward. In a few hours it begins to molt; the head capsule and body skin crack and peel off upwardly to expose the pupa. At the rear (upper) end of the pupa is a spike, the cremaster. As the last of the caterpillar's skin is molted, the pupa must engage the cremaster in the sil pad where many tiny hooks catch and hold the fibers. Thi is quite a trick, because the cremaster is *inside* the skin while the proleg hooklets are on the outside. Imagine you self hanging by one gloved hand and having to slip ou of the glove and remain hanging by your bare hand. Som how the pupa accomplishes this, then hangs free, support only by the cremaster. At first the pupa is wet, misshape and greenish yellow, but in a couple of hours it dries, be comes more compact, and changes to a lovely transluce yellow-green. There is also a raised ridge at the base of th pupa's abdomen with a number of small, bright gold spots The pupa now hangs for ten days to two weeks, with littl visible change. Inside, however, the structures of the adu butterfly are being formed and caterpillar structures ar being broken down. Through the transparent coverings c the wings, for instance, the rather meandering trachea or air tubes, can be seen straightening out to be replace by the firm, tubular veins that later will act as wing sup ports. During the last twenty-four hours of molting th bold, orange-brown, black, and white colors of the adu butterfly will be formed in its scales and hairs. Thus fo a while an exact miniature pattern of the wings show plainly in the pupa, signifying that the adult butterfly wi soon emerge. This usually seems to take place quite earl in the morning.

When all is ready, air and blood are pumped into th head and thorax, expanding them and cracking th lower part of the pupal shell. The butterfly first pushe itself through the crack, then, as it gets its legs out, pul with them until it finally emerges from the shell, wet an weak. The brand new monarch climbs to a support fro which it can hang, expand its wings, and harden its oute skeleton. In addition, the butterfly must straighten out th two slender half-tubes of its maxillae and fit them togethe to form the long, tubular proboscis, or tongue, throug which it will be able to suck nectar or other liquids. Whe properly assembled, the tongue is coiled like a watch sprin beneath the face. This immediate postemergence period both crucial and precarious in the life of the monarc Any undue disturbance may cause crumpled or misshape wings, or damage to other newly formed structures. If a goes well, however, the butterfly accomplishes these fin processes in relatively short time, and within a half hou to an hour the new monarch is ready to take off.

HER than serving as a disguise,
l crossbands remind predators that
monarch is a most unpleasant meal.



In series at right, caterpillar sheds skin and metamorphizes to pupa stage where butterfly structures will form.

Wing Pattern shows through pupa at top left, indicating that adult butterfly will soon emerge. Insect cracks the pupal shell, *lower le* and frees itself. Gradually wir expand and outer skeleton harde

About the Authors

Dr. Bernard Goldman, the author of "Bronzes of Luristan," is Associate Professor of the History of Art at Wayne State University's College of Liberal Arts. Dr. Goldman received his doctorate in ancient art and archeology from the University of Michigan, and he has traveled in the East as a Fellow of the American Council of Learned Societies. His scholarly works on Luristan have appeared in a number of archeological journals in the United States and abroad.

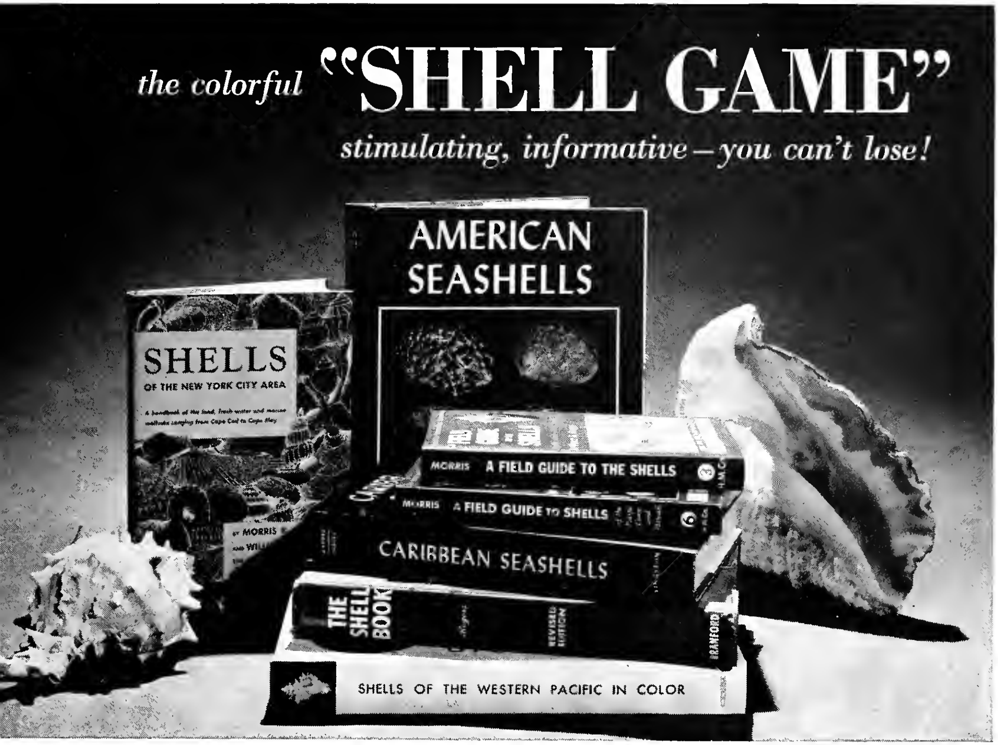
The discussion of the natural processes that cause the formation of stalactites and stalagmites is the work of Mr. Edward O'Donnell, Substitute in Geology at Queens College, in New York City. Mr. O'Donnell has worked as an Assistant Field Hydrologist with the U.S. Geological Survey, and in 1963, while with the Lamont Geological Observatory, he participated in Project Equalant, a survey of the tropical Atlantic.

Mrs. Kay Breeden, who wrote of Australian fruit bats under the title "Fructivorous Fliers," is a writer on Australian natural history subjects. The photographs that illustrate her article were made by her husband, Mr. Stanley Breeden, official photographer of The Queensland Museum, in Brisbane. Mrs. Breeden gathered material for her article during two years of periodic field observations, performed with the co-operation of the Zoology Department of the University of Queensland.

The fluctuating fortunes—in the wild and in the market place—of the herb ginseng in North America during the past two and a half centuries are chronicled in the article by Mr. H. Lea Lawrence. The author, who holds a degree in biology, is Chief of Public Relations with the Tennessee Game and Fish Commission. Mr. Lawrence was formerly a newspaperman, and his by-line has also appeared in several national magazines.

Mr. Arthur Leipzig, who concludes in this issue his article about the Meban tribe in the Sudan, has traveled widely in search of subject matter for camera and typewriter. A professional photographer, Mr. Leipzig spent several weeks covering Dr. Samuel Rosen's third expedition to the Sudan to assemble data on the Meban's unusual state of health. Dr. Rosen, a prominent New York otologist who is on the faculty of Columbia University's College of Physicians and Surgeons, offered invaluable assistance in summarizing the expedition's findings.

The emergence of a monarch butterfly is described by Dr. Alexander B. Klots, Professor of Biology at The City College of New York. Dr. Klots, who is also a Research Associate in The American Museum's Department of Entomology, is particularly interested in Lepidoptera.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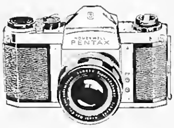

TRAVEL / FAR AND NEAR

The meteorite search

By D. Moreau Barringer

At the end of the last century it was known that meteorites occasionally fell out of the sky. But only a handful of men believed the larger meteorites left scars on the surface of the earth that could be observed and studied by geological methods. Among these was my father, Daniel Moreau Barringer, whose ideas on this subject have had a great effect on scientific thought. It was partly his persistence, in the face of apathy, opposition, and even ridicule, that brought about acceptance by the scientific community of the meteoritic origin of the great crater in northeastern Arizona that now bears his name.

A visitor approaching the Barringer Meteor Crater on the dry Arizona flatland sees first a gray, truncated hill that resembles a mesa. Made up of over three hundred million tons of rock and earth, the crater's rim rises more than 150 feet above the surrounding plain. The bowl of the crater is nearly a mile across at its largest diameter, and about three miles in circumference. The crater's depth is 570 feet.

For some unknown reason, the earliest discoverers of the crater called it Franklin's Hole. Indians had long been familiar with it; the Hopi tribe gathered finely powdered white silica at the crater and used this "rock flour" at their ceremonies. Around 1870, the crater was known as Coon Butte, although even at this comparatively recent date, few travelers had visited it. It was not until the last decade of the nineteenth century that a scientific investigation was made. Dr. G. K. Gilbert of the U.S. Geological Survey visited the crater and concluded that the hole had been formed by a steam or other gaseous explosion. Gilbert's team collected many meteorites from the site, but explained their presence as a coincidence. Gilbert theorized that meteorites had just happened to arrive at the exact moment of the explosion or perhaps had triggered it.

Shortly after the first investigation of the crater, the Atlantic and Pacific Railroad became interested in it as a possible mine site. Dr. A. E. Foote, a leading geologist, examined the crater for the railroad and confirmed the presence of meteorites. Although neither Foote nor Gilbert reported finding any trace of lava, obsidian, or other volcanic products, the scientific consensus at the end of the century held that "Crater Mountain" in all probability represented the last vestige of a once-active volcano.

In 1902, Daniel Moreau Barringer developed an interest in the crater controversy. My father was a consulting minin engineer and geologist of Philadelphia then at work in the Southwest. From th beginning, he believed the crater mus have been caused by a meteoritic impact. His reasoning was simple. Firs the crater was an unexplained hole in th ground; around it, on the same squar mile of land, lay thousands, perhap millions, of iron meteorites—more tha had been found in all the rest of th world. Since there are about 57 millio square miles of land on the surface o the earth, it seemed to my father tha the chances that the hole had been mad by meteorites were in the order of 5 million to one. Moreover, results of hi excavations showed that the meteoriti fragments were arranged, with respe to the terrestrial rocks with which the were found, in such a way that their a rival had to be simultaneous with th explosion that formed the crater. Th odds against a meteorite shower arri ing at that spot exactly at the time of natural disturbance, but not being r sponsible for it, were so great that would have been meaningless to hav calculated them. Thus my father looke for the buried meteoritic mass and fo more evidence to support his theory tha the crater had been caused by meteorit impact, a quest that occupied the la thirty years of his life.

Crater Floor Drilled

By the end of 1909, he had drilled 2 holes at the crater and had sunk number of shafts as well. Although th drilling and digging failed to uncov any large meteorites, the cores reveale that rocks from different strata we mixed together at depths more than thousand feet below the crater floor. Bu under that level lay the Supai sandsto in undisturbed layers. The crater, the could not have been made by a for from below, like a volcano.

In succeeding years, Daniel Morea Barringer pressed his attempts to u cover meteorites from beneath the flo of the crater. The most significant r sults came in 1919. The United Stat Smelting Refining and Mining Explor tion Company, following his instruction set up an eight-inch churn drill ne the center of the south rim, direct above the high point of the arched ro strata. At one thousand feet, the dr

tered obstacles that proved to be
tic fragments; the final discovery
rted in the log as follows: "The
drillman says he has drilled in all
f formations but has never en-
ed anything like this. From the
thed appearance of the drill bits,
s we must be passing through
of solid metal . . . started ream-
3:00 A.M. and at 11:00 A.M. had
only one foot. At 11:00, rotary
ng nicely when bit stuck in bot-
hole and stopped rotary." When
o free the bit failed, the hole was
ned, but the drill had reached a
f 1,376 feet and many pieces of
l meteoritic material containing
and platinum had been brought
e searchers, therefore, assumed
eir probe had reached the main
te cluster and was halted near
ing place of the greatest mete-
ass. Because of a heavy flow of
n subsequent shaft could not be
uch below water level. However,
y father died in 1929, it was with
ef that the approximately 1,300-
netration of U.S. Smelting had
his case. Since his death, of
the scientific community has
on the crater's meteoritic origin.
science of meteoritics has ad-
remarkably since my father's
in his day men characterized as
the idea of meteorite scars on
oday scientists avidly seek out
Perhaps the first step in recog-
neteorite craters that no longer
e craters was taken by Beals and
n, the Canadians who investi-
wo sites in Ontario that have
en accepted as meteorite craters
Paleozoic Age. In both these
nown as the Brent and Holleford
, the meteorites struck on an an-
recambrian surface and gouged
the typical circular shape. Both
then underwent extensive erosion
gely obliterated the rims. The
were also submerged beneath
ic seas that filled their cavities
liments. Later they were exposed
erial erosion as well as to gla-
and today can be discerned on
hotographs only as wide and very
circular depressions.
ypical underground structure of
ct crater, however, has been im-
ly established by core drilling
of these Canadian sites. It is clear
ne craters of larger size than
rringer Crater are filled, first,
hardened layer of breccia from
out of the target rocks; second, by talus from the crater walls; third by subaqueous rocks of much later date.

Since the work on the Brent and Holleford sites, at least half a dozen other areas in the Canadian Precambrian shield have been singled out for similar speculation. These include a six-mile circular bay on the edge of Reindeer Lake, Saskatchewan; two almost tangential circular lakes in Quebec (collectively called Clearwater Lake), each twenty miles or so in diameter; and the lake at the bottom of Chubb Crater on the Ungava Peninsula near Hudson Strait.

Coesite Provides Evidence

RECENTLY, by one of those fortunate coincidences that have often assisted research, a new silica form, called coesite after its discoverer, Loring Coes, Jr., has become a criterion for the recognition of meteorite scars. Coes, a scientist of the Norton Company, found that under a pressure of 20 kilobars or more, ordinary silica assumed a new and considerably denser form with a specific gravity of nearly 3. This density results from a tighter packing of the silicon and oxygen atoms than is found in ordinary forms of SiO_2.

Coesite remained a laboratory curiosity until two investigators working for the United States Geological Survey recognized, in samples of crushed sandstone from the Barringer Crater, the typical X-ray diffraction pattern of coesite. It has since been determined that an appreciable percentage of the crushed and altered sandstone that partially fills the Barringer Crater is coesite. Outside the laboratory, no known crustal process, including volcanic eruptions and nuclear explosions, produces pressures in the range of 20,000 atmospheres. The discoverers of coesite in the crater therefore reasoned that only the impact of a great meteorite could naturally develop such pressures on the surface of the earth. Subsequently, Stishov, in Russia, discovered an even denser form of silica (now called stishovite), with a specific gravity of about 4.5. It was reported to form under a pressure of 160 kilobars (later, I believe, revised to 120 kilobars). This is roughly eight times as great as the force required to produce coesite. Stishovite has been identified in very small quantities in material from the Barringer Crater. Coesite and/or stishovite also have been found in other craters, including a twenty-mile circular valley in Germany called the Rieskessel, and a lake area in Ashanti Province, Ghana.

It is now thought by some that South Africa's Vredefort Ring, a circular outcropping of sedimentary rocks fifty miles in diameter, is of meteoritic origin. Here it would appear that the removal of a large mass of crust caused by the impact

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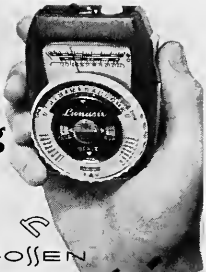
DREAU BARRINGER died in 1962.
article is based on a paper he
to the New Jersey Geological
y, and papers by him and N. S.
u in *Foote Prints*, journal of
ote Mineral Co., Philadelphia.



of such a gigantic meteorite allowed the liquefaction and intrusion of a quantity of deep-seated sial rock. The lower part of this solidified into granite; the upper part may have been a finer-grained intrusive or extrusive rock that erosion has since removed. The rim is also gone. Only the "roots" of the crater are left—a circular area of granite surrounded by radially dipping sedimentaries.

Other developments have also far surpassed the techniques used in my father's day. Dr. Robert Dietz, of the U. S. Navy Electronics Laboratory, has studied structures named shatter cones. Shatter cones have been identified in sandstone, limestone, and certain igneous rocks, but apparently also occur in any other rock of sufficient cohesion. A fractured surface of such a rock exhibits a series of intergrown and overlapping conical structures, with apices all pointing one way, and sides outlined by minor faulting. Shatter cones probably result from the violent shock wave accompanied by tremendous momentary pressure that radiates from a center of meteoritic impact. They would naturally be expected to occur below the crater formed by such an impact, and hence are not likely to be accessible unless the site has eroded to a great depth. But geologists have found shatter cones in connection with at least six formations—in Tennessee, Indiana, and Texas—hitherto called cryptovolcanic. Shatter cones have also been observed at the Steinheim Basin and the Rieskessel in Germany and the Vredefort Ring in South Africa. Only one doubtful specimen has been found at the Barringer Crater, which may be because erosion has not yet exposed the rocks that lay below the center of impact of that collision.

Scientists have searched without success for the presence of both coesite and shatter cones in craters at the atomic bomb testing site in Nevada. Apparently, the explosions were not of sufficient force to produce the tremendous momentary pressure required for the conversio quartz to coesite, or the intense sh wave that can create shatter cones. S larly, it would seem that infal meteorites cannot be smaller than a tain minimum size if they are to proc these effects. For instance, the Ari meteorite, which made a hole four t sand feet in diameter, was capabl producing coesite, but a meteorite fell at Odessa, Texas, and made a about five hundred feet in diame seems to have been too small.

Lost and Found Meteorites

THERE is another very large answered question with regard meteorite impacts—what has becom the meteorite? The opinion is widesp that any meteorite above a certain c cal size retains a large fraction o original velocity when it strikes ground; therefore the conversion of tremendous energy is sufficient to va ize both the projectile and part of target. The impact may spread the sulting vapor, which eventually reso fies, over such a wide area that fin the original meteorite would be im sible. This explanation has been g for the failure so far clearly to de the mass that made the Barringer Cr and for the unsuccessful effort to lo the mass under the main Odessa cr

Yet this theory runs into some rem able contradictions. Alongside the m crater at Odessa, Texas, a smaller cr some 75 feet in diameter, was discov by magnetometric survey. It was c pletely excavated. From its cente compact mass of about six tons of nic iron oxide was recovered. Moreo Peary's 34-ton meteorite from Green (now in The American Museum-Hay Planetarium), or the 85-ton Hoba m orite in southwestern Africa obvio did not volatilize; they are now her the earth in recognizable form.

Then too, we are faced with the

AT ITS LARGEST DIAMETER, the 570-foot-deep crater is ne a mile across. The bowl's circumference is three miles.

ound the Barringer Crater have und many thousands of solid iron tes that are probably pretty much ed from their form in outer space. f them may show a fusion crust outside, and most display the d Widmanstätten figures. This ine structure, first noted in 1808 s von Widmanstätten of Vienna, when a polished surface of me- iron has been etched. It has been trated that the structure is de- by moderate temperatures of F. or less. Clearly, the solid iron around the Barringer Crater did heated to anywhere near volatili- emperature.

her important difficulty in the the explosion hypothesis is posed tructure of the rim of the Barrin- iter. If the major crater-forming as that of an atomizing explosion, t should be accurately symmetri- ut a central point. An explosion ct equally in all directions and ar surpass the excavating effect notion of the meteorite itself. Yet metry of the crater is not radial a point, but is on either side of forming a north-south diameter. ructure is so clearly determined question of its origin must be ed before one can accept the hat the entire crater-forming ef- s due to an explosion. Further- the concentration of meteoritic l deep below the southern and stern portions of the crater floor e explained. The questions sur- g this subject can only be re- by thorough underground ex- n of one or more big craters, a at would involve an amount of not so far available.

most recent crater-forming me- fell on the Soviet Union, in the most province of Siberia, in 1947. eteorite either broke into a great ieces in the atmosphere, or con- originally of a cluster of small fragments. It gave rise to some 120 craters spread over a small area, the largest of them about 20 yards in diameter. The shower sprinkled the ground in between with thousands of iron fragments that apparently struck at a very moderate rate of speed. Although many of them showed signs of fusion and deformation in the atmosphere, they retained neither enough heat nor speed to char the wood of the trees they struck. Some were even found imbedded in standing tree trunks, with no sign of heat effect on the wood.

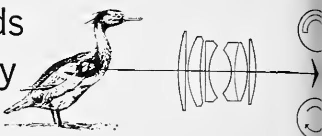
Can we forecast another dramatic fall like the recent Siberian one? Although the supply of large meteorites in the solar system may have been reduced radically over the earth's life span, I certainly think we can expect more large meteorites to drop in the future. Time and place, however, are completely unpredictable. And because two-thirds of the earth's surface is covered with water, a new meteorite is more likely than not to land in the ocean and leave no traces.

In discussing the Barringer Crater and related topics, I have not, of course, been able to mention all the advances in meteoritics that have come about since my father's early contribution, nor have I touched upon some fascinating subjects, such as tektites—the small lumps of siliceous glass thought of by some as spray or splash resulting from meteoritic impacts. But one of the most interesting historical facets of the science of meteorites is the Barringer Crater itself. To the crater come an increasing number of visitors. They inspect the museum on the northern rim, observe the crater bowl through the panoramic picture window, and the more ambitious of these meteoritic amateurs often hike the three miles around the crater's rim. Many descend to the bottom of the hole where Daniel Moreau Barringer began his lifelong exploration for the lost meteorite—where crater and impact research began, and the modern science of meteoritics took a valuable, exciting step forward.

ising 150 feet above the Arizona desert, is made up r three hundred million tons of earth and rock.

NATURE and the CAMER

Some simple methods for photomicrography



By David Linton

It seems these days that every well-equipped youngster has both a microscope and a camera. Mail-order catalogues and toy stores feature microscopes in many price ranges, and a number of families have found that even simple, inexpensive instruments can give valuable instruction as well as enjoyment. Often, the beginning microscopist would like to photograph his discoveries.

Photographing of microscope images is routine in scientific work; its correct name is photomicrography. (Microphotography means making photographs that are very much smaller than the subject, like a microfilm of a newspaper.) It is not too well known, however, that photomicrographs can be made with even the simplest of cameras.

The image in a microscope is formed exactly the same way as the image in a camera or that seen with a magnifying glass. In fact, a magnifying glass with a supporting structure is known technically as a "simple microscope."

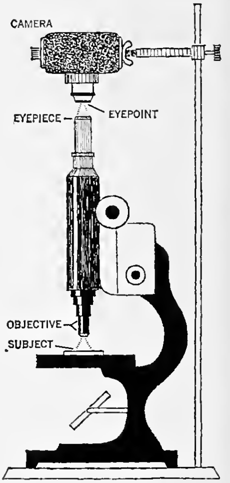
We know that objects will look larger when we are close to them than when we are far away, and that when we want to study small details of an object we "examine it closely" by holding it near our eyes. If we are taking a picture, we make it a "close-up." For both the eye and camera, however, there is a limit as to how close we can get to an object and still form a clear image. The magnifying glass allows us, in effect, to get even closer. We hold the glass near the object and examine not the object itself but its image formed by the glass. With the camera we get this result by using an auxiliary close-up lens slipped over the regular lens or, if possible, by bringing the regular lens closer to the subject with extension tubes or bellows.

The Compound Microscope

The magnification that can be obtained in this way is limited. To achieve greater magnification it is necessary to use two lenses—one to form a magnified image of the object and another to enlarge that image and project it where it can be seen by the eye or camera. Such an arrangement is called a "compound microscope," and it is used in the familiar laboratory instrument. An image of the subject is formed by the objective lens, especially designed to work very close to the subject and to produce a much-enlarged image. Th
image, although magnified, is still ti
and must be further enlarged by tl
ocular lens, or eyepiece, before it can l
viewed. The total magnification is tl
mathematical product of the magnific
tions of the two lenses.

It follows that the objective lens
the most important part of the optic
chain. Since the objective forms tl
original image, nothing that occurs fa
ther along, in the eyepiece or camer
can *improve* that image. But an ey
piece or camera that is of poor quali
or improperly adjusted may fail to r
produce all that is in the image. Sim
larly, the objective lens alone dete
mines the usable magnification. Tl
objective can discriminate details dov
to a specific minimum size, but its resol
ing power has a limit that is determine
by its design and quality.

When the image that it produces ha
been enlarged—by an eyepiece, camer
photographic enlargement, or any con
bination of these—the details that a
ready have been resolved by the objectiv
lens will become *larger* and may ther
fore look clearer. But enlargement ca
not add detail that is not in the origina
image. Enlargement beyond the resol



Ordinary laboratory stand may be use
as shown above to hold a simple camer
at the eyepoint of the focused microscop

LINTON's by-line has appeared
photographs in all the nation's
g magazines. His camera column
egular feature on these pages.

er of the objective lens is called
magnification."
naximum real, or "significant,"
ation of an objective lens can be
d if the characteristics of the
known. It is well to remember,
, that this figure refers to an
at is viewed at normal distances
king directly into the micro-
or example, or by looking at a
phic print held in the hand.
tograph is enlarged enough to
from across the room, or a slide
cted in an auditorium, the pic-
al magnification is not as large
measured size would indicate,
e picture is viewed at a greater-
mal distance.

Simple Cameras

a microscope is focused visu-
for comfortable direct viewing,
erver's eye sees the image as
it were some distance away. In
ords, the eye is focused at in-
he image can be photographed
most any camera that is also
at infinity and is placed at the
t." The eyepoint is the spot
e light rays emerging from the
of the microscope converge to
smallest point of light. With the
pe meticulously focused and the
rce turned on, the eyepoint can
d by holding a piece of paper
e eyepiece and moving it up and
ntil the narrowest point in the
found. The camera should be
o that this point is at the cen-
he front surface of the camera
regular laboratory ring stand is
convenient camera support. Not
ould the camera be focused at
but the lens diaphragm (if there
should be wide open. It cannot
to control the amount of light
the film, as in normal photog-
because the microscope lenses
en added to the system, and the
diaphragm is not in the right
the total array to control the
ition evenly. Closing the dia-
would result in cutting off the
f the image. Exposure is con-
by time alone.
it is the objective lens that de-
s the quality and magnification
mage, the camera lens has very
fect. A simple, slow lens of the
und on inexpensive cameras is
o work better than a more com-
ns because it has fewer glass
s and is less subject to the inter-
ections known as "flare."

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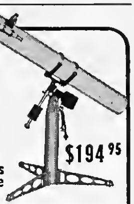

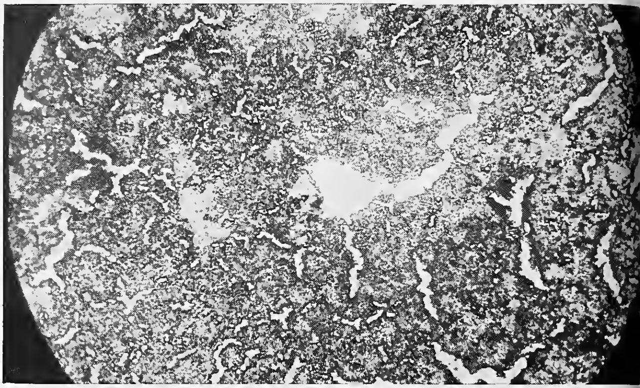

PHOTOMICROGRAPH of a yeast culture is easily obtai

Such an arrangement—a simple camera focused at infinity and placed at the eyepoint of the microscope—will give tolerable results with no special equipment or techniques. The main drawback is that the image may fill only a small part of the film frame and may be surrounded by the out-of-focus edges of the microscope field and a lot of empty space. The center area of the negative must then be considerably enlarged in order to produce a print that will look like the image seen in the microscope.

Specialized Cameras

THERE are other disadvantages. With the camera in this position, it is not possible to see the image that is being recorded. This makes it impractical to use this setup with moving subjects, and it leaves some doubt as to whether flare will be found when the film is developed. Cameras designed specifically for microscope recording have either a "beam splitter" that allows the image to be seen while it is being photographed, or a ground glass on which it can be examined just before the exposure.

A camera that has an interchangeable lens can be used with the lens removed to record the image formed by the microscope, and it can easily be placed so that the image will fill the film frame. For many such cameras, microscope adapters are available that provide a mechanical coupling between the camera and the microscope, a means of excluding room light from the camera, and, sometimes, a means of viewing the image. The popular single-lens reflex camera is very convenient because it has its own built-in viewing system. Another especially convenient type is a view camera (used without lens) that will accept Polaroid Land films as well as conventional films. With this instrument, photographic tests can be made and developed on the spot while the photography is proceeding: if sheet film is used for the final exposures, each negative can be veloped individually.

Determining exposure for photomi graphs can be difficult because ordin light meters cannot measure the bri ness of a microscope image. Until cently, one could determine the right posure only by making test shots, de oping the film, and picking the exposure. In such a series, each fr should receive twice as much expos as the preceding one. When the pho rapher has had some experience with particular microscope, camera, and l source, he will be able to judge expos for most subjects without having to peat the test series.

Some of the recently developed mium sulfide light meters are cap of measuring the brightness of the ac image on the ground glass of a cam a feat that was formerly achieved by highly specialized and expensive tronic laboratory instruments. One single-lens reflex camera has a cadm sulfide meter inside it to measure brightness of the image inside the era. It is ideal for microscope work least in theory. In practice, these me have limitations, but they are an provement over trial and error.

The photographer who graduates f the basic recording methods descri here to more complex photomicrogra will soon find that the problems in specialized field are not so much ph graphic challenges as they are probl of subject preparation and of light

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This list details the photographer, a or other source of illustrations, by p

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5—Joseph Sedacca
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Garden
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38-45—Arthur Leipz
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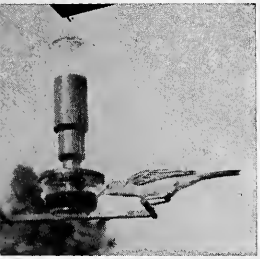

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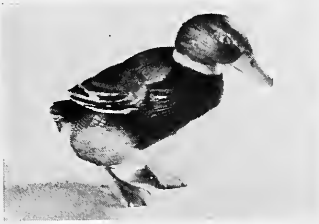

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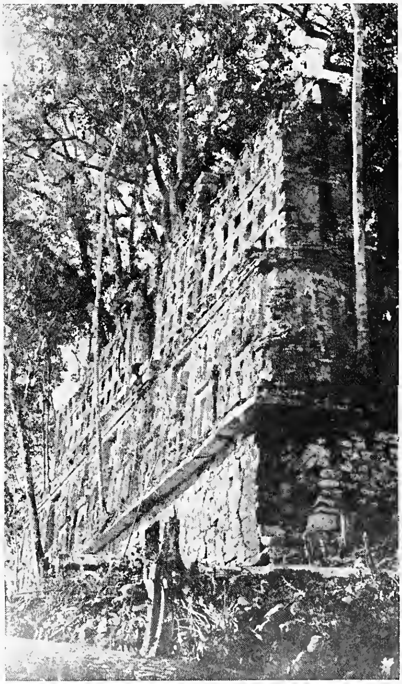

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They asked for help. They got help—from Kentucky's governors, legislators, congressmen. From service clubs, conservation groups, businessmen. They worked for years to arouse the nation; in 1941, their work was rewarded when Mammoth Cave became a National Park.

Now, it belongs to you, as it will to your children and their children's children. Exploring its fantastic caverns, coming face to face with million-year-old beauty, future generations will feel the same inspiration you feel today. They, too, will sense the force and majesty of Nature, and every man's need of her awesome wonders for bodily refreshment and spiritual satisfaction.

For man is a natural creature. He will always need Nature for his well being. But all the national treasures so far saved are not enough. We are a growing nation. Americans yet unborn must have opportunity to know the natural beauty of our land as our forefathers did. Like them, they must feel its challenge and reward, its promise and its fulfillment.

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Through his efforts, the Virginia Conservation and Economic Development Commission made a study. Local chambers of commerce helped. So did the Potomac Appalachian Trail Club. Some 24,000 Virginians pledged a million dollars. In 1927, Governor Harry F. Byrd signed a state appropriation for another million. And Shenandoah became *your* National Park.

Since then, our population has increased by 50 million. We need more Shenandoahs. We need more lands for outdoor recreation, so that more of our people will have the opportunity to know Nature's blessings and, through them, find refreshment of body and spirit. Everyone benefits from such conservation. That's why conservation is everyone's job.

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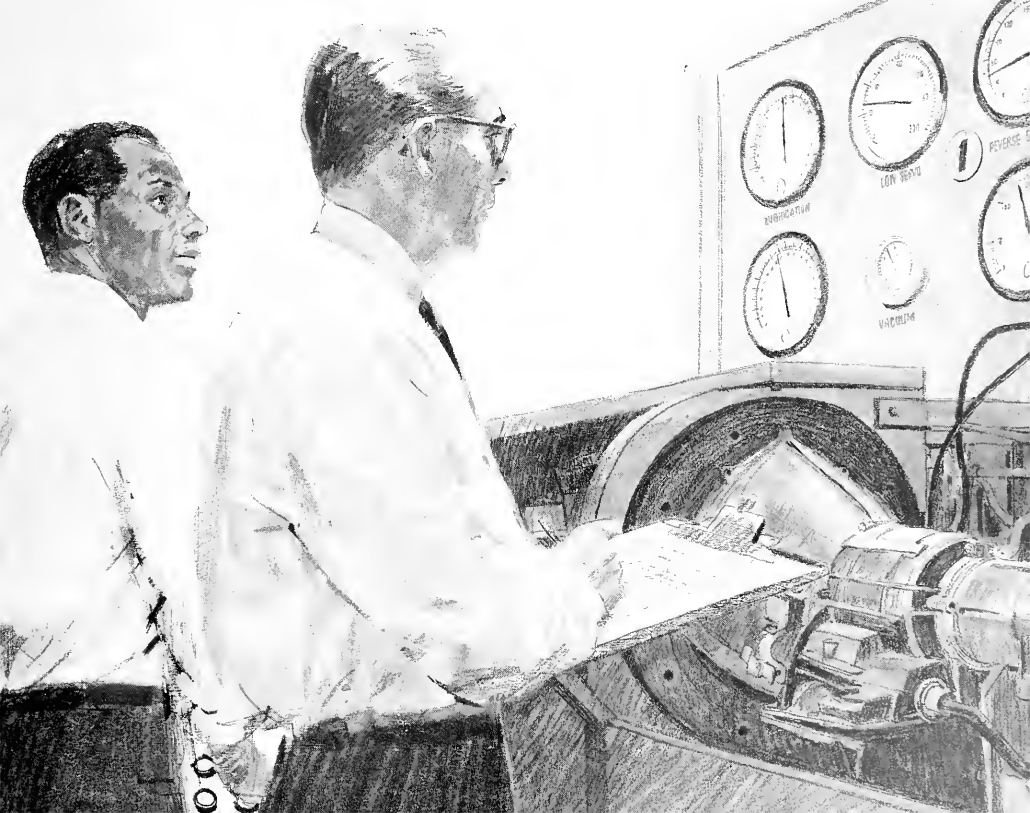

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DEPARTMENTS

COVER: When the remarkably moving paintings executed by Paleolithic n on cave walls in Spain and France (and, later, in the Sahara and vari other sites) first came to the attention of modern man, a new chapter in the st of prehistory began. Strangely, however, few people know that similar works e in our own southwestern United States; the one on the cover is on a rock shel in the San Emigdio Range near Santa Barbara, California. Mr. Campbell Gra author of the article that begins on page 32, is a student of these drawin He also took the photographs and made the paintings that accompany his t

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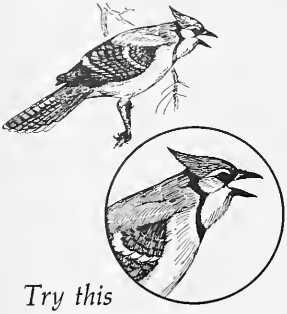

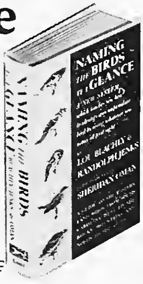

BOOKS / IN REVIEW

Science v. the humanitie

By George Gaylord Simpson

The Role of Science in Civilization, by Robert Bruce Lindsay. *Harper and Row, $6.00; 318 pp.* Science: The Glorious Entertainment, by Jacques Barzun. *Harper and Row, $6.00; 322 pp.*

The authors of these books are well-known pedagogues at sister institutions: Lindsay a professor of physics at Brown University, Barzun a dean and literary historian at Columbia University. The books have the same subject and are issued at almost the same time by the same publisher. Neither author mentions the other, although there is evidence on Lindsay's side that this is not due to ignorance. The points of view are completely different, and this in itself is enlightening as regards their common topic. The scientist treats the humanities with comprehension and appreciation. The humanist treats science with bias and disgust.

Lindsay's work is not organized or presented as a textbook, but it embodies the substance of one of his university courses. The style is clear and readable, but it is occasionally rather dryly didactic. One of Lindsay's main concerns is to discuss the interaction of science and the humanities. He recognizes that this has some negative aspects and also that it is rarely appreciated by scholars in the humanities. He strives to alleviate that antagonism by demonstrating the congruence and even, in some respects, identity of aims in the two fields. The quiet argument should convince almost anyone, although Barzun's book is evidence that some of the more rabid humanistic apologists are hopelessly irreconcilable. To a scientist also interested in the humanities, the only criticism is that Lindsay so greatly stresses the compatibility of the two that he almost loses the distinction between them. His definition of science tends to become blurred.

Lindsay then discusses more specifically the relationships of science with philosophy, history, and communication. Modern science necessarily impinges on formal philosophy and necessarily has a basis, usually less formal and often unperceived, in philosophy. The discussion of these interactions will be enlightening to any scientist, philosopher, or layman. Here and in some other passages it must be admitted that Lindsay's moderation becomes an almost excessive impartiality. The treatment of science and history is again excellent and can be highly recommended, but it does exhil another weakness, one common to t great majority of works on the natu philosophy, and history of science. T concentration is on physical science, a the other sciences are either ignored treated with bias and inadequate kno edge. The attitude toward history wou be quite different if the point of vi were that of one of the several scien that are themselves historical.

A chapter on science and communi tion includes semitechnical summar of acoustics, cybernetics, informati theory, entropy, and statistical lingu tics. The compression of all this, and bit more, comprehensibly into sixty-fo pages is a real tour de force and riches the book beyond the essentials its central theme.

The most important impacts of scien are not the most obvious. Lindsay h wisely devoted the greater part of book (about two-thirds) to these l obvious aspects. The most obvious asp is of course technological, and this h been discussed elsewhere at what m fairly be called oppressive length. Lin say's essay on the subject (in extre contrast to Barzun's book) is brief a is characterized by calm good sense. of course recognizes the distressing s effects of technological advance, but c cludes that, "The chief impact of t materialistic evolution brought about technology is simply a widening of h man experience."

A chapter on science and the st discusses, necessarily in somewhat g eral terms, the need for science (beyo technology) by governments, the ag cies set up for that purpose, and the i pact of increasing governmental supp for science. The relationship of scien to warfare is described, as well as t presence or absence of controls in s ence under public support—both in rather noncommittal way. It is perha enough at this stage to point out t issues do exist and to explain exac what they are. More could have be made of the fact, here mentioned alm in passing, that the enormous sums, p lic and private, spent for "research a development" go mostly to engineeri with technology second and science very poor third. The figures are wid understood as indicative of our supp of science, but less than a tenth of t stated sums goes for scientific resea in any reasonable sense of the wor

"I FELT A BRIEF SPASM OF PANIC..."

". . . with the male gorilla only thirty feet from me. Cautiously, I ascended a tree. Slowly, as if daring each other to come closer, the whole group of gorillas advanced toward my tree."

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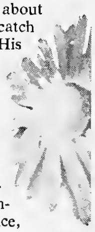

In fact we are *not* supporting science generously or even adequately.

Lindsay's last chapter is a very brief consideration of science and ethics. It is surprising to find an author hitherto so judicious and restrained supporting the outright bizarre notion of what he calls "the thermodynamic imperative" as a scientific basis for ethics.

Barzun's is decidedly the more interesting and readable of the two books. That is partly a simple matter of skill. Lindsay himself makes the point that scientists generally are not good at communicating in writing, and although he is better than most scientists he is not equal to a first-class littérateur like Barzun. Other reasons for the fact that Barzun's book is more entertaining are not really to its credit. It is witty rather than reasonable. It substitutes uncontrolled exaggeration and calculated misrepresentation for judgment. Lindsay is a scientist trying to evaluate a whole situation. Barzun is an artist reacting emotionally to a strongly slanted perception of a part of that situation.

Barzun's premise is "the proposition which thinking beholders no longer dispute: the life man has made for himself is not worth living." It is characteristic that he accuses other artists (literary, visual, and musical) of treason because they reiterate this proposition "to the point of nausea"—and that he makes this accusation in a book wholly devoted to that same reiteration!

Much of Barzun's book is devoted not to science but to technology, which he calls "techne" and which he considers an unmitigated horror. The significance of the book's title is that Barzun finds science diverting in a gruesome sort of way and that beyond that he considers it and its works completely pernicious. He lays about him with broad strokes and even roundly whacks his fellow artists (in all fields). With more than dubious logic he finds that their failure to follow his impeccable standards is all the fault of science. In short, this is just another of the too many humanistic attacks on science and, indeed, on rationality. Its only virtue is that it is cleverer than most.

There is little doubt that Barzun's book will be more widely acclaimed and read than Lindsay's. That is a bad omen for civilization.

Dr. Simpson who is on the staff of the Museum of Comparative Zoology and who is the Agassiz Professor of Vertebrate Paleontology at Harvard, was until 1959 the Chairman of The American Museum's Department of Geology and Paleontology. During his distinguished career he has written, among hundreds of publications, the classic "Horses" and "The Meaning of Evolution." His most recent book is "This View of Life."

HARNESSING SPACE, edited by Willy L
The Macmillan Co., $6.50; 314 pp., il

THIS volume is a handbook on rock
and artificial satellites. Willy Ley
been explaining these matters to the
initiated for forty years. Here he
collected all pertinent information ab
artificial satellites and the methods
launching them and has written a conc
introduction unifying the material.
the beginning of his book, Mr. Ley
tablishes a firm foundation for the und
standing of the material in a recital
the basic physical laws that govern
rocket and satellite activity. This is
lowed by a history of man's efforts
put satellites and himself into space.

After this beginning, *Harnessing Sp*
is a brief encyclopedia of rockets
propulsion systems, their fuels, meth
of launching, dimensions, and, in f
every detail of their operation. The a
ficial satellites that have already b
launched—or those we are preparing
launch—are described in the same det
The various more complex and am
tious projects, such as Project Merc
and Project Apollo, are detailed and
progress to date is outlined.

The last third of this book is a se
of appendixes and the titles descr
their purposes: "A Listing of U.S. Ro
ets with Space Capability," "Chronol
of Meteorological Satellite Even
"Chronology of Communication Satel
Events." The book closes with an ext
sive glossary of space terms and a lis
titles for further reading. Similar l
are given at the end of each of the v
ous sections throughout the book. Th
are a number of good photographs
well-made diagrams throughout the t

Harnessing Space should be of con
erable value as a quick reference bo
particularly for those whose work or
terest calls for a specialized knowle
of details in this field.

JAMES S. PICKER
American Museum-Hayden Planetar

MAYA ARCHAEOLOGIST, by J. Eric
Thompson. *University of Oklaho*
Press, $5.00; 284 pp., illus.

ERIC THOMPSON's name is well kno
to everyone who has looked into
subject of Maya archeology. He has b
one of the most productive schol
working in this challenging field,
witnessed by his more technical pu
cations such as *Maya Hieroglyp*
Writing, An Introduction, and his m
general work *Rise and Fall of M*
Civilization. The latter is undoubte
the best available introduction to
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In *Maya Archaeologist*, Thomp
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vating at Chichen Itza. In succeeding years he worked at many different sites and also spent several seasons with the primitive modern Maya in the forests of British Honduras to see what their customs might reveal of the life of the ancient Maya. These studies provide ample opportunity for reflections on many things—on the pains and excitement of the dig, on the life of a primitive people who still gesture and pose like the figures on the carved stones, and on the changes that have come about in the life of the native people and of the field archeologist with the encroachment of civilization.

The account is both erudite and charmingly humorous. For my part, I wish the author had told more of his work with Maya hieroglyphics and the calendar, for he made the greatest contributions in this area of Maya research. That, he would probably say, was mere "slugging" hard work in his study and of little interest to anyone, but certainly it would have more fully revealed the man himself. Despite this omission, I can recommend the book highly to anyone with an interest in Maya archeology or in archeologists—or both.

Gordon F. Ekholm
The American Museum

The Dolphin in History, by Ashley Montagu and John C. Lilly. *Clark Memorial Library, $2.00; 55 pp., illus.*

This little book consists of two lectures on the dolphin, one of which is primarily concerned with ancient Greek myths, and the other with a more recent fable. Both were presented at a recent symposium given at the University of California.

Ashley Montagu, in his essay, quotes liberally from Aristotle, Pliny, and other classical writers. Unfortunately, he gives credence to many superstitions and personifications of the dolphin, some of which are on the level of Reynard the Fox and Peter Rabbit stories. On such a basis, he concludes that dolphins intrinsically like people. A separate section gives a classification of the dolphins and porpoises. The list, however, omits many important species and its nomenclature is out of date.

In the second article, John C. Lilly presents his thesis for the great intelligence of the dolphin as stated in his earlier book, *Man and Dolphin*. He is struck by the large size of the dolphin's brain, and he equates brain size with intelligence and language. He persists in confusing mimicry with language, and his arguments are extrapolations from little evidence and much hypothesis.

For the many people interested in these fascinating animals, we recommend two recently published works: *Dolphins, Myth and Mammal*, by Anthony Alpers, a reliable account of the
life and history of the dolphin; an
Porpoises and Sonar, by Winthrop N
Kellogg, an objective description o
scientific studies on the animals' re
markable echo-locating abilities.

William N. & Margaret C. Tavolg
The American Museum

A Field Guide to Rocky Mountai
Wildflowers, by Ray J. Davis, John J
and Frank C. Craighead, Jr. *Houghto*
Mifflin Co., $4.95; 277 pp., illus.

This welcome addition to the Peter
son Field Guides treats the wild
flowers of a part of the country that, al
though a tourist's paradise and a happ
hunting ground for botanists, ha
strangely lacked any such popula
work; indeed there is still no good tech
nical volume available for the entir
region. As the introduction states, to in
clude all the species of the Rocky Moun
tains in a book of usable size would b
impossible; 590 are selected (of the pos
sible 5,000!). Of these, 209 are illus
trated in full-color photographs an
118 by drawings. This seems rathe
skimpy. The authors evidently felt tha
"interesting facts" about the plants—th
flight of owls when a species is in bloom
the usefulness of another species to roc
climbers, the feeding of rabbits on th
bulbs of yet another—should take prece
dence over a more extensive treatment
I should have preferred to see, at least
illustrations of every species mentioned
However, within their limitations, th
authors have done a creditable job, an
the book will without doubt be usefu
As the editor says, it is more importan
to place flowers in their families than t
name "every last species" (but there ar
no descriptions of families).

The authors provide an informativ
introduction to plant life and classifica
tion. At the end of the book there is a
18-page "key to plants," which the ama
teur will find too difficult. In fact, the en
tire treatment leans toward an unneces
sary technicality. It is unpleasant t
have to add that the glossary of term
is badly done, the definitions being b
turns unclear, incorrect, and, in som
cases, ungrammatical.

H. W. Ricket
N. Y. Botanical Garde

Man and the Conquest of the Poles
by Paul-Emile Victor. *Simon and Schus*
ter, $6.95; 320 pp., illus.

A distinguished French explorer her
traces the history of the Arctic an
Antarctic regions from the semilegend
ary voyage of Pytheas in the fourth cen
tury B.C. to the massive expeditions tha
were conducted during the Interna
tional Geophysical Year and the fina
conquest of the ice-filled Arctic Ocea
by atomic submarines. In the interven

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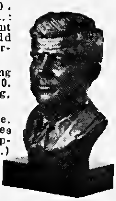

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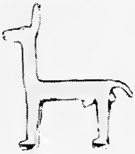

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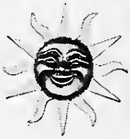

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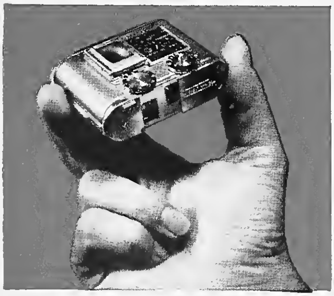


ing centuries described by the author, polar travel has sometimes prospered, sometimes been neglected, but slowly and certainly the mystery, fear, and ignorance of these vast areas of the earth have been replaced by confidence and knowledge. Today, with the aid of modern technology, even the polar winters are ignored by man, who lives, works, and travels the year round in the lands and waters that lie beyond the Antarctic and Arctic Circles.

The polar regions are still, I suppose, somewhat mystic, legendary, and adventurous lands to most persons. But I daresay that there is hardly one of us today who does not count among his relatives, friends, or acquaintances someone who has crossed the Arctic or Antarctic Circles. For we are now, as Paul-Emile Victor states, entered upon the age of Arctic exploitation. The age of Arctic discovery is long since past, and even the age of Arctic exploration is in its declining moments. Today we are using the polar regions more than we are learning about them—using them commercially as well as scientifically.

But Victor himself is one of the few remaining Arctic explorers, still bent on wringing its few remaining secrets from the frozen lands near the poles. As such, he surely has a great love and a great respect for the hardy men who have opened up the polar regions to the knowledge and use of mankind. His admiration for the discoverers and explorers of the past, and for the lands and waters over which they journeyed, is evident in this well-written and interesting account of their accomplishments.

THOMAS D. NICHOLSON
American Museum-Hayden Planetarium

THE WORLD OF THE PAST, edited by Jacquetta Hawkes. *Alfred A. Knopf, $20.00; Vol. I, 601 pp., Vol. II, 709 pp., illus.*

THERE has been much discussion during the past year or two about "creative writing in science," and the general difficulty of communicating the results of scientific endeavor to the intelligent lay public. Editors often say that scientists cannot write, and promptly turn over the job to professional writers.

Jacquetta Hawkes has set out to prove that this cliché is spurious. She aims to restore archeology to its practitioners, using their own words to emphasize the wealth of human experience represented. She has combed the literature—both formal reports and private letters—and created an anthology that will delight anyone interested in the subject, whether he be amateur or professional. In selecting the materials, the editor has done more than gather together a haphazard collection of excerpts. She has selected them to construct a history

archeology and of archeological wledge. At the same time, she brings er scholars to our attention in a way t clearly shows their very real con- utions to the discipline. This effort most useful in view of the facile icism that too frequently castigates h men without taking into consider- n that these personal documents re- l their point of view in the context of times in which they wrote.

'o assist in orienting the reader to eology as a general study, Miss vkes has written an introduction that ns a historical sketch of the develop- it of archeology since the Greeks. s fine essay makes interesting read- for all students of intellectual his- who are concerned with the ortance of personal contacts and the lapping of fields of study as con- utory factors to the creation of new s. With these general trends in d, the reader may then read the two mes as a continuing chronicle.

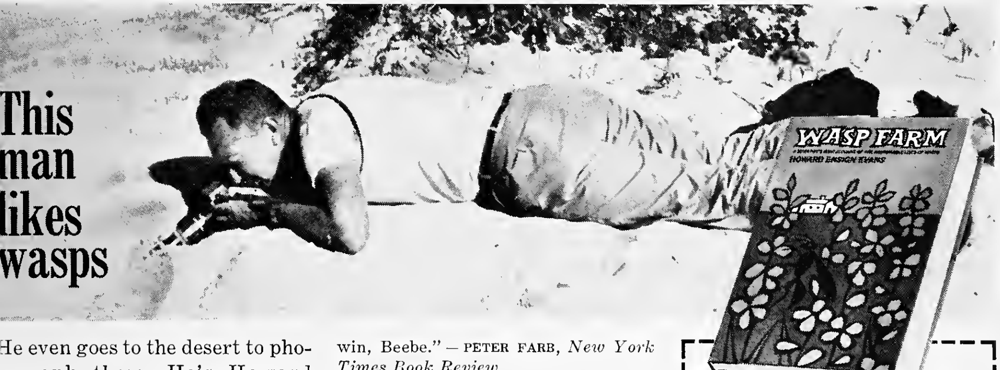
he first sections are arranged in s of "the evolution of man and the elopment of his culture for so long t has universal meaning—that is to the history of the early hunting cul- s and of the origins and spread of ning." Later periods are dealt with regional groupings that cover both the Old and the New Worlds. Occasional figures and photographic plates are scattered through the text, but they are subordinate to the main presentation. The authors quoted will, in many cases, be familiar to the reader by name at least—they include Herodotus, Huxley, Darwin, Layard, Schliemann, Morley, and Vaillant. Others, such as Mac Enery, Rich, and Hilprecht may be less well known. In each instance, however, the quotation used presents a firsthand account of some experience, often one of the major discoveries, such as the unearthing of the Sutton Hoo Treasure or the descent into the pyramid tomb at Palenque. Again and again we see what fascinating and expressive minds have dealt with archeology over the years. Quite rightly Miss Hawkes disapproves of those "Modern archaeologists . . . [who] are inclined to think that literary skill will diminish, and unnecessary jargon enhance, their scientific reputations." This statement is only a half-truth, however, since a number of the men included in this anthology are "modern" archeologists still vigorously writing without the use of jargon.

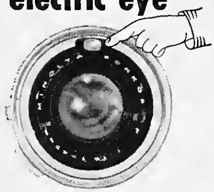
Perhaps these volumes will most entertain those already somewhat acquainted with the subject. The items included are episodic and require an understanding of what archeology is about to be fully appreciated. The reader with no background at all may find himself a bit frustrated by the brevity of presentation. Nevertheless, the bold reader may enjoy sallying forth to an exciting personal encounter with a host of archeologists.

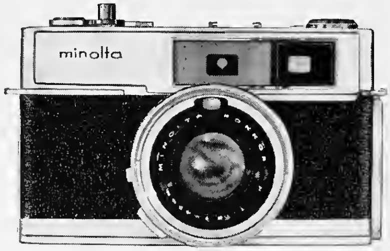
ROBERT H. DYSON, JR.
University Museum, Univ. of Penn.

THE PLANTS, by Frits W. Went. *Time, Inc., $3.95; 194 pp., illus.*

DR. FRITS WENT, Director of the Missouri Botanical Garden, has written a comprehensive work for the "Life Nature Library." *The Plants* is a relatively small book, with a large portion of its space taken up by striking and highly informative illustrations (in color and black and white), but it is packed with significant botanical information carefully chosen from the whole field of the science. There are chapters devoted to the history of plant evolution, cellular anatomy, photosynthesis, physical problems of water use, stimulation and control of plant growth, plant ecology, and plant interrelations ranging from symbiosis to lethal parasitism. Then, finally, Went discusses the history of man's relationship with plants from the days







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pared to a standard text of botany an
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touched upon lightly, if at all. But it
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tist and is in no way superficial in th
treatment of its subjects. It is written
a most lively and interesting fashio
One of its greatest values to the read
lies in its inevitable stimulus to furth
interest in the fascinating and rewar
ing field of plant study wherever the o
portunity presents itself—in the ou
doors, the greenhouse, or the library.

The illustrations have been so chose
that their graphic qualities illustrate th
phenomena or principles under discu
sion interestingly and efficiently. In o
or two cases more informative captio
might have helped but in all other cas
there is no lack of clarity.

In a diagram illustrating the geolog
cal timetable of plant evolution the dat
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rent botanical and geological texts. Th
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cophyta, and Gymnospermae are give
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ian, and the Carboniferous Periods r
spectively. This agrees with other b
tanical and geological authorities. B
the dates of these periods are far earlie
than some authorities place them.
the change is a correction, the sourc
should be mentioned.

VIRGIL N. ARG
The City College of N.

SNAKE LORE, by John Crompton. *Doubl*
day & Co., $3.95; 152 pp., illus.

THE author of *Snake Lore* seldo
bothered to find out what was know
about snakes. Otherwise it might be su
pected that he was following Mar
Twain's facetious admonition, "Get you
facts first, and then you can distort 'e
as much as you please."

Rather than waste time and space o
detailed criticisms of a sloppily writte
book, it is tempting to damn it with fai
praise. Without improvements in th
text, the editing, and most of the illus
trations, however, *Snake Lore* scarcel
deserves anything better than the mos
imperceptible praise a reviewer migh
devise. This anecdotal account can b
recommended only for readers who bu
books they can ill afford to take time t
read. *Snake Lore* will not add to thei
frustrations, for they will have n
qualms about putting it down. Bette
still, they might leave it unopened.

CHARLES M. BOGER
The American Museu

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The Amazon's Rate

# of Flow

Amazon River, here viewed from near its mouth, expels enough water every day to cover Texas to a one-inch depth.

Measurements shatter previous estimates

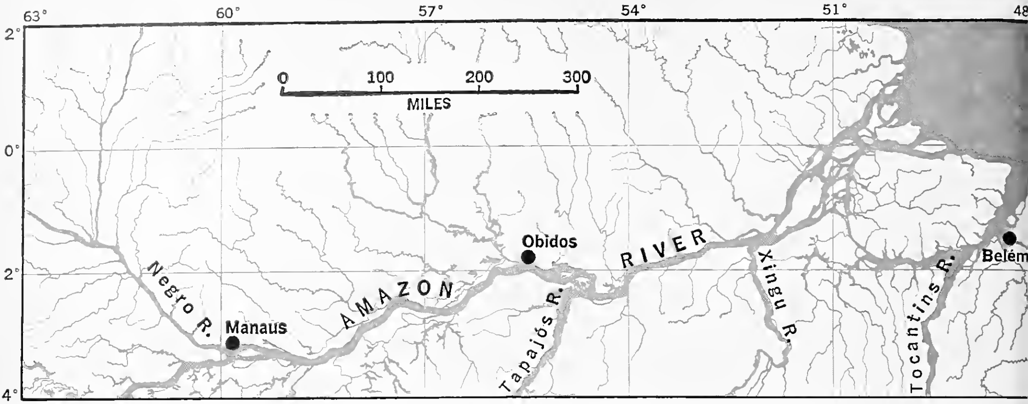
By Luther C. Davis, Jr.

The mighty Amazon River begins its long eastward journey to the Atlantic Ocean, almost 4,000 miles away, from a chain of glacier-fed lakes in the Peruvian Andes only about 100 miles from the Pacific. Sweeping majestically through the vast, steaming equatorial forest of Brazil, sometimes described as the world's most spectacular natural greenhouse, the Amazon provides drainage from an area three-fourths the size of the conterminous United States before it empties into the Atlantic at the Equator.

Long known as the world's largest river, the actual size of the Amazon, in terms of average rate of flow, has hitherto been unknown, although estimates have been made by several earth scientists. These estimates, necessarily based on very limited information, have generally ranged from three to five million cubic feet per second.

Owing to increased interest within the community of earth and water scientists, the Chief Hydrologist of the United States Geological Survey and the head of the geography department of the University of Brazil began negotiations in mid-1961 to sponsor a joint Amazon expedition, one of whose objectives would be to gather hydrologic data sufficient for the computation of the average discharge of the river. As a result, a United States-Brazilian hydrologic field party, consisting of engineers from the United States Geological Survey, the University of Brazil, and the Brazilian Navy, assembled in 1963 at Belém, a noted port city of nearly 500,000 population, located near the mouth of the Amazon.

The party ascended the river in the Brazilian Navy corvette *Mearim*, and succeeded in accurately measuring the great waterway in July, 1963, during the flood season, and again in November, 1963, during the low-water season at Obidos, a jute-exporting center of approximately 20,000 population located about 500 miles upstream from the river's mouth. Based on these measurements, plus river-stage readings made at Obidos during a 19-year period from 1928 to 1946, the average flow of the Amazon at this point is tentatively computed at 6,600,000 cubic feet per second. This represents the average flow from about 80 per cent of the total Amazon drainage area. To determine the average flow from the total drainage area into the ocean, an analysis of the drainage area below Obidos was made, using available meteorological records. Based on this analysis and the computed average flow at Obidos, the total average flow of the Amazon into the ocean is tentatively computed at 7,500,000 cubic feet per second. This is equiva-

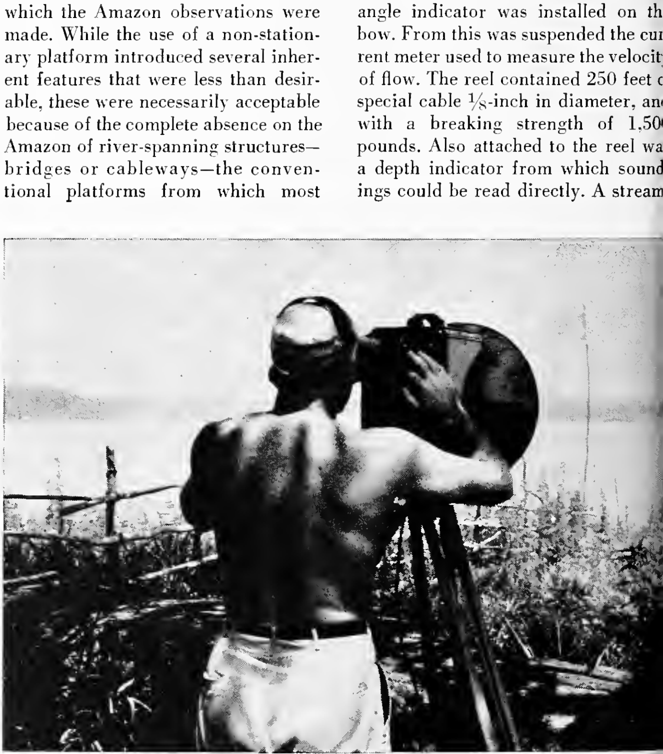


FROM BELÉM, where 1963 expedition began, to Manaus, the terminal area of the study, is about 900 miles. The river drains a basin of some 2,300,000 square miles and expel 3,400,000,000 gallons of water per minute to the ocea

lent to 3,400,000,000 gallons per minute or about 1,600 cubic miles per year. This tremendous rate of flow accounts for about 18 per cent of all the fresh water flowing to the oceans from the rivers of all the continents of the earth, and provides a volume of water in just one day sufficient to cover the entire state of Texas to a depth of over one inch, the state of New York to a depth of nearly 6 inches or New Jersey to a depth of 3 feet. The flow of the Amazon is more than five times that of the Congo River, the world's second largest river, and twelve times that of the Mississippi, the world's seventh largest, and the largest on the North American continent.

THE corvette, about 160 feet long, was used as the platform from which the Amazon observations were made. While the use of a non-stationary platform introduced several inherent features that were less than desirable, these were necessarily acceptable because of the complete absence on the Amazon of river-spanning structures—bridges or cableways—the conventional platforms from which most large rivers are measured by the Geological Survey in the United States.

To adapt the corvette for measurin the Amazon, a specially designed 9 foot boom equipped with an electrically powered reel and a vertica angle indicator was installed on th bow. From this was suspended the current meter used to measure the velocit of flow. The reel contained 250 feet c special cable ⅛-inch in diameter, an with a breaking strength of 1,50 pounds. Also attached to the reel wa a depth indicator from which soundings could be read directly. A stream



OBSERVATIONS with a fathometer, *left*, showed Amazon's bed was series of sand dunes covering long reaches of river.

PRECISE distance measurements wer made with electronic Tellurometer se up at the shore control station, *abov*

ed 300-pound lead sounding weight
s suspended just below the current
ter to hold the suspension line in the
rent in as nearly a vertical position
practicable. When high-current ve-
ities caused the meter to be carried
wnstream from the vertical and,
currently, the suspension line to
d at a downstream angle from the
tical, the angle of departure was
d from the vertical angle indicator
ated at the protruding end of the
pension boom. I will describe later
v corrections that were based on
s measured angle are applied.

FTER consulting all available re-
liable information, including
ps and aerial photographs, followed
an on-spot reconnaissance survey,
neasurement site was selected at
idos. For several reasons, Obidos
eared to be a logical location. In-
ad of flowing in several, relatively
le, ill-defined channels as it char-
eristically does, the Amazon at
idos is confined to a single, rela-
ly narrow, uniform channel ap-
ximately 7,500 feet wide. The tidal
ct, which extends a considerable
tance up the Amazon from the
an, becomes negligible at Obidos.
addition, the record of the 19 years
river-stage readings that had been
en at Obidos was available.
irst, a suitable measuring section

AT OBIDOS, 500 miles from the Atlantic, river is about 7.500 feet wide. High-stage flow at this point was clocked at 7.600.000 cubic feet per second.

that was perpendicular to the flow of the river was selected at this site. A prominent feature, such as a tree or a building that was easily visible from a distance, was pointed out at each end of the section to assist the captain in maintaining the ship as nearly on station as possible. It was necessary to keep position by continuously changing engine speed and rudder settings, because the river was too deep at this section to allow effective anchoring.

A shore control station, consisting of a theodolite, for measuring horizontal angles, and a remote Tellurometer, for measuring ship-to-shore distances, was then established on the right bank, in line with the selected section. Shore control was necessary to assist the ship's captain further in maintaining station and to determine corrections, caused by the ship's drift, to be applied to the velocity readings obtained from the current meter. While all efforts were made to eliminate corrections by keeping the ship absolutely on station, this proved an impossible feat because of the limited maneuverability of the ship, even with expert handling. Although the theodo-

UNDING WEIGHT and a current meter,
ched to cable reel on suspension
m, are lowered for depth readings.

lite or other similar surveying instruments, such as the transit, had been used previously in stream-gauging operations, the Tellurometer, a highly accurate distance-measuring system, had not been used, so far as is known. The Tellurometer system operates on the radar principle, and consists of two units—the master and the remote. For the Amazon operation, the master unit was mounted on the ship near the bow, and the remote unit was mounted on shore. An operator was required for each of these units.

Just prior to commencement of the measuring activities, the selected cross section of the river channel was then divided into a number of subsections, each about 300 feet wide. This is in accordance with standard United States Geological Survey procedure for measuring purposes, whereby a river channel is theoretically subdivided into a convenient number of subsections, usually numbering from 25 to 30, and each is measured separately. The sum of the flows in each of the subsections is the total flow in the full river cross section. This method of calculation tends to balance out inherent errors and has been found to produce results within 5 per cent of accuracy.

After these initial steps were taken, the following procedure was employed in making the measurement:

(1) Using instructions from the shipboard Tellurometer operator and an observer stationed at the gyrocompass on the bridge as a guide, the ship's captain maneuvered the vessel to a position directly over the first subsection of the measuring section.

Total average flow of Amazon is here compared to other rivers of the world.

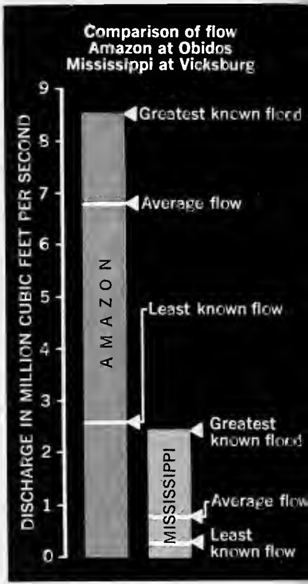
(2) When the ship had been stabilized as accurately as possible on the subsection, the 300-pound sounding weight was lowered and the depth, in feet, was read from the depth indicator. When the vertical angle indicator showed the suspension line to be tending at a downstream angle from the vertical because of the river current, the angle of departure was read. Based on this shipboard reading, a numerical correction was applied to the observed depth to obtain the true vertical depth. This corrected depth observation was compared with depth readings that were continuously recorded on a portable fathometer that was installed near the bow of the ship. With the recording fathometer, or echo sounder, a detailed cross-sectional profile of the channel bed could be determined and depths greater than 230 feet could be measured. (The maximum depth that could be ascertained with the sounding weight and available suspension cable was 230 feet.) Although depths of over 300 feet—which is well below sea level—were recorded by the fathometer at several points while ascending the river from Belém, where the expedition originated, the maximum depth that was encountered in the Obidos measuring section was slightly over 200 feet.

(3) The current meter, located in a fixed position one foot above the sounding weight, was then raised in the channel subsection until it was at a point, measured from the water's surface, of 80 per cent of the total vertical depth. For example, in a 200-foot subsection the current meter would be placed at a depth of 160 feet.

(4) At a given signal the velocity measurement of the river flow at this depth began.

(5) At the same instant the shipboard Tellurometer operator recorded the exact distance the ship was from shore by interpreting reflected microwaves from the shore unit. The shore-stationed theodolite operator, having received the starting signal by a walkie-talkie radio circuit, noted the azimuth location of the ship.

(6) At a second given signal, from 40 to 60 seconds later, the velocity measurement, in feet per second, was completed, and second Tellurometer (distance) and theodolite (azimuth) readings were made. The difference between the first and second Tellurometer readings showed the distance the ship moved laterally during the interval of time during which the veloci
measurement was being made. Tl
difference between the theodolite rea
ings was the angular distance the sh
moved, during the same interval
time, in an upstream or downstrea
direction from the line defining t
measuring section. This angular d
tance is converted trigonometrically
a linear distance, based on knowled
of the ship-to-shore linear distance
shown by the Tellurometer readin
These two linear distances constitu
the components of the ship's horizon
movement during the 40- to 60-seco
interval of time during which the
locity measurement was being ma
Using these components, the ship's
tual path during the measurement
terval was graphically computed a
converted to a rate of movement in f
per second. The correction was then
plied to the measured velocity—add
when the ship's movement was dow
stream and subtracted when upstrea
—to obtain the corrected velocity.



Mississippi's greatest known flood
same as Amazon's least known flo

(7) Following completion of t
velocity measurement at the 80 p
cent of depth point in the channel su
section, the current meter was th
raised to a point at 20 per cent of t
total depth. In a 200-foot subsecti
this would be 40 feet below the surfa

(To determine the average veloci
in a subsection, velocity measureme

e necessary at more than one depth cause velocities vary with depth—ierally being slowest near bottom.)

(8) The same procedures described steps 4 to 6 were then repeated, and corrected velocity measurements de at the 20 per cent and 80 per it of depth points were averaged. e two velocity measurements, one h at the 20 and 80 per cent of depth nts, were made because broad exience by the United States Geoical Survey has shown that in deep ers the average of these two figures ovides an accurate measurement of average velocity in the subsection.

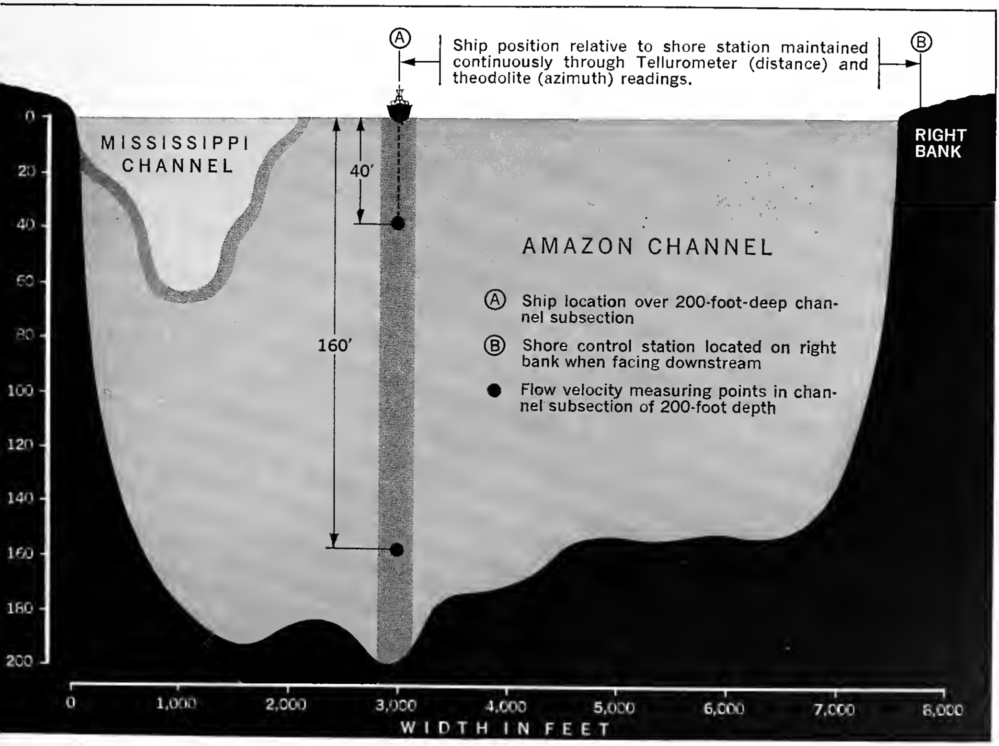
(9) The ship was then moved to the t subsection and the same proce-e was repeated.

(10) In making the final computais of the flow in the entire channel ss section, the widths of the indiual subsections were computed m the differences between the shipshore Tellurometer distance measments at adjacent subsections. The nputed subsectional widths were then multiplied by the depths to determine the cross-sectional areas of the subsections. The products of these cross-sectional areas and the corresponding average subsectional velocities, provided in step 8, give the flows in the channel subsections. The total rate of flow in the full channel cross section is then computed by summing up all the flows that have been measured and computed in the 25 to 30 channel subsections.

THE immediate objective of the United States Geological Survey in undertaking the Amazon expedition was to gather data to substantiate recently advanced theories pertaining to the properties of rivers in the United States (NATURAL HISTORY, January, 1964, *page 10*). This objective was achieved because the measurements showed that the flow of the largest of rivers is several times the flow of the second largest river. Furthermore, the measured velocities, depths, and widths of the largest river substantiated theories that previously had been based only on data collected on small rivers in the United States.

A second objective was to close a glaring gap in hydrologic knowledge that previously existed in the library of world hydrology. This gap has become particularly evident during studies that are now being made as part of a program participated in by the United States Geological Survey. In this program, computations are being made of the water and of the total dissolved and suspended solids that are carried by the world's rivers from the continents to the oceans—one step in determining the total erosion of all continents. These computations are also to be used better to define the salt budget of the world oceans, thereby providing a further increment to man's knowledge of his planet.

EDITOR'S NOTE: This is the second in a series of articles that will describe the wide-ranging research activities of the United States Geological Survey.



MPARISON of channel cross sections of the Amazon River Obidos and the Mississippi at Vicksburg also shows the techniques used in measuring the Amazon's flow. Vertical scale is exaggerated in relation to the horizontal scale.

Expositions, Exhibits

New display methods merge academic and commercial heritages

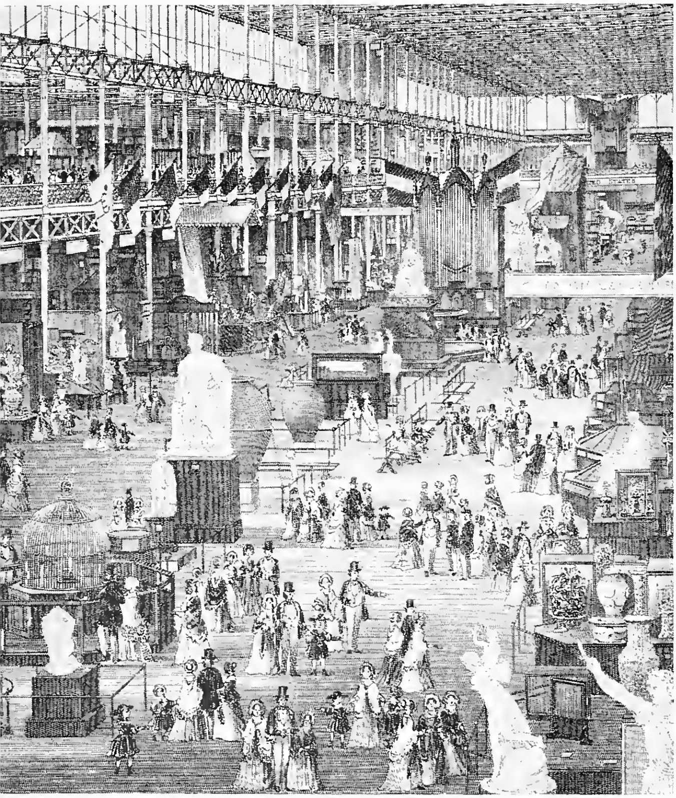
By Gordon Reekie

The Great Exhibition in the Crystal Palace in Hyde Park, London, closed on October 11, 1851. Since its opening on the first of May, more than 6,000,000 people had inspected the exhibits of this first world's fair, and a new era of public participation in expositions and, subsequently, museums had dawned.

Hitherto, museums, including the great national collections, had been very much the enclave of scholars and rich amateurs. Indeed, with universal free education still far distant in all countries, this was not surprising. What did surprise the authorities of the 1851 Great Exhibition was the enthusiasm of the uneducated lower classes for these displays of artistry and industry. The newly formed railway companies were instrumental in generating this enthusiasm by arranging cheap excursions from all parts of Britain, so that "the more deserving poor may enrich their minds." Prince Albert insisted that all London school children should visit the exhibition. It seemed logical, therefore, that at the time of its closing, of the various suggestions for spending the £186,000 ne profit, the founding of a series of new popular museums was decided upon Such was the origin of the famou South Kensington museum complex i London—the Natural History Museum the Science Museum, the Geologica Museum, and the Victoria and Alber Museum of Fine and Applied Arts.

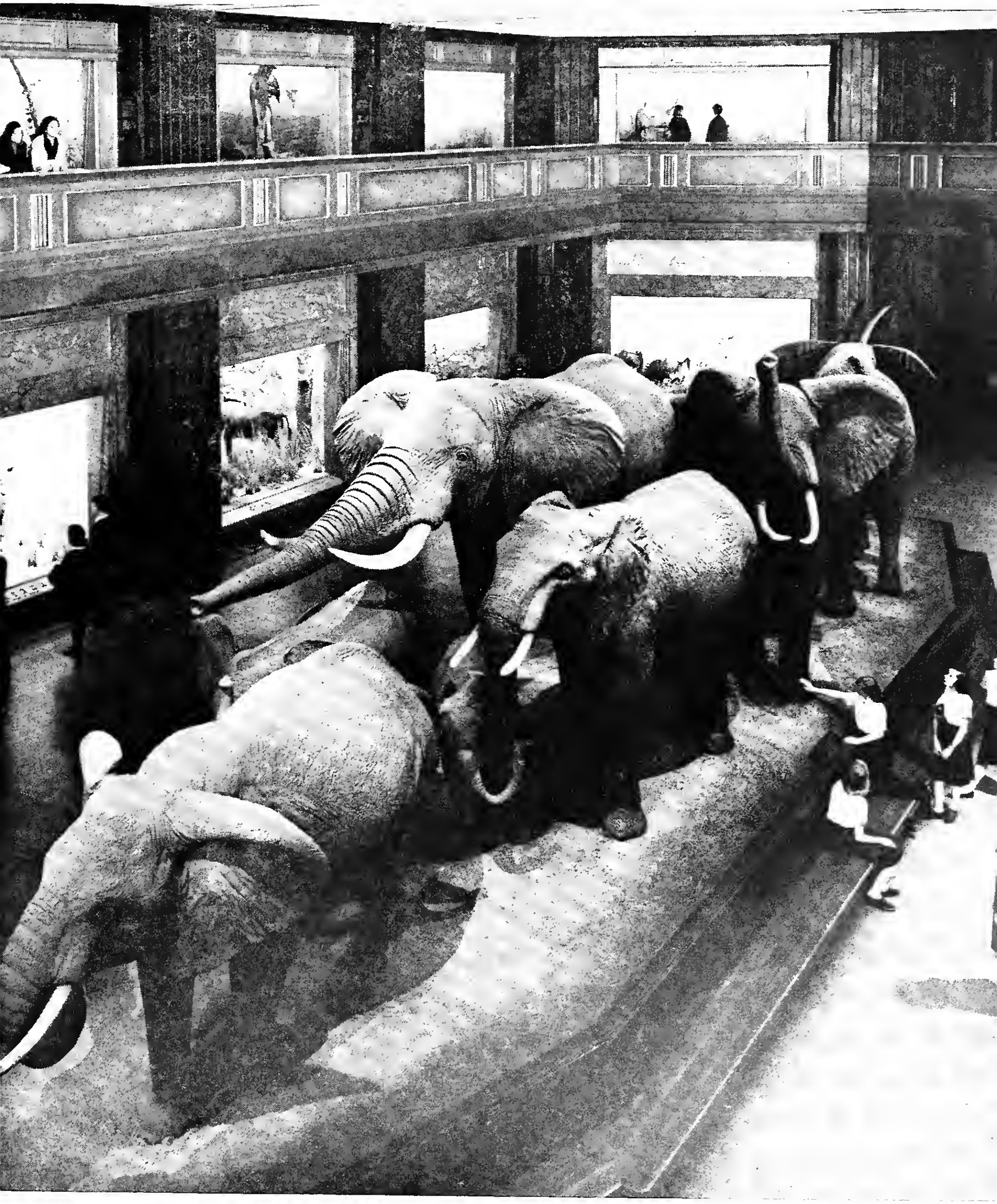
From that time on, the relationshi between world's fairs and museum has grown. Most notable has been th incorporation into a fair site of a permanent building designed to be use later as a museum. Some of the best known museums in the United State originated in this manner, includin the Chicago Museum of Science an Industry (1893) and the City Art Museum of St. Louis (1904). From th earliest days, too, problems of exhibi preparation drew exposition and museum authorities together. After th close of the Paris Exhibition of 186 M. Le Play, the Commissioner-General, advocated the establishment o permanent museums to house the sam types of material as displayed at th world's fairs. He rightly observed tha there was too little time to prepare th exhibits properly, and that they wer on display too briefly for full advantage to be taken of them. While thes reactions were pointing the way to museums of science and industry, th nature of world's fair exhibits themselves was being discussed and criticized. An endless succession of fair devoted to the ever more ingeniou products of industry was thought t be eventually self-defeating, and in thi Paris exposition were included th first so-called cultural exhibits. Thes were "The History of Labor," whic told the story of the arts and crafts o mankind from prehistory to the end o the eighteenth century, and a sectio called, rather ominously, "Social an Moral Problems."

These displays seemed to be precursors of anthropological exhibits in museums. In the meantime, authorities o the Philadelphia Centennial Exhibi



Contemporary illustration depicts the exhibits at Crystal Palace in 1851.

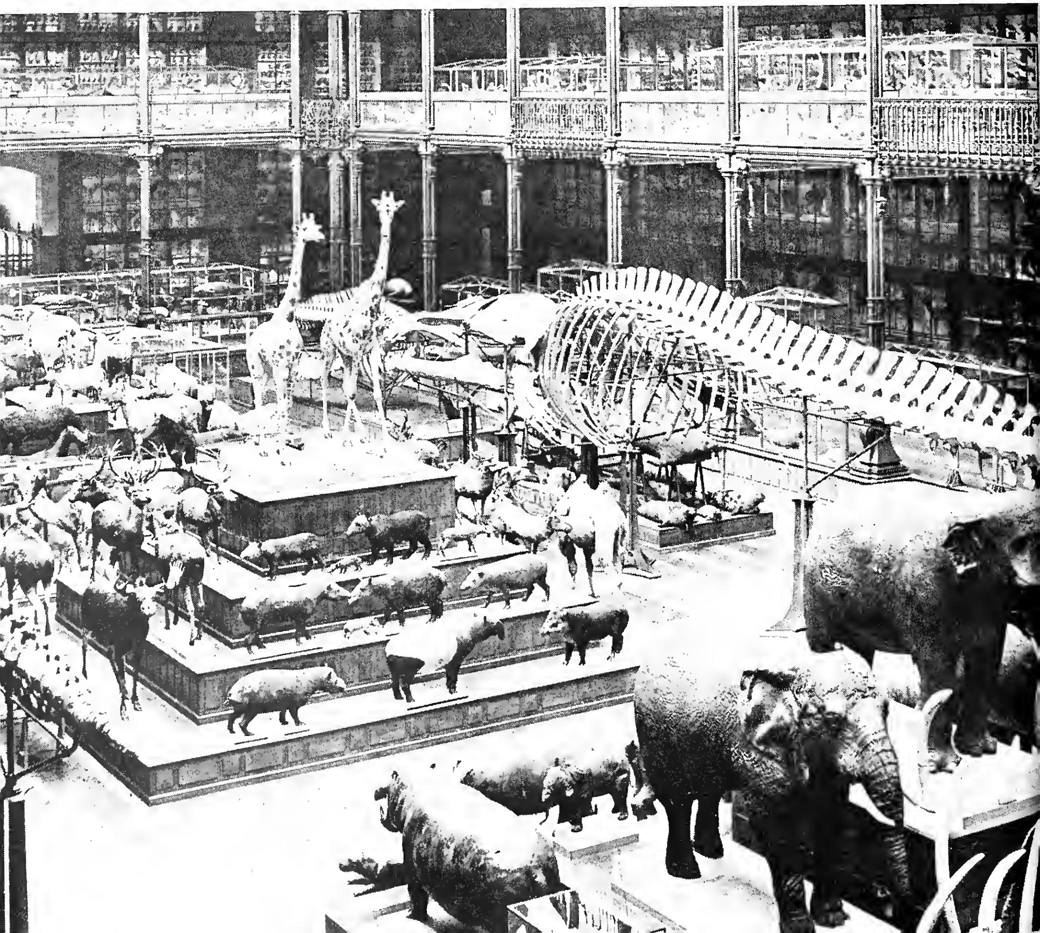
and Today's Museums



phant group in Akeley African Hall at American Museum of Natural History owes much to perfection of preparation.

Animals were shown at Philadelphia Centennial Exhibition.

Natural history museum hall opened in Paris in 1889



ic guests attended the 1877 opening ceremonies of The American Museum.

tion of 1876 decided that a cross section of wildlife exhibits would provide a cultural counterweight to the vast displays of machinery and consumer goods. Accordingly, a special building was constructed to contain exhibits of representative American mammals, birds, and fish, all of which were installed in a manner indistinguishable from the museum style of the day.

What was this manner of display? Basically, in both museums and expositions it was a magnification of the curio cabinet style of arrangement. Thus the main hall of the Zoological Gallery in the National Museum of Natural History in Paris, opened in 1889, was a gigantic version of the display of exotic objects to be found in a well-traveled eighteenth-century gentleman's home. The similarity between this and the interior of the 1851 Crystal Palace is remarkable. Skeletons and animal mounts take the place of machinery, furniture, and statuary.

In the Bird Hall of The American Museum of Natural History, which was officially opened in 1877, the effect was not so overwhelming because of the smaller scale of the exhibits. However, each glass-enclosed case was still a curio cabinet, filled to overflowing, and could be compared with the display cases of objects in trade expositions of the period. Indeed, this was the universal form of display; shopwindows of the time were treated similarly. The principle was to try to arrange as tastefully as possible the maximum number of objects in a given space.

Just as most museums still have examples of this kind of display, so there are shopwindows that adhere to the idea that the more you show, the better. The five-and-ten-cent stores are good examples, but for retention of the real flavor of old-fashioned crowding, hardware stores are unsurpassed. In effect they are like modern curio cabinets of everyday objects or scaled-down versions of industrial expositions. That is the biggest reason for their appeal. For in contrast to today's almost bleakly tasteful window displays, there is something reassuring and cheerful about this gloriously disorganized muddle.

Until the end of the nineteenth century such methods of display continued almost unchallenged for museums, expositions, and shops. The World's Columbian Exposition in Chicago in 1893 surpassed all previous fairs in size and number of displays, but broke no new ground in exhibition techniques. Like the highly successful Paris Exhibition of 1889, however, it used the recently invented electric light in lavish and unusual ways.

The introduction of the incandescent lamp, although it did not immediately revolutionize display techniques, made possible new solutions to old problems. The newly emergent department stores had ambitious ideas about window display, far different from the friendly, crowded, corner draper's. They looked to the theater with envy, at the proscenium-enclosed stage, the equivalent of their own plate-glass display windows. But until the introduction of electricity they could not adapt the stage-set type of display to their own uses. Gas lighting was safe for the theater, but when it was installed in an enclosed space, such as a store window, it was certainly not.

Museums, too, were limited in the way they could use gas lighting. It was utilized solely for general illumination, outside the exhibit cases, and served only to brighten halls on dark days. Like department stores, museums needed electric light before their displays could be basically changed.

Some developments in these techniques were taking place, however, and they were paving the way for the displays we are familiar with today. As the collections of the major museums grew, and hall after hall proliferated, the repetition of the curio cabinet type of display began to pall. What had been an orderly presentation of several hundred objects in a small museum developed into a stupefyingly monotonous presentation of several hundred thousand objects in a large museum. Minerals, birds, arrowheads, all were shown in the same way.

It was logical that birds should have provided the impetus for the first attempts to break away from this tradition. The ornamental arrangement of mounted birds on an artificial bush had long been a conversation piece in Victorian drawing rooms. It is probable that curators in many museums realized at about the same time that this kind of display held possibilities for their bird collections. Thus originated the "semihabitat" exhibits. The first attempts were little more than the placement of small birds in small glass cases, surrounded by appropriate vegetation. However, some early specialists exhibited great skill in refining these vignettes of nature to a high degree of artistry and realism. In the 1887-88 Annual Report of The American Museum, it was noted that 1887 was a memorable year for the bird collection. The report listed the addition to the exhibits of "a series of bird groups, eighteen in number, each consisting of a pair of birds, with its nest and eggs, mounted in characteristic attitudes, and surrounded by natural accessories, each group being a facsimile reproduction from nature of the vegetable and other surroundings of the nest." The report continued: "These groups, modeled after the plan of the bird groups in the British Museum at South Kensington, are the first of the kind to be placed on exhibition in America." One of these original groups is still in existence, although not on display.

Experimentation with larger naturalistic arrangements of this kind was proceeding elsewhere, too. An early example was an extraordinary tableau, constructed in Paris during the 1860's for a temporary exposition, and subsequently housed for a number of years in The American Museum of Natural History. Entitled "A Camel-Driver Attacked by Lions," it was originally exhibited in a four-sided glass case. It is now beautifully restored, a background painting has been added, and it can be seen at the Carnegie Museum in Pittsburgh.

Early example of naturalistic display showed lions attacking camel driver.

The semihabitat group grew in size and in popularity as a form of display. It is still an effective method of exhibiting both small and extremely large subjects. A good deal of the environment of small birds can be presented economically in a few square feet. At the other end of the scale, in the Hall of Early Dinosaurs at The American Museum *(pages 28-29)* the *Brontosaurus* skeleton reconstructions surmount a base that is a facsimile of the locality in which their fossil remains were found. This is a form of semihabitat, although a rather arbitrary one, as considerations of space preclude a more revealing landscape. On the other hand, the impracticability of a totally enclosed diorama with the same composition at the same scale makes this an effective substitute.

At the turn of the century, display methods were beginning to change in many ways. More specialized expositions and trade fairs were being organized, reflecting the growth of the consumers' goods field (as exemplified by the automobile industry). The role of the department store as a show place was being established, and different kinds of museums and museum exhibits were arising. All were influenced by theatrical techniques and the freedom to use them that was provided by the introduction of electric light.

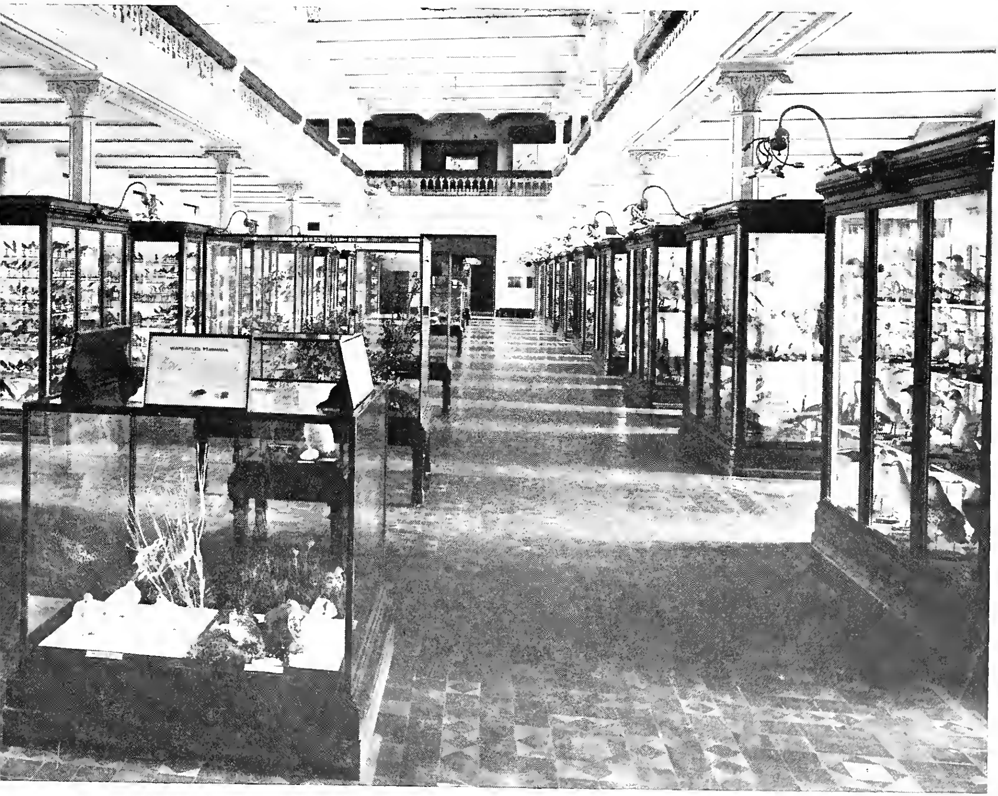
Parallel development in what could be called both indoor and outdoor habitat groups occurred in the early 1900's. These were basically variants of the boxed-in, stage-set formula, put to use for new purposes. The first of the "new look" department store window displays were very simple stage-sets, suggesting sparsely furnished but elegant rooms (plain paneled walls, a crystal chandelier, a Louis chair).

Amid such uncluttered settings, the statuesque mannequins of the period were placed in more or less naturalistic poses, their gowns and furs (and the background) bathed in uniformly brilliant white light. However, it was some time before this method of display was used by stores for showing furniture and furnishings. A trade publication of that time observed that few store windows were of sufficient size or suitable proportions to enhance a realistic grouping of furniture. To an extent this is still true today, and great care in composing and lighting such displays is needed to avoid an uncomfortable, cramped look.

In the meantime, the *art nouveau* movement of the 1890's had generated much interest in new furniture and textile designs. At the Paris Exhibition of 1900, these were displayed in realistic room arrangements that did not suffer from the confining proportions of the store window. By 1902, at the International Exhibition of Modern

bins perched near nest in semihabitat group of 1880's.

This glass-enclosed bird display dates from the 1890's.



urn of the century, glass cases in exhibit hall of The American Museum were lighted externally by clustered bulbs.

Bygone era is preserved in a period room at the Norsk Folkemuseum in Oslo.

Decorative Arts in Turin, the three-sided "stage-set" furnished room had become a standard method of displaying such merchandise—where there were no space limitations. One of the technique's greatest appeals to exhibitors in a crowded hall was that, as in the theater, there was a barrier between the show and the audience.

Revived public interest in the decorative arts, set in motion by *art nouveau* protagonists, did more than stir up the ideas of contemporary designers. For more than fifty years there had been no stimulus for the industrial and decorative arts, other than the technical developments that had made possible mass-produced—and artistically debased—adaptations of late eighteenth- and early nineteenth-century design. This was especially true of home furnishings, and when, at the turn of the century, a breath of fresh air made possible a new look to the future, it also brought about a desire to reappraise the past and study anew the heritage of the applied arts.

This new awareness of what can be called the history of the human habitat stimulated the construction of period rooms in many art and historical museums. Furniture had hitherto been little exhibited in museums and, when it had been, was more often than not just assembled, as in a warehouse. Rough-and-ready "period settings" were arranged in the halls of larger museums. The settings incorporated period ornament and decoration into the display area to provide a sympathetic background.

It was in the newly established folk museums of Scandinavia, in the early 1900's, that the true period room exhibit was developed and later perfected. These rooms re-create the totality of living conditions, providing down to the last detail a perfect reconstruction of an indoor habitat as lived in at the time. At the Nordiska Museet in Stockholm, these displays are used to show changes in living arrangements over as short a span as ten years (how remarkable a period room of 1934 is, for example), while a series of dining rooms traces the history of eating habits from late medieval times to the present. Every single item of food, in the right quantity and in the right style of serving, is duplicated with exacting and loving care.

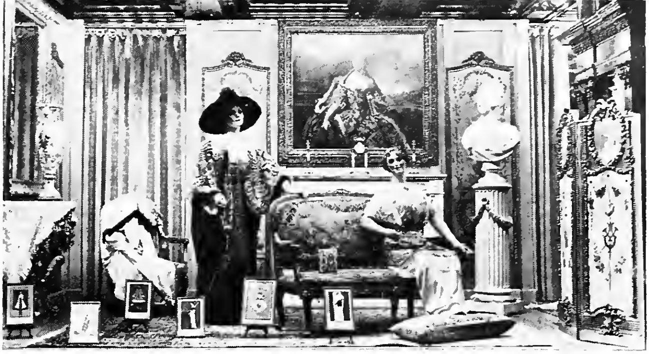
It is not surprising that the new realism in the presentation of interiors should have influenced natural history museums although, independently, the recessed, stage-set type of display had been developed for smaller semihabitat groups. It was the development o the curved-back wall in the recessed case, however, that permitted the effective union of background painting and three-dimensional foreground material that led to the full-fledged habitat group. This took place in The American Museum during the time that exhibits for the Hall of North American Birds were being made.

A number of exhibits had been completed in big, floor-standing, wooden-framed glass cases that were placed against the walls of the gallery. The back surfaces of these cases were covered with canvas, and realistic landscapes had been painted on them. The shallow foreground (really no more than floor covering) was realistically constructed, and mounted birds were placed in this foreground or suspended by wires from the tops of the cases

Gorilla habitat group in Akeley African Hall at The American Museum is a

· exhibits were lit initially from
side the cases, indicating that light-
must have been an afterthought.
hese exhibits, although impressive
cale, were not satisfactory in con-
ing a unity of distant landscape
intimate foreground. Essentially,
e were two exhibits in each case—
ural of an over-all scene and some
ls in a semihabitat placed in front
ie mural. Today, visitors to this re-
ly renovated hall, which has just
n reopened, can see one of the twen-
oot backgrounds now used as a
al. It is a painting of a flamingo
ny, by Louis Agassiz Fuertes, on
north wall of the gallery.

R. Frank Chapman, then Associ-
ate Curator of the Museum's De-
ment of Ornithology, was among
e who began to experiment with
ved backgrounds. It was soon
nd that it was much easier to
eve satisfactory results with small-
roups because of the limited depth
ie exhibits. The first such display—
first true habitat group—was
shed in 1902. It was the Cobb
nd exhibit, on the north side of the Hall of North American Birds. Although this group no longer exists, many of the other displays in the new hall date from the early 1900's.



Stage effects influenced displays of early twentieth-century department stores.

The habitat group is only one way of constructing a natural history exhibit. Why is it given such emphasis in all descriptions of natural history museums? There are two answers: it was the first really original contribution from the museum world to the art of display, and its re-creation of a complete, natural environment captured the imagination of the public as no other museum exhibits had done before. It was as if a new popular art form had appeared upon the scene. Indeed it had, in the sense that the combined skills of scientist, painter, and modelmaker had produced a new, purposeful, instructive art medium. Visitors looking at the famous gorilla group in the Museum's Akeley African Hall do not first count the number of leaves, wonder how the vines are made, or ponder the perspective of the background painting. They receive an aesthetic and emotional experience. Later, their curiosity aroused, they may begin to ask questions.

It is, of course, the technical perfection of these later habitat groups that gives rise to much curiosity about how they are made. Basic to the concept of habitat groups is skillful taxidermy. In a naturalistic setting, stiffly mounted animals without any hint of their normal attitudes look absurd. Muscle structure in relation to the position and activity of the animal was given intensive study in the Museum in the early years of the century, and paved the way for the African and North American groups that were constructed during the 1930's and 40's.

Use of a double-curved wall, in which the background curves into the ceiling as well as bending around to meet the front plane of the group, gave the background painter much greater freedom. New plastics augmented the traditional paper and wax for making leaves and flowers. New "directional" lighting made possible near fidelity to outdoor light and eliminated the overall floodlighting previously used. But with all the technical advances to help make these groups more outstanding in their re-creation of nature, it is the painstaking care of artist and

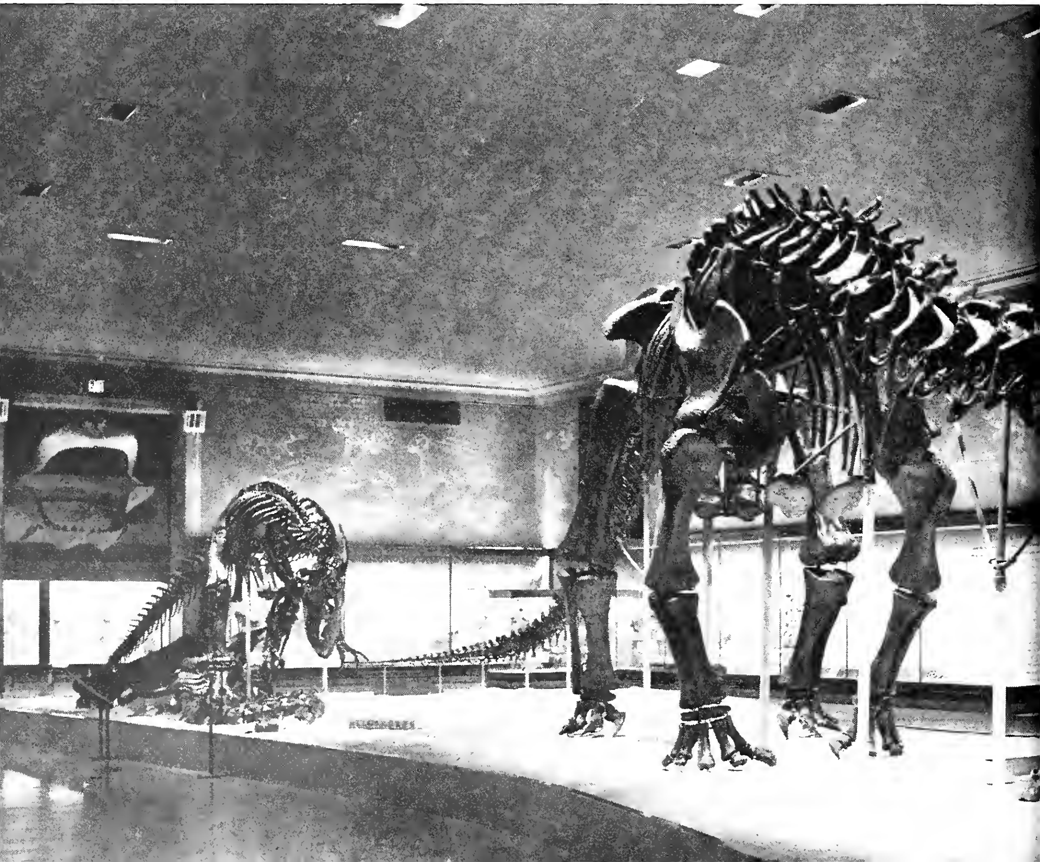
nple of the striking realism that is attainable with this type of display.

craftsman that matters most: the ski with which the join between background painting and foreground hidden: the ingenuity in devising i visible support for birds in flight; th use of concealed mirrors to reflect ligh and thus to simulate the penetratio of sunlight into forest.

Even making shadows is an art. N artificial lighting can ever cast shadows similar to those cast by the su In recent years, when material for ne groups has been collected, among th many photographs taken at the fiel sites have been pictures shot specifical to record the shadows at the particula time of day the group will represen When the group is near compl tion in the Museum, and final lightin has been installed, the shadows cast b the artificial light are removed, an new shadows, as recorded in the fiel replace them. This is done by paintin hard surfaces with an airbrush, or b replacing sand or loose soil of on color with those of another.

Dinosaur mock-ups are featured in an exhibit at New York World's Fair.

The American Museum's dinosaur displays are favorites with the public.

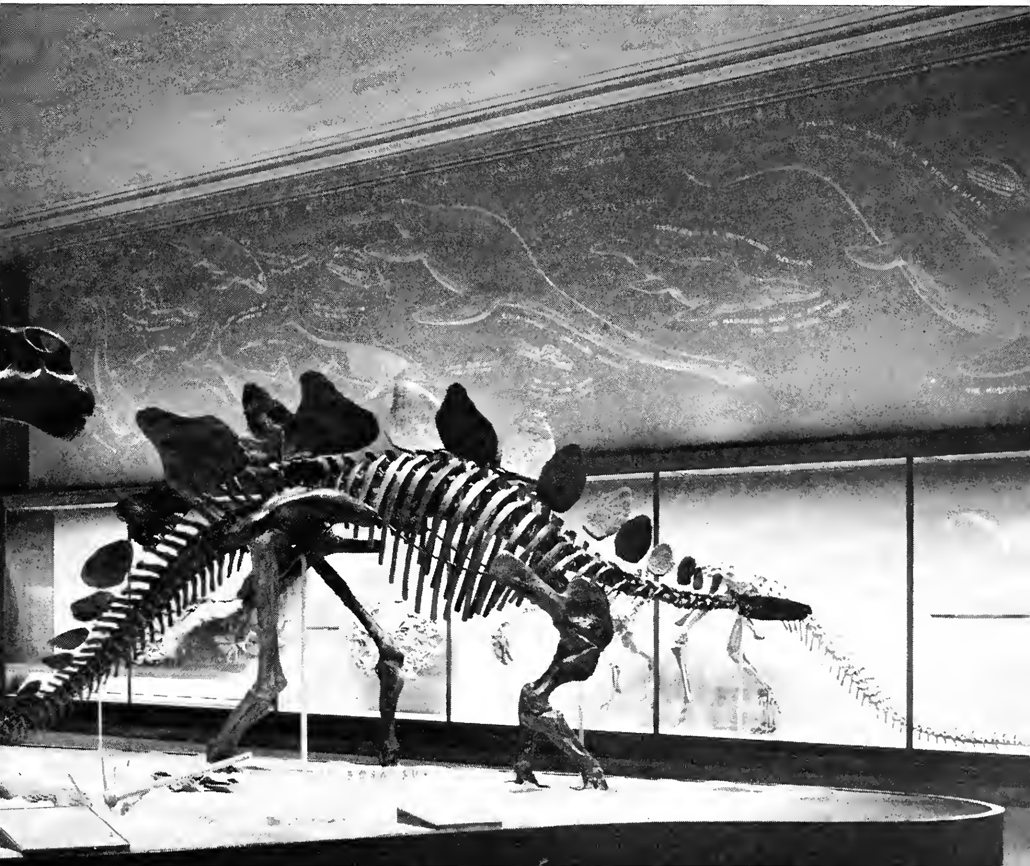


HE influence of habitat groups
in The American Museum on other
as of display has been very much
nected with this perfectionism. A
lic used to the African and North
erican exhibits in the Museum will
respond enthusiastically to the dio-
mas he sees in trade shows or
ld's fairs unless their execution is
east comparable. But in return, the
lic now being dazzled by new and
astic techniques of display at the
v York World's Fair will expect
parable exhibits at the Museum to
designed with equal wit and in-
uity. It is not only in this area that
interrelationship between fair and
seum continues. One of the out-
ding exhibits at the New York
rld's Fair is that of the Sinclair Oil
npany, in which a remarkable
es of dinosaur reconstructions is
ured. The phenomenal interest
wn over the years in the Museum's
osaur exhibits is thus reflected in
revival of a commercial exploitation of the same subject. For, in spite of newer and more complex exhibits in the Museum, the dinosaurs remain one of its greatest attractions.

What will the Museum derive from the current Fair? A shot in the arm, so to speak, such as many world's fairs have provided in the past? In Brussels in 1958 it was generally agreed that the unique display feature of the first postwar world's fair was the extraordinary and varied use to which photography was put. Quite apart from the introduction of 360-degree camera projection by both Czechoslovakia and the United States, the adaptation of the traditional photomural to new forms was outstanding. There were three-dimensional photomurals to be walked through, climbed over, and sat upon. There were photographic mobiles, stabiles, and building blocks. Photographic ingenuity was limitless and brought exciting new ideas into general display use.

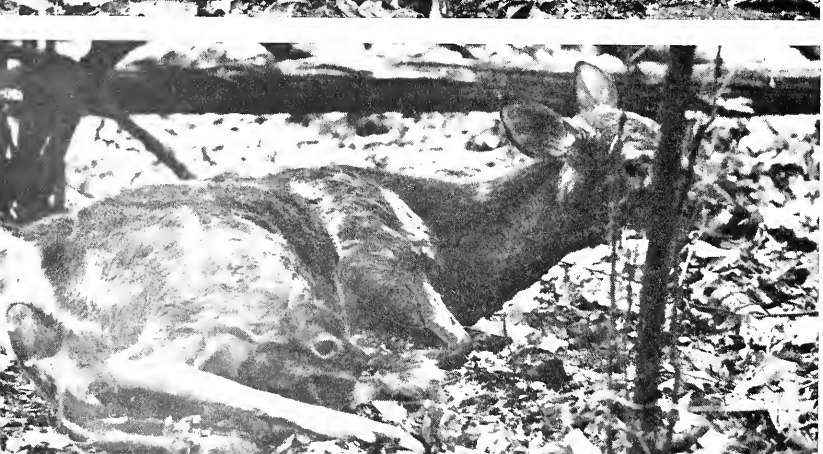
Greater use of animation in exhibits is one of the influences for which the 1964-65 New York World's Fair will be most noted. The development of reliable, compact, and inexpensive mechanical and electronic equipment for sequence animation has taken many years, and until recently museums have not made extensive use of such equipment. Combined with slide and motion picture projection, a new world of exciting, audio-visual presentation is now being revealed to us. It is in this area that exhibits being planned for completion by the time of the Museum's centennial in 1969 are most likely to be affected.

THE introduction to an early guidebook to the Museum said: "The ideal museum presents, in logical order, the entire story of the universe, the earth, and its inhabitants, together with their total relation to each other." With such a sweeping goal in mind, the display techniques of tomorrow will not have arrived a moment too soon.



Coat of a newborn whitetail deer fawn, at left above, is still wet as fawn nuzzles the doe, which is about to bear second in set of twins.

After nursing at age of seven minutes, first fawn rests at the doe's side as its twin starts to emerge, *below*. Such double births are usual.



Doe nurses fawns f some four to six week or longer, although th young begin nibbling nearby vegetation on a few days after birt

Birth of Two Whitetails

Photographs by Leonard Lee Rue III

ne of the most numerous and widespread big game
nals of North America, the whitetail deer is found
he United States and Canada from the East Coast
ar west, roughly, as the Rocky Mountains. Maximum
eding activity of the whitetail occurs from November
ugh January, depending on geographical location,
gestation lasts approximately 196 days. Conse-
ntly, fawns are generally born in the spring. Al-
ugh a doe's first breeding usually results in a single
h, twin fawns are common in subsequent breedings
triple births are not uncommon. A newborn fawn
ghs three to five pounds and is able to walk, albeit
kily. The white spots on its coat disappear during the
umn, when it grows its first winter coat. The life ex-
ancy of the whitetail deer is seldom more than ten
s when it is living in the wild, but tame or captive
have been known to live as long as twenty years.

Second fawn, ten minutes old, is able to stand and walk. At birth, whitetails weigh from three to about five pounds.

California's Legacy

# of Indian Rock Art

Pictograph discovered in San Rafael Mountains of California is part of a vast western legacy of early Indian rock art that confronts archeologists.

by CAMPBELL GRANT

SCATTERED THROUGH THE MOUNTAINS of eastern and southern California are great numbers of strangely painted caves and rocks. The designs are semiabstract or geometric and are often of great complexity and beauty. It is curious that these prehistoric works of art are practically unknown. Since the discovery of the great Paleolithic paintings at Altamira in northern Spain in 1879, there has been enormous interest in the continuing discoveries of rock painting in France and Spain and, more recently, in Africa and Australia, but somehow the rock art of the United States has attracted few investigators. A survey of all current information on the pictographs of the United States indicates that with few exceptions rock painting is confined to the mountainous country west of the Mississippi, with two zones of concentration—one in southwest Texas and the other in California, south of San Francisco.

The rock art in California and throughout the West has long been neglected by the archeologists because of the difficulty of dating the paintings or relating them to a specific aboriginal culture. With a single exception that will be noted later, we have no ethnographic knowledge of the purpose of these pictures. In California, thousands of prehistoric village and camp sites have kept generations of archeologists busy with spade and notebook, and only recently a few workers have begun to attack the riddle of the painted rocks.

It is interesting that one site near Santa Barbara was recorded years before the discovery of the Altamira Cave. However, the first published book mentioning California paintings was Garrick Mallery's *Pictographs of the North American Indians* (1886), in which he described sites from California. It was not until 1929 that Julian Steward wrote *Petroglyphs of California and Adjoining States,* the

Works in this article were copied by the author from faded originals. In this Caliente Range example, the "target," top left, was moved into picture from left.

first attempt at a systematic classification of design elements, including 70 painted sites from California. These two books, long out of print and very rare, are the only ones available to students of California pictographs. Since 1929, many more sites have been recorded by the University of California and the Santa Barbara Museum of Natural History. There are at present over 500 known locations of rock art in California.

This art form is divided into two categories: pictographs, or painted rocks, and petroglyphs, rocks with pecked or incised designs. Near the eastern border of the state the crest of the Sierra Nevada separates the predominantly petroglyph areas to the east from the pictograph regions to the west. There is a certain amount of overlap between the two techniques, especially north and south of the mountain range, but mainly the separation is marked. East of the crest, smooth basaltic rocks are common, and here the designs are pecked into the surface with a pointed rock. The lighter tone of the underrock gives a good contrast to the outline. West of the crest is the granite of the Sierra foothills and the sandstone of the coastal ranges, where most of the paintings are found. Of the known sites, 278 are pictographs, 197 are petroglyphs, and at 42 sites both techniques are present.

Most of the pictographs in California are found in four areas ranging in environment from redwood forest to Joshua tree desert. The first of these is in the northeastern part of the state, isolated by several hundred miles from the other pictograph regions to the south. Here there are numerous pictograph and petroglyph sites, and at a number of these, too, the two techniques occur together. This is high desert country, centering around Tule Lake and the extensive Modoc lava beds to the south. Although there is much similarity between the design elements of the pictographs and petroglyphs of the area, the latter, judging from the surface weathering, appear to be much older. Most of the paintings are done in red with simple curvilinear and geometric designs that feature sun disks, concentric circles, triangles, zigzags, and, rarely, men. Some show many dotted lines, and in a few cases there is polychrome painting, similar to some of the Santa Barbara-Tulare sites far to the south.

Moving southward, the next concentration of rock paintings is in the Tulare area—the Sierra Nevada foothills of the San Joaquin Valley and the Tehachapi Mountains adjoining the southern tip of the Sierra Nevada. The San Joaquin area is characterized by great granite boulders in rolling grasslands and oak groves, while the Tehachapi Range is a dry semidesert country with sandstone and granite. All the common mineral colors occur here: red, white, black, and yellow, which are often combined to make striking polychrome effects. Simple curvilinear designs are rare and the combination of design elements into complex patterns is common. There is an over-all effect of abstract, non-representational art, with numerous anthropomorphic and zoomorphic creatures. At only a few sites have recognizable animals been painted—turtle, lizard, beaver, centipede, and horse.

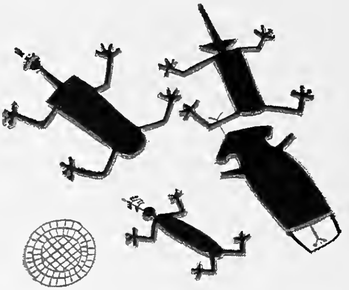
To the west and southwest of the Tulare area is the Santa Barbara region where the California rock paintings reach their peak in elaborate design and skillful execution. Here the paintings are found in the coastal ranges, a region of short, intermittent streams and dense underbrush. The common rock is sandstone, although a few sites are known in conglomerate and basaltic formations. The paintings are usually in shallow, wind-scoured rock shelters, not unlike the *abris* of southern France, or on vertical cliff faces. There is always water nearby, either a spring or a running stream, and frequently bedrock mortars are found close to the paintings. I have investigated this region intensively for the past several years, and as a result the known sites have more than tripled. Although close to the cities of Santa Barbara and Ventura, the rough, mountainous back country with its head-high brush is so difficult to penetrate that many beautiful sites have remained hidden. Some Santa Barbara sites are covered with a bewildering assortment of zoomorphic creatures that often suggest insects, while in others basically simple shapes like concentric circles have been elaborated on to create effects of great richness and beauty.

Far up the coast is an isolated pictograph area that seems to be an extension of the Santa Barbara or Tulare influence. The paintings are highly localized in the redwood-pine forest country of the Santa Lucia Range. These designs are chiefly linear, with some polychrome in red, black, and white.

The fourth pictograph complex is in the southwestern part of the state, with a marked concentration near the city of Twenty-nine Palms. The eastern side of southwestern California is true desert, while the western side is a continuation of the brush-covered coastal ranges noted in the Santa Barbara area. This whole region is dominated by red, geometric, linear designs, often in chains of diamonds or parallel rows of chevrons and zigzags, which are usually painted on the vertical faces of isolated boulders.

In addition to the four main areas, isolated painted rocks are scattered throughout the state. The colors are all earth colors, the most permanent of pigments; in well-protected spots they are as brilliant as they must have been when first applied. The red was an iron oxide, hematite; the yellow was derived from another iron oxide, limonite. White paint was made of diatomaceous earth and the black could be charcoal, burned graphite, or a manganese, while the rare blues and greens came from serpentine or copper ore rocks.

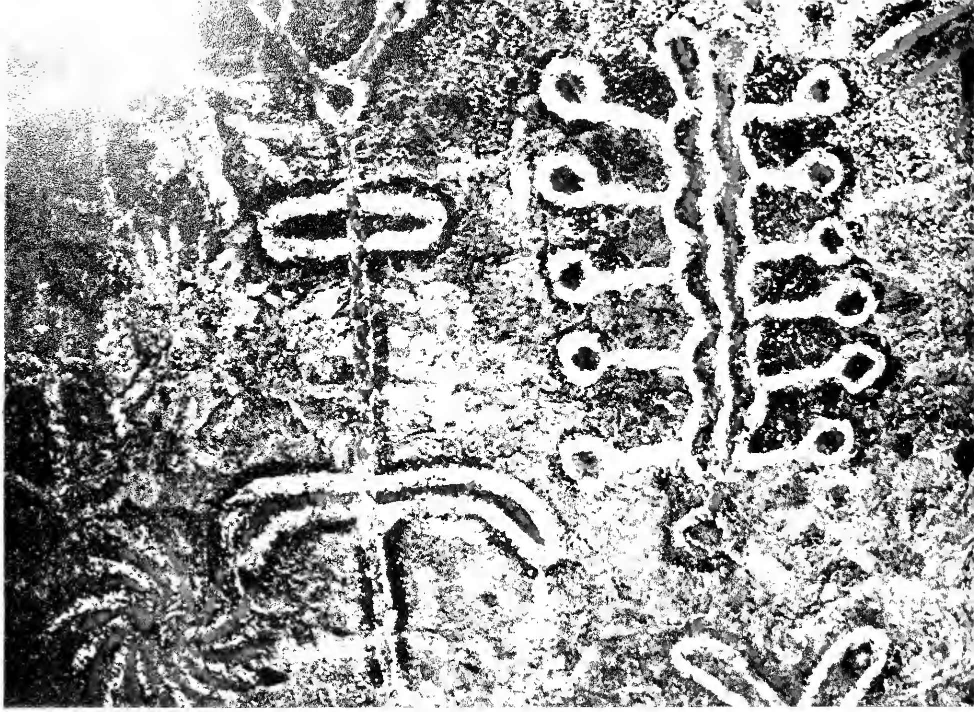
It is a thrilling experience to search, sometimes for days, through the rough underbrush and at last come upon some of these exciting examples of aboriginal art. But seeing them and enjoying them as art is not quite enough—one wants to know more. Who painted them? What do they mean? How old are they?

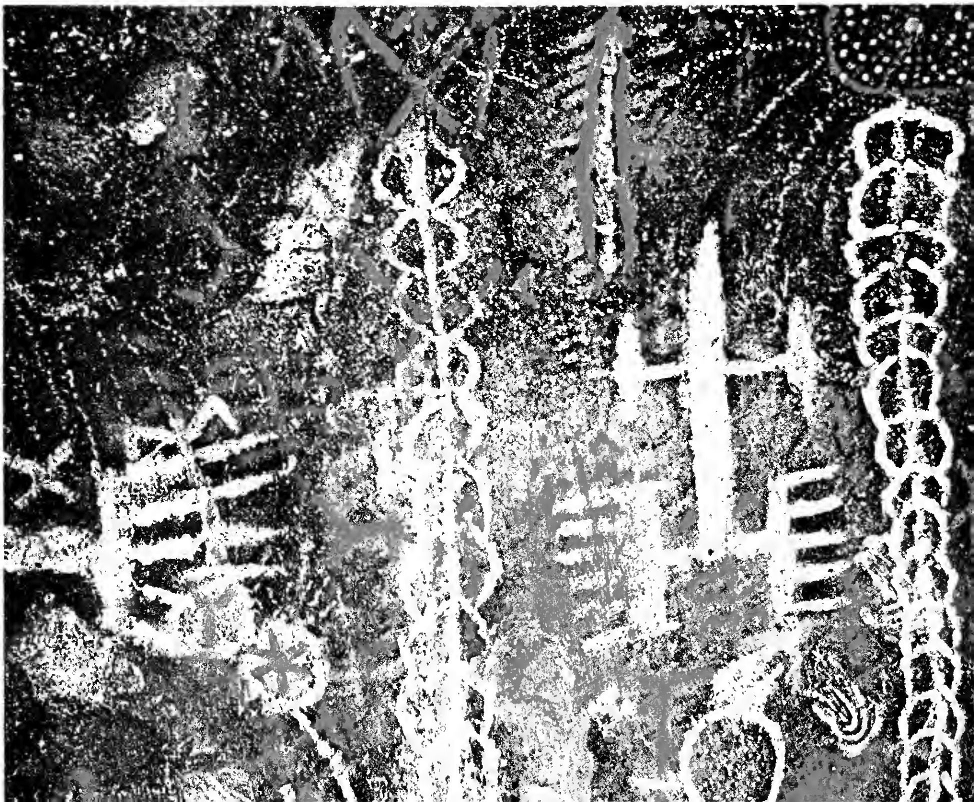


Humorous figures are from a cave region in a high mountain meadow in south central California.
A total of six caves bore several hundred of them.

Possibly a rendering of a medicine man, this figure has antlered head and darts stuck in his sides. Painting is from a cave in the San Rafael Mountains.

Five-foot-long composition that appears on ceiling of a small cave in California's San Emigdio Range is among most complex in design and colors.





etail of very large painting from Tulare region
the Sierra Nevada Mountains is 22 inches
h and resembles coastal range works in technique.

In answering these questions, the amateurs have rushed in where professionals feared to tread. Their theories about the paintings and carvings are marvelously diverse and usually are exotic or exciting. Invariably the theorists approach the problem in reverse, examining the pictograph to find symbols that will back up a favorite idea. They see ancient invasions of our continent by Egyptians, Chinese, Greeks, Romans, and even the ubiquitous Ten Lost Tribes of Israel. Only last year I was photographing a wall at the well-known Painted Cave near Santa Barbara, when a group of pilgrims listened as their solemn-faced leader pointed out Babylonian symbols! The tenacious fabrications about the lost continents of Atlantis and Mu, and Aztec migrations are injected. Another school sees in the designs a long-lost art of picture writing, awaiting only a modern Champollion to decipher them.

Alas, there are no facts to back up these interesting theories, only unshakable wishful thinking. Overwhelming evidence points to the California Indians as the creators of the California rock art. A partial answer to who painted the pictures, why, and when can be given through a knowledge of the Indians who were in possession of the pictograph regions when the White occupation began.

In 1769 Father Junípero Serra founded the first of the twenty-one California missions. It has been estimated that there were 133,000 Indians in the state, nearly half of whom were directly or indirectly affected by the missions. After sixty-five years of benevolent exploitation, the mission system ended, and the few Indians who had survived the Spanish-introduced diseases lived around the crumbling missions until the final disaster—the discovery of gold on the American River. The deluge of gold seekers swept into eastern and northern California—areas that had been spared the mission experience—and dealt mercilessly with the peaceful California Indians. Those who were not killed were driven into the mountains and were eventually gathered on small reservations. By 1910, the Indian population of California had been decreased by nearly 90 per cent. The previous generations having disposed of the "Indian problem," anthropologists began in the 1870's to reconstruct the vanished cultures, and today we know a good deal about an ancient way of life.

There is radiocarbon evidence that man has lived in California for more than 10,000 years. One hundred five different tribes, speaking more than 100 dialects of five language stocks, reflected many invasions and migrations through the centuries. Most of the Indians were seed gatherers; others hunted and fished along the coast and in the mountains. Along the lower Colorado River, the Yuma and Mohave tribes practiced agriculture. Excepting the nomadic peoples of the eastern California deserts, the Indians led a sedentary village life, secured by an abundance of food. All tribes had shamans, or medicine men, who were the interpreters of nature and claimed the power to communicate with the unseen spirits of good and evil. The primary function of the shaman was curing disease. In addition, there were specialized shamans known as rain or weather doctors; rattlesnake doctors who cured snake bites; and bear doctors who could take on the shape of a grizzly bear and destroy enemies. Throughout the state a number of ritual cults were practiced with elaborate ceremonies. For instance, rites of the Chinigchinich cult of southern California used both sand painting and *toloache,* a vision-inducing narcotic.

elatively clear pictograph from Santa Susana
untains near Santa Barbara is part of large group
was overpainted several times by Indians.

In one of the pictograph regions we have ethnographic evidence of the purpose of the paintings. Both the Luiseño and Cupeño tribes of the southwest had girls' puberty rites, which included the use of pictographs. The girls first spent three days in a pit with heated rocks. On the morning of the fourth day they were taken from the pit, their faces were painted black and remained so for a month. In the second month, vertical white lines were painted on their faces, and in the third month wavy, red, horizontal lines were added. After ceremonies, including sand painting, the girls raced to a certain rock where red pigment was given them by relatives and where they then painted diamond-shaped designs representing the rattlesnake. Such designs are common in the region.

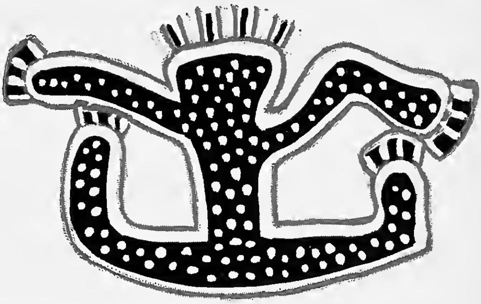
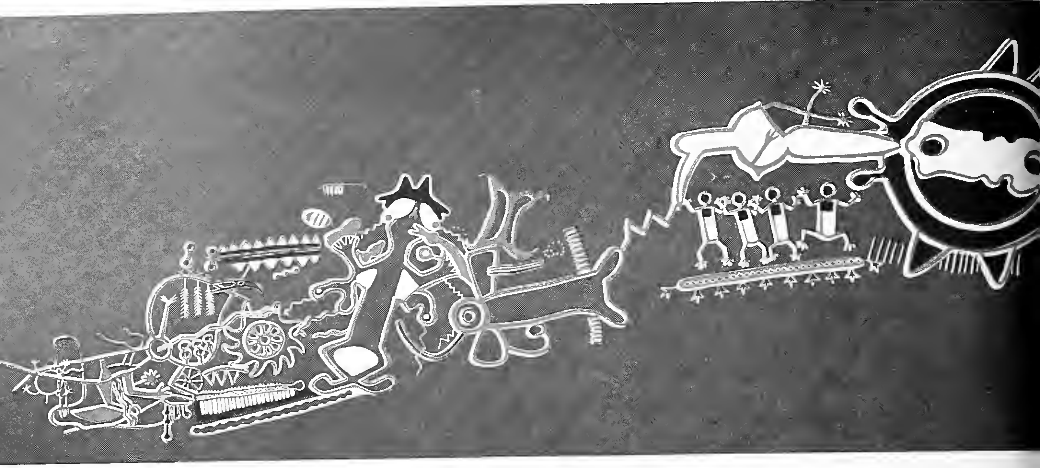


Figure in red, black, and white is about five
inches high and is from area of the Seape River near
Santa Barbara. Site had more than 40 odd figures.

Several hundred Yokuts in the Tulare area have survived and, although they have no knowledge of the meaning or purpose of the ancient pictures, they are able to give precise descriptions of the preparation of paints for ceremonial use. The pigment materials were reduced to powder in a mortar and then, by the addition of a little water, molded into fist-sized cakes. Brushes were made of bound fiber, although paint was sometimes applied with a finger or a pointed stick.

We have no ethnographic knowledge about the paintings in the Santa Barbara area. The small Esselen tribe of the Santa Lucia Range to the north and the great Chumash nation to the south had ceased to exist by the time the investigators came on the scene. The situation is the same with the Modocs of the northeastern area—we have no direct information. The only approach to some understanding of the mysterious significance of these pictures must, therefore, be indirect.

Fortunately, there are at least two places where painting of this type is still done. The Navaho of Arizona and New Mexico make sand paintings during elaborate ceremonies designed both to heal and to drive away malign spirits. These feature highly stylized anthropomorphic beings similar to those on the California rock paintings. They are done by relatives and friends of the patient under the direction of the medicine men, and the figures



personify powerful beings and animals that will aid in the cure. In Australia, where both rock and sand paintings are made ritually, there are the curious *wondjina* paintings on rock. Every year just before the rains these pictographs are repainted by the chief of the tribe under the protection of a *wondjina*—the bestower of all good things.

Circumstantial evidence is strong that most of the pictographs in California were made in connection with some ceremony, either by the shamans or under their guidance. They are often hidden in the most remote and inaccessible places, and were certainly not for display as art for art's sake. One of the most elaborate paintings I have seen is approached by crawling into a narrow, two-foot-wide cleft, where only a small section of the sixteen-foot-long picture can be seen at a time. Such paintings apparently consist of elements added from time to time and inspired by the original creation. Thus it appears that pictures were not only made but sometimes added to in connection with ceremonies. The exact meaning of any individual painting will never be known, and it is doubtful that we could understand the significance even if the creator were alive to explain it. The Indian did not think as we do, nor did he interpret his ideas as we would. Theodora Kroeber, in her book *Ishi in Two Worlds*, says: "The California Indian was . . . an introvert, reserved, contemplative and philosophical. He lived at ease with the supernatural and the mystical, which was pervasive in all aspects of life. He felt no need to differentiate mystical truth from direct or material truth, or the supernatural from the natural; one was as manifest as the other in his system of values and perceptions and beliefs."

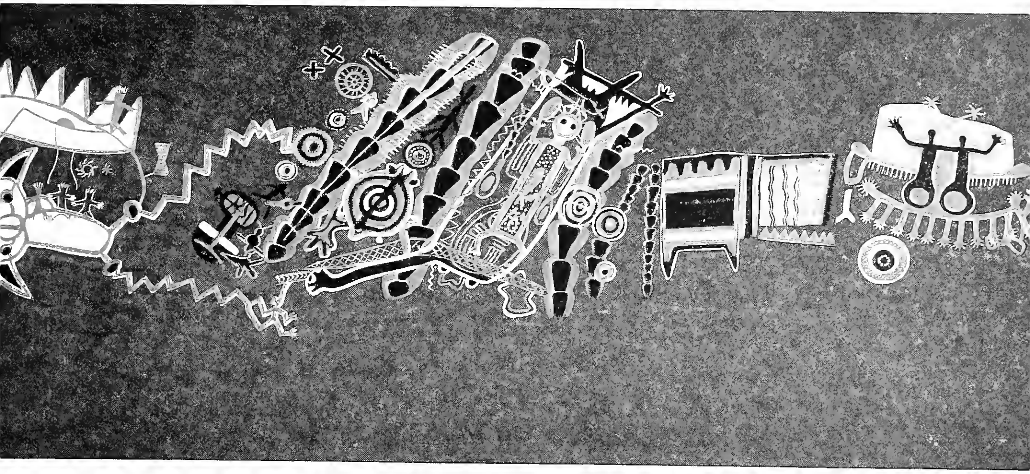
WHILE most of the pictographs were certainly made for religious purposes, some of the simpler ones may have been trail markers; others, like a series of short, parallel lines, suggest a primitive method of counting. In the eastern Sierra Nevada there are sites showing game animals, generally in petroglyph form. They could have been made for the purpose of hunting magic, to bring an increase of game or luck. Many of the great Paleolithic cave paintings in Europe were undoubtedly made for these same purposes.

The tendency of art to develop into abstract forms from naturalistic beginnings is well demonstrated by the pictographs in the western United States. In areas of long-settled community life, such as the Pacific Northwest, California, and the Pueblo country, the design elements are overwhelmingly abstract. The areas populated by nomadic bands of hunting peoples have chiefly naturalistic forms—large game animals, hunters, and warriors. As nomadic tribes settled into a sedentary existence, their visualizations of the natural and supernatural tended to depart further from realism.

The question of dating the pictographs is an extremely difficult one. In the Santa Barbara area one cave shows four horsemen in profile, which inevitably dates it from the early Spanish era, since prior to that time the horse was unknown. These cannot have been very old. I have tried to date paint fragments from a Santa Barbara site by the radiocarbon method, hoping that enough of the organic oil binder remained in the sample. The result was inconclusive, but the laboratory comment indicated no great age. Recently many artifacts of the last Chumash culture have been found in the Santa Barbara Mountains, cached in caves adjacent to painted rocks. A basketry fragment from such a find has been dated at 120 years, plus or minus 80. The Chumash-speaking people, however, had been in continuous occupation of the area for several thousand years. Some paintings in protected spots are covered with a patina of lichens and could be very old. Other sites show extensive painting under later designs, suggesting a respectable antiquity.

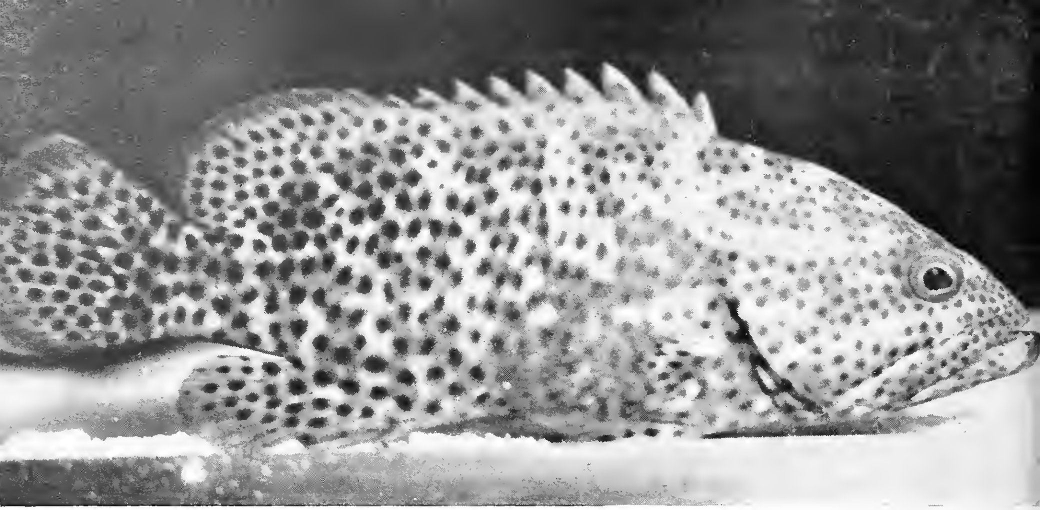
The paintings in the Santa Lucia Range are probably an extension of the Santa Barbara tradition, and the dating would be similar. The problem in the Tulare and northeastern regions is more difficult, as the pictographs are on granite or basalt, which have a very slow rate of erosion. Some of these may be much older than the oldest in the Santa Barbara country.

The most likely conclusion we can come to is that rock painting was part of a long-established Indian ceremonial tradition, enduring in some areas until the Spanish mission period. Even though we do not know what these pictographs meant to the original creators, we can still enjoy them as art. The curious combinations of form and color are a constant joy to the eye. These mysterious paintings are reminders of man's ceaseless efforts to identify himself with the unseen world of the mind and spirit.



rom major site in the Santa Barbara locale, this
foot-long, vandal-destroyed pictograph was
onstructed from photos that were made in the 1890's.

This composition in the Caliente Range seems to feature a central fertility figure. Artist moved the lower cluster of figures into picture from left.



Hermaphroditism in Bahama Groupers

Born as females, tropical sea basses later change into male

By C. Lavett Smith

Sexual reproduction is the process whereby new individuals result from the union of an egg cell with a sperm cell. Among the vertebrates it is usual to have separate sexes, but in some fishes the male and female organs are housed in the same individual. It now appears that the large sea basses called groupers begin life as females and later change into males. This type of hermaphroditism is called protogyny, and its study may have far-reaching implications in our efforts to trace the evolution of sexual mechanisms. It may also aid in tracing the evolutionary history of the fishes.

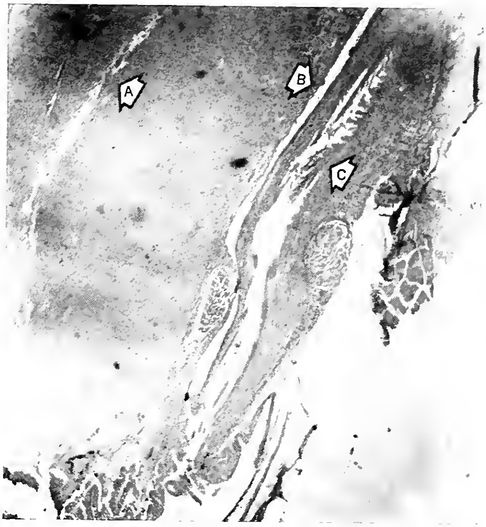
The groupers are large or moderately large fishes that live in reef areas of warm seas. The spectacular jewfish, which reaches a weight of over seven hundred pounds, is a grouper, and the red hind and coney are also groupers. There are thirty-three species of groupers in the New World and probably over one hundred throughout the world.

Several years ago the Bermuda Government supported a program of basic research on the local groupers, which make up something over three-fourths of the commercial fish catch. It was during this study that I first became aware of the existence of protogynous hermaphroditism in groupers. One of my first tasks was to learn how to tell the sexes apart in order to eliminate any possibility that what appeared to be two different species might in fact be males and females of the same kind. To my consternation, I soon found that unless the fish were in spawning condition I could not determine their sex, even when I dissected them and examined the reproductive organs. In order to clarify the situation I prepared some of these organs for microscopic examination. All of the first dozen or so checked proved to be female. At first this seemed to indicate that the males might have different habits and were not being caught in the traps; then I remembered that commercial fishermen had said that when the sexes could be distinguishe the males tended to be larger than t females and that the very largest fis were always males.

From this there emerged the fasci ating possibility that these fishes begi life as females and later become male It seemed unlikely, but it is known tha certain near relatives of the grouper also members of the family Serran dae, are synchronous hermaphrodite —male and female at the same time and some Mediterranean porgies a first males and then females. Thus, th hypothesis of a sex change was n entirely unreasonable, and I set abou finding ways to test it.

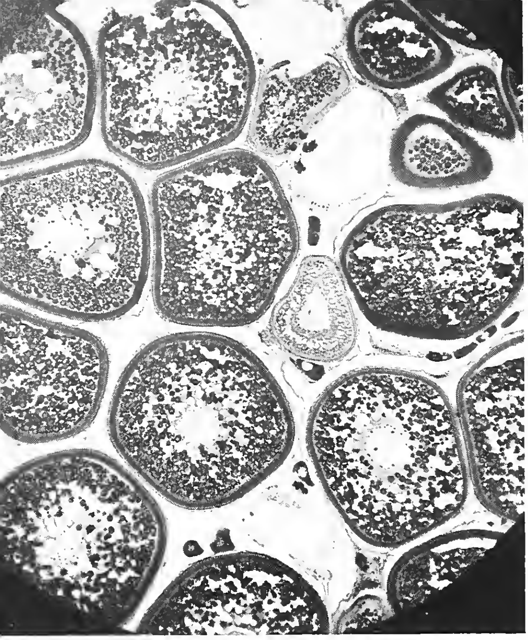
First, field data pertaining to rip fishes were re-examined and they co firmed the fishermen's observation In general, the males were larger, bu there is a wide range of sizes at whic the fish can be either males or female This was suggestive but not conclu sive, because it might only have mean that the males mature later and gro to a larger size than the females. Next

OUPER AT LEFT is a graysby (*Petrometopon cruentatum*). ngitudinal section of a female reproductive organ shows) eggs developing in central cavity, (B) urinary bladder.

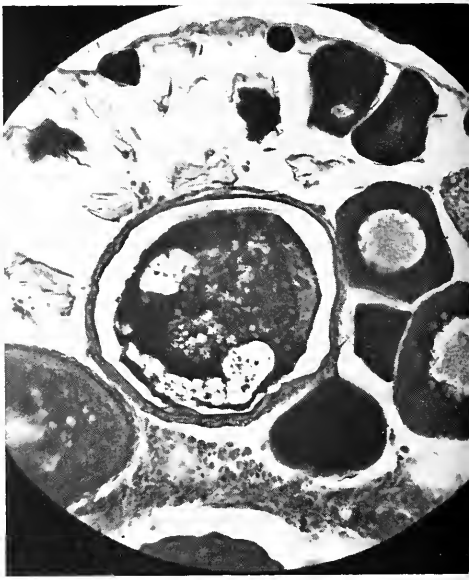


SECTION AT RIGHT is of ripe female's lower reproductive tract, and shows the existence of both the egg canal (A) and sperm duct (B). Third cavity (C) is the urinary duct.

CROSS SECTION of ovary of a developing female. *below*, rounded dark masses are oöcytes in various stages of elopment in lamellae that extend into the central cavity.



EGGS, OR OÖCYTES, are ready for spawning. In the largest eggs, clear nucleus is surrounded by dark yolk materials.



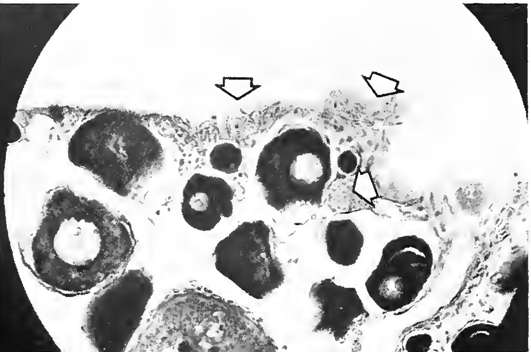
HIGHER MAGNIFICATION reveals the degeneration of conter *above*, in an egg that was not released at time of spawni

I prepared a large series of reproductive organs for histological study. The tissue must be properly preserved, then impregnated and embedded in paraffin. It is then cut into thin slices on a machine called a microtome, the paraffin is removed, the tissue is stained to bring out the cellular detail, and the sections are mounted for study. Altogether we examined the gonads of over three hundred specimens representing nine species of groupers. The pattern remained: all of the smallest fish were females and most of the largest were males, although there was a wide overlap. In a few species—the mutton hamlets, for instance—females were bigger than the males, possibly because the samples were inadequate and did not include the largest sizes that are indigenous to that area.

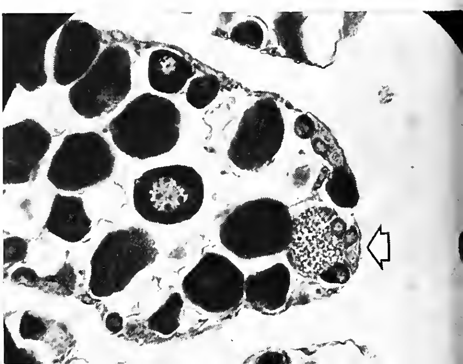
We also found males that appeared to be transforming. These contained male tissue that consisted of little nests of cells in various stages of spermatogenesis. They also contained several stages of developing and degenerating eggs. Even the largest males had structures that appeared to be the remains of eggs scattered throughout their reproductive organs. Apparently these were eggs that developed during the female stage but for one reason or another were not released.

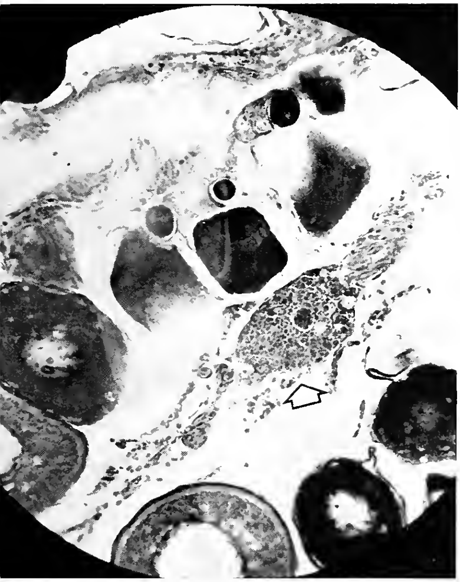
We then turned to the general structure of the grouper reproducti system. Each ovary is a hollow sac, t right and left ovaries joining at t back of the body cavity to form a tu that is the common oviduct. T walls of the ovary are lined with fol or lamellae. each consisting of a c tral layer of spongy connective tiss and an outer layer of germinal e thelium. The eggs develop from ce of this germinal layer, and as th grow they fill the lamella. Blood v sels run in the spongy layer to all pa of the lamella. At the time of spaw ing, eggs are released into the cent cavity of the organ and pass down common oviduct. Normally the o duct ends in a spongy mass of tiss

CELL NESTS (*arrows*) in the female will become testicular tissues, known as seminiferous crypts, in the male stage.

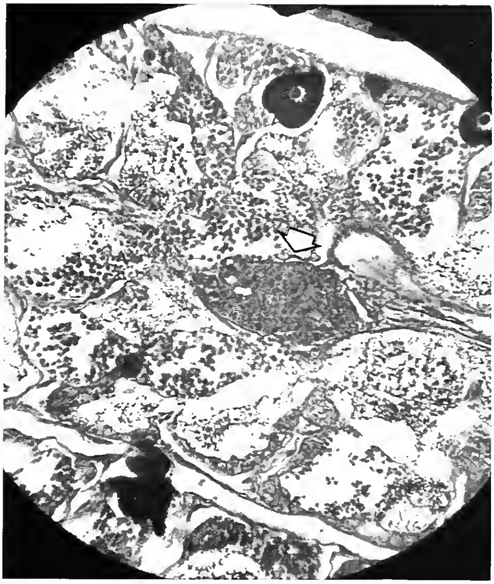


MAGNIFICATION shows that while still in immature fem stage, some seminiferous crypts (*arrow*) fill with sper





HE FINAL STAGES of degeneration of the unreleased egg, erial (*arrow*) is transported to central part of lamella.



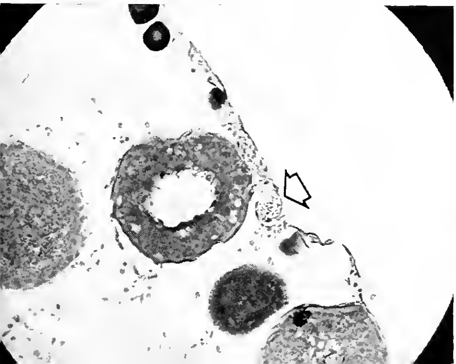
EGG REMNANTS (*arrow*) are retained by the functional male in the same position as when fish was in the female stage.

ruptures, allowing eggs to pass out. hermaphroditic fishes, the basic cture of the male organ is the same hat of the female. Sperms are pro- ed in small pockets, or crypts, in lamellae, but instead of being re- ed into the central cavity they el through irregular, intercon- ed spaces into sperm sinuses in outer region of the testis. Eventu- these empty into a single sperm . The duct, which opens to the out- , is located in the posterior wall of common oviduct. The ovarian en remains in the male but is no er used. In fishes with separate s, however, there is no central ty; rather, the testis is solid with sperm tubules and a sperm duct is at one side. Further study revealed that the sperm duct is present in juveniles and females long before it becomes functional during the male phase.

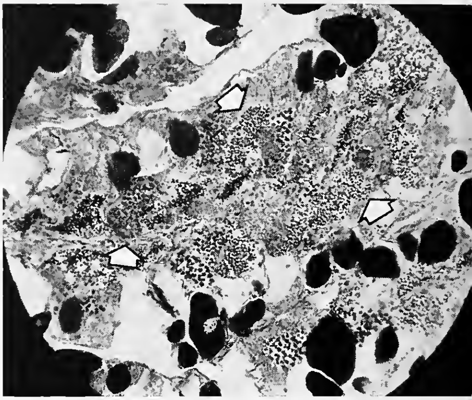
THERE is yet a problem in interpreting the significance of these reproductive tissues. It has been shown by other workers that some fishes pass through a temporarily non-functional hermaphroditic stage during their development. In this indifferent period the gonad contains cells that look like developing eggs, but in males they never become functional. Could it be that in groupers this temporary condition is prolonged in the males until they reach the size at which some of the females are already mature? I think not, because the remnants often seem to be those of advanced eggs in which the membranous shells had already formed. Therefore, these animals must have functioned as females.

It has been difficult to determine how long groupers remain females or at what age they transform into males. Because they are found in tropical and semitropical waters, the usual method of determining age—by counting annual rings on scales and other bony parts—is somewhat unreliable. Rings are only deposited where there are pronounced seasonal variations. Preliminary studies by the Florida State

ENCE of hermaphroditism is seen by presence of crypt ow) adjacent to ripening oöcyte in a spawning female.



MATURE SPERM taken at an X900 magnification indicates that even while spawning, fish is changing to male stage.



Board of Conservation indicate that one rather large species, *Mycteroperca microlepis* (known as gag) matures as a female at four or five years and transforms to a male at about ten.

The ultimate test, of course, is to keep the fish in captivity and watch the transformation. Since there are no external features for distinguishing the sexes it is necessary to operate on the fish and remove a piece of the reproductive organ for microscopic examination in order to establish its original sex. We have now performed this operation on a group of fish at The American Museum's Lerner Marine Laboratory in the Bahamas, but so far none has transformed. It is entirely possible that the fish will not transform in captivity or that the operation prevents the change.

Before we can understand the fundamental processes involved we must know more about the structure of the gonad itself. Careful study of the germinal epithelial layer has revealed that in juveniles and in ripe females there are small nests of cells (spermatogonia) that give rise to the sperm-producing crypts. These cells are very similar to the cells (oögonia) that give rise to eggs, but there are certain distinguishing characteristics. Occasionally these spermatogonia undergo a precocious spermatogenesis that results in the appearance of small clusters of sperm cells even in fully ripe females. These isolated groups of sperm are probably non-functional, because there is apparently no way in which they can get beyond the membrane that encloses them.

Thus it appears that this type of protogynous gonad is really a compound organ with male and female tissues admixed. This raises a whole set of new questions: Are any hormones involved and, if so, where are they produced? Is the change triggered by some factor in the environment, or is it an innate property of the tissues? If the latter is the case, perhaps we can learn something of the general problems of aging by studying these fish organs. Sex of other vertebrates is controlled by special chromosomes—do hermaphrodites have sex chromosomes?

ANOTHER aspect worth considering is the adaptive value of this type of hermaphroditism to the animals themselves. In these protogynous hermaphrodites the sexes are functionally distinct, and at least two individuals are required for reproduction. Thus, this type of sexuality lacks the obvious advantage of synchronous hermaphroditism, in which one individual can fertilize its own eggs and reproduce without a mate. It may be suggested that protogyny would tend to increase egg production because every individual—not just the females—would produce some eggs. Furthermore, after the fish have transformed only the males would die, but usually one male can fertilize the eggs produced by several females. On the other hand, transformation has the same effect as the death of a female. That is, for purposes of egg production a transformed female no longer exists as a female. Until we know much more about mortality rates and other population phenomena we cannot begin to evaluate the significance of these contrasting influences.

It is interesting to speculate on the origin of the hermaphroditic mechanism. Perhaps protogyny is just amplification of the condition where the males pass through a female-li indifferent stage. If the indiffere cells merely continue to develop eg protogynous hermaphroditism w occur. But then what of the norn females that do not transform? Cou there be two kinds of female groupe —those that become males and tho that do not? Such a situation has cently been reported in some Medit ranean wrasses (a related family)

Detailed studies may clarify the lationship between the protogyno groupers and the synchronously h maphroditic relatives. Structural culiarities may confirm or elimin the possibility of one type havi given rise to the other type. This l of investigation is being pursued in t hope that it will provide clues to t evolutionary history of certain simi genera and families of fishes.

It might seem that intensive stu of hermaphroditism in vertebrates h limited significance because so f forms are hermaphroditic. We mu however, bear in mind that unusu phenomena sometimes indicate c tain basic family relationships th otherwise could not be detected. R cently it has been shown that hermap roditism of one type or another curs in at least ten diverse fish famil representing five entirely differe orders. Are these independently rived, parallel modifications of the productive system, or are they indic tions of common ancestry? We c expect that a careful investigation sexual mechanisms will contrib significantly to the long-range obj tive of constructing an improv higher classification of all the fish

INIFEROUS CRYPTS (*arrows*) in series, *left*, are along
edge of lamella in transitional stage, and then fill it.
rent-sized cell nuclei indicate that spermatogenesis
king place. Dark masses are the remains of oöcytes.

TRANSFORMED MALE shows mature testicular tissue and oöcyte remnants. White areas are the remains of ovarian lumen. Dark area in upper right (*arrow*) is sperm duct.

FULLY MATURE MALE, sperm duct, or sinus (*arrow*),
cked with sperm. A few of the oöcyte particles still
in in lamellae that are separated by radial spaces.

g curve is one of the two
w scales flanking Samrat
a, the principal sundial-like
ment at observatory.

In front of Jai Singh's palace are a small version of Samrat Yantra, center, and a target-like equatorial sundial, at left.

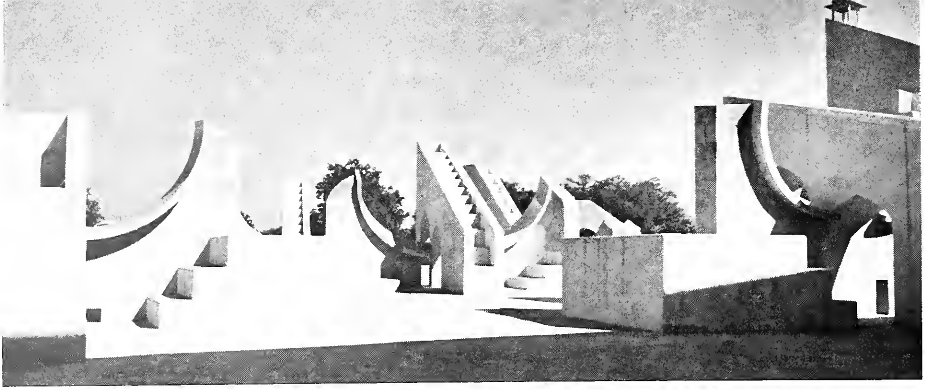
ASTRONOMY'S PAST PRESERVED AT Jaipur

by DEREK J. de SOLLA PRICE

In the city of Jaipur, sixty miles southwest of Delhi, tands a spacious palace courtyard filled with massive tructures of masonry, the pure scientific and functional lines of which make them appear to be part of hat space-age architecture that has become familiar rom rocketry and radio telescopes. This huge observatory, for such it is, provides a remarkable intance, from other times and another culture than ur own, of extremely heavy governmental expendiure on behalf of science.

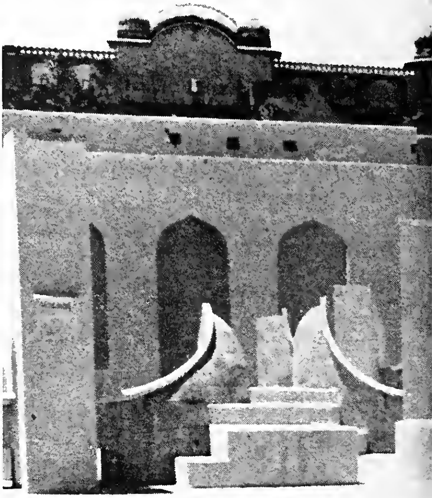
It was built about 1728 by Maharaja Sawai Jai ingh II (1686-1743) in his favorite, newly created apital city, as one of five structures located in the iggest towns of the Amber Territory, which he ruled nder the Mogul Emperor Mohammed Shah. In some vays it is fantastic that a country torn by war and amine, as Hindustan was in those darkest days following the death of Emperor Aurangzeb, should give p such a large part of its work and precious reources to build great observatories in the most opuent traditions of the Egyptian pyramids and the medieval cathedrals. It is even more puzzling when we consider that, although Jai Singh was no mean scholar, his primary fame and interests were with the Machiavellian politics that he waged so successfully to keep his territory and settle it.

Most fantastic of all, this observatory represents the magnificent culmination of all of ancient and medieval astronomy, but so much too late that Europe had already seen not only Copernicus and Tycho Brahe, but also the telescope of Galileo and the powerful mathematics of Newton. Jai Singh was centuries too late with all his splendor, but, strangely enough, it was out of a conservatism of purpose rather than any ignorance of the new astronomy of Europe. His translators into Sanskrit and his Portuguese Jesuit missionary friends used as emissaries enabled him to know and make use of the finest astronomical tables of early eighteenth-century England and France (those of Flamsteed and La Hire), as well as the wisdom of the Greek and Arab astronomers that preceded him in his own tradition.

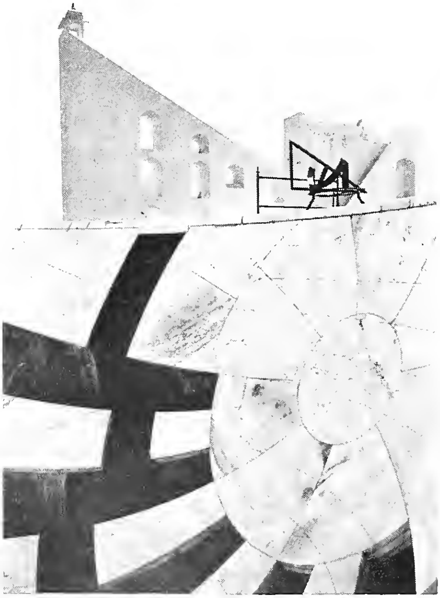


Rasi Valaya comprises twelve miniature versions of main device, each aligned for a zodiacal sign. Cupola at right rear is on top of Samrat Yantra.

Before Rasi Valaya is one of large, hemispherical pits of the Jai Prakash. Its graduated marble surface acts as a bowl sundial, showing rising times.



Bold, black patterns of Jai Prakash bowl are cutouts through which observers behind shell would sight the stars during installation's brief use.



ars Had a Bearing on Earthly Power

Jai Singh is only the last in a long series of poten- ates within the Moslem cultural area who were lriven, almost every century, to build an observatory nd draw up astronomical tables. Behind this move- nent is something much stronger than a mere love f the cause of pure science. In ancient times, the romulgation of the calendar was an imperial right nd a mark of sovereignty as well as an important practical matter. It was perhaps what the use of coinage and postage stamps is in contemporary societies. The acceptance of the rule implied the use of the calendar and vice versa. And for the Moslems, the calendar also had a religious significance.

Now, in order to maintain an accurate calendar it is, of course, desirable to have good and correct astronomical tables to yield the motions of the sun

A Splendid But Unnecessary Gesture

and moon. Fortunately, as early as the second century A.D., Claudius Ptolemaeus of Alexandria had been successful in erecting a complete and satisfying astronomical theory that could give with great exactness the motions of stars and planets. Even though the earth was taken as a stationary point of reference, it may be shown that this system, once set up with the correct initial parameters, would continue to provide almost all possible predicted occurrences to an accuracy as good as the naked eye could detect.

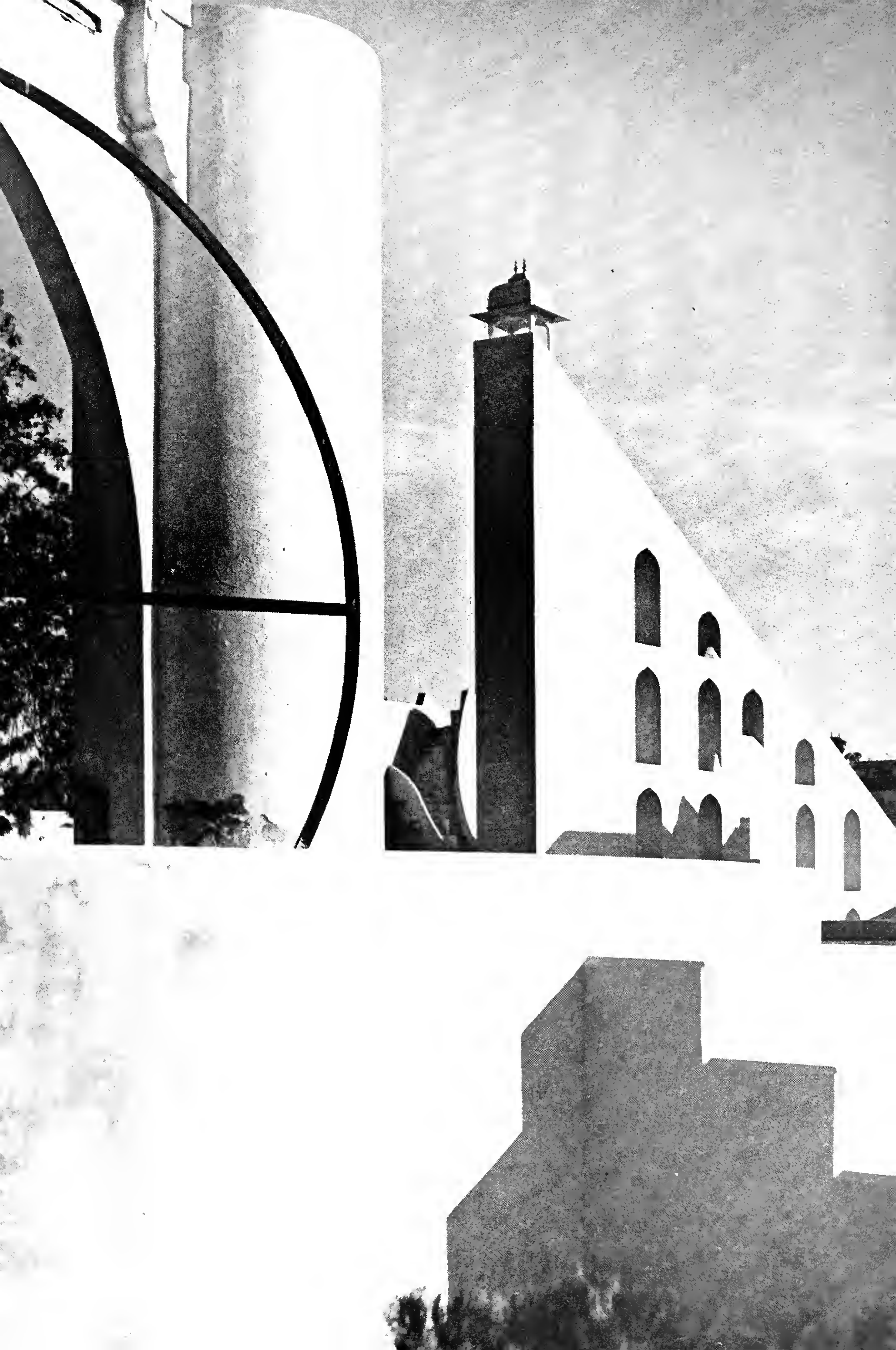
There is, however, one small snag. Even when the principal motions of stars and planets are accounted for in their chief daily, annual, and periodic cycles, there remain a number of small and steady changes, the secular motions, which amount to shifts in position and co-ordinate systems of magnitudes of the order of one degree per century. The best known of these motions is precession, discovered in antiquity but assigned an incorrect value that was hard to depose because of the authority and success of the founders of mathematical astronomy.

The effect of secular motions was to present medieval astronomers with a paradox: Ptolemaic theory was superbly precise, and a firm rock on which accurate calendars could be erected, yet after a few generations it always fell into error and the base values had to be remeasured so that the whole system might be restored to its pristine elegance and precision. It was to this very end that medieval astronomers undertook, at least every century, to determine once more the few basic constants of planetary motion and, thus armed, produce a revised edition of the standard tables that were fundamental to the most powerful science then known and the one that provided so much basis for authority and divine power. Jai Singh was simply following in this tradition, in which he had as predecessors the observatory of al-Mamun at Baghdad in the ninth century, and the later medieval observatories that had been established at Cairo and Maragha, and that of Ulugh-Beg at Samarkand. He was, it may be said, the last medieval astronomer of this line, a conservative who found that Newtonian mathematical understanding and its new outlook upon astronomy did not supplant his persistent need for the traditional functions of calendrical craft and the making of tables.

The paradox of the Jaipur observatory becomes even more dramatic when one realizes that this entire munificence of precision instrument building was provided and used for this single short purpose rather than for any set of extensive observations. The rectification of secular motions would entail probably not more than half a dozen sightings with each of the devices. Possibly they were used a little longer, just out of wonder and for training, but it was not necessary, and the whole grand site could safely be allowed to lapse into disuse (as it did) for another century of secular motion. And yet, although there was so little to do, it must needs be done well, and the monumental size of the devices was dictated by the accuracy that was essential. The acuity of the naked eye is about one minute of arc; to mark divisions on a scale with minutes denoted by lines about one millimeter apart (about as close as one can come with hand-divided scales), it takes a circle about eight yards across—a quadrant as large as a good, old-fashioned living room wall. Like a modern particle accelerator or radio telescope, the instruments had to be large and very expensive in order to work at all, and after working, they rapidly became obsolescent.

History seems to play cruel jests with the most heroic efforts of astronomers. Tycho Brahe, author of the most precise and painstaking observations in naked-eye astronomy, supported by a lifetime of work and a king's ransom of instrumentation, died just before the invention of the telescope was to make all his labors in vain. More than a century later, just as scientific contacts between India and Europe had been established, Jai Singh repeated the tragedy of Brahe, aware, but uncomprehending, of the scientific revolution that had overtaken Europe and that was to lead to an era in which the functional architecture and big expenditure of the Jaipur observatory were to be regarded as a commonplace of civilization.

Cupola-topped Samrat Yantra, about ninety
tall, is in center of the instrument complex at Jai
best-preserved monument to ancient astrono



SKY REPORTER

ar's first total lunar eclipse will be visible on June 24th

By Thomas D. Nicholson

E FIRST of two total lunar eclipses visible this year in ıe United States occurs on the evening of June 24. e part of the eclipse can be seen from most of the try (*see map, page 56*), but it will already be in prog- vhen the moon rises. On December 18, the second total eclipse of 1964 will be visible in its entirety through- he United States, except for Hawaii and southwestern a, where part of the event will be visible.

like a total solar eclipse, which can be seen from only tricted part of the world, a lunar eclipse is visible any part of the world where the moon is above the on at the time of the event. Thus, it is usually stated ach lunar eclipse can be seen from half of the world. on this point later, but for now it explains why we the opportunity to observe more lunar than solar es, although the former are not so common. The rela- roportion of the two types throughout the world is nearly three solar to two lunar eclipses.

ring a total lunar eclipse, we observe the moon as it through the earth's shadow at the time of full moon, he bright full moon darkens considerably. How- the moon does not disappear completely when it the earth's shadow. Generally, there is enough sun- in the shadow of the earth to make the moon's sha- surface appear a dull coppery-red. The light that n the moon when it is in the earth's shadow is be- to be sunlight that has been refracted, or bent, by the s atmosphere. Since the blue light in sunlight is mostly ed by the atmosphere (thus producing the blue of ytime sky), it is red light that passes through the air, into the shadow of the earth, and falls on the moon a lunar eclipse.

s light, however, is not uniform from eclipse to . During some eclipses, the portion of the moon in w appears to be quite bright and almost brick-red r. At other times, the eclipsed moon may be so dark almost disappears. Such was the case during the last unar eclipse on December 30, 1963. Many observers United States reported at that time that the moon ery dark or actually invisible, and even those who see the moon during the total phase reported it to k gray or nearly black rather than copper-toned. In n, some observers described a peculiar bluish color moon along one edge of the earth's shadow and an strange brightness on the edge of the moon that was t to the center of the earth's shadow. These peculiari- de the eclipse a memorable event for observers.

ther the total lunar eclipses of June 24 and December also be unusually dark, or whether they will con- o the pattern of most lunar eclipses, cannot be predicted. There were a number of exceptionally dark eclipses following the volcanic explosion at Krakatoa in 1883, and it has been suggested that the dark eclipse last December may have been caused in part by the dust scattered into the atmosphere by a violent eruption on the island of Bali early in 1963. If so, this may also affect this year's eclipses, but nothing can be said with certainty.

The timetable for the June 24 eclipse is shown on page 56. Times given are Eastern Standard Time, and should be adjusted by subtracting one hour each for Central Standard Time, Mountain Standard Time, and Pacific Standard Time. Communities on daylight time should add one hour.

The penumbra identified in the table is the partial shadow of the earth. When the moon is in the penumbra, direct sunlight still shines on all of its surface, but the brightness is somewhat less than that of the uneclipsed full moon. The umbra is the total shadow of the earth. The darkening of the penumbra is difficult to observe, but the portion of the moon within the umbra is easily seen to be darker than direct sunlight on the full moon. The umbral portions of a lunar eclipse are more interesting to observe than are the penumbral portions.

SINCE the eclipse will already be in progress when the moon rises in the United States, readers may refer to the map again to find out what phases of the eclipse can be observed from various communities. Throughout the eastern portion of the country, the moon will rise during the total phase of the eclipse (before mid-eclipse along the East Coast). When the moon rises it will be seen completely within the earth's shadow, and its emergence from the shadow can be observed from 8:57 P.M. to 10:03 P.M., EST. From the central portion of the United States, the rising moon will appear partly shadowed by the earth and will continue to leave the shadow as it rises. The umbral phases of the eclipse will end before moonrise in the western portion of the country, but the moon will still be in the penumbra, except in the northwestern area shown on the map.

One advantage of a lunar eclipse that is already in progress at moonrise is that it affords the opportunity to take a photograph with some interesting landscape effects, as the one shown on the opposite page. The moon is low enough so that the landscape can easily be included in the camera frame, and there is still plenty of twilight for illumination. Relatively distant landscape features should be selected so they will be sharp at the infinity focus necessary for moon pictures. A telephoto lens is desirable, since the longer focal length results in larger images. A tripod should also be used, if available, because exposures of about two seconds, with fast film, are needed to catch the faint light on the eclipsed moon.

It is interesting to consider how much of the world can observe a lunar eclipse. If the effects of atmospheric refraction and the horizontal parallax of the moon are not taken into consideration, it is approximately true that the

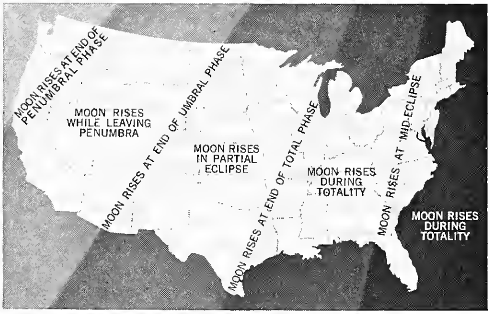
L ECLIPSE of July 15, 1954, seen at moonrise from an Museum-Hayden Planetarium. Rising in an east to notion, moon gradually moves out of earth's shadow.

Irregularity of the earth's shadow is caused by variations in the elevation and darkness of the surface of the moon.

In total eclipse of December, 1963, strange bright lower left, is from sunlight bent by earth's atmosp

moon can be seen from half the world at any one moment. But when we consider that a lunar eclipse lasts for several hours at least, and that the moon will be setting at some places and rising at others during those hours, it becomes apparent that any one such eclipse can actually be observed from much more than half of the world.

The lunar eclipse of June 24, for example, can be observed from part or all of every major land mass except Australia, and it does not even miss Australia by much. When the moon first enters the earth's dark shadow at 6:09 P.M., EST, it will be directly overhead at a point just off the west coast of Africa near Walvis Bay; the half of the world that extends from Sumatra and the eastern Indian Ocean to western South America can see this ta place. When the moon leaves the umbra, nearly four h later, it will be overhead at a point off the coast of Br near Rio de Janeiro, and can be seen from central A westward to the central Pacific, nearly to New Zea From everywhere within these two overlapping h spheres—an area that includes nearly two-thirds of world—some part of the umbral phase of the eclipse be observed. If we also consider the penumbral phas the eclipse (when the moon is within the earth's pa shadow), the area of the earth from which some pa the June 24 eclipse can be seen becomes even greate then includes nearly three-fourths of the earth.



TOTAL LUNAR ECLIPSE JUNE 24, 1964	
Moon enters penumbra	4:58 P.M., EST
Moon enters umbra	6:09 P.M., EST
Total eclipse begins	7:16 P.M., EST
Middle of eclipse	8:06 P.M., EST
Total eclipse ends	8:57 P.M., EST
Moon leaves umbra	10:03 P.M., EST
Moon leaves penumbra	11:14 P.M., EST

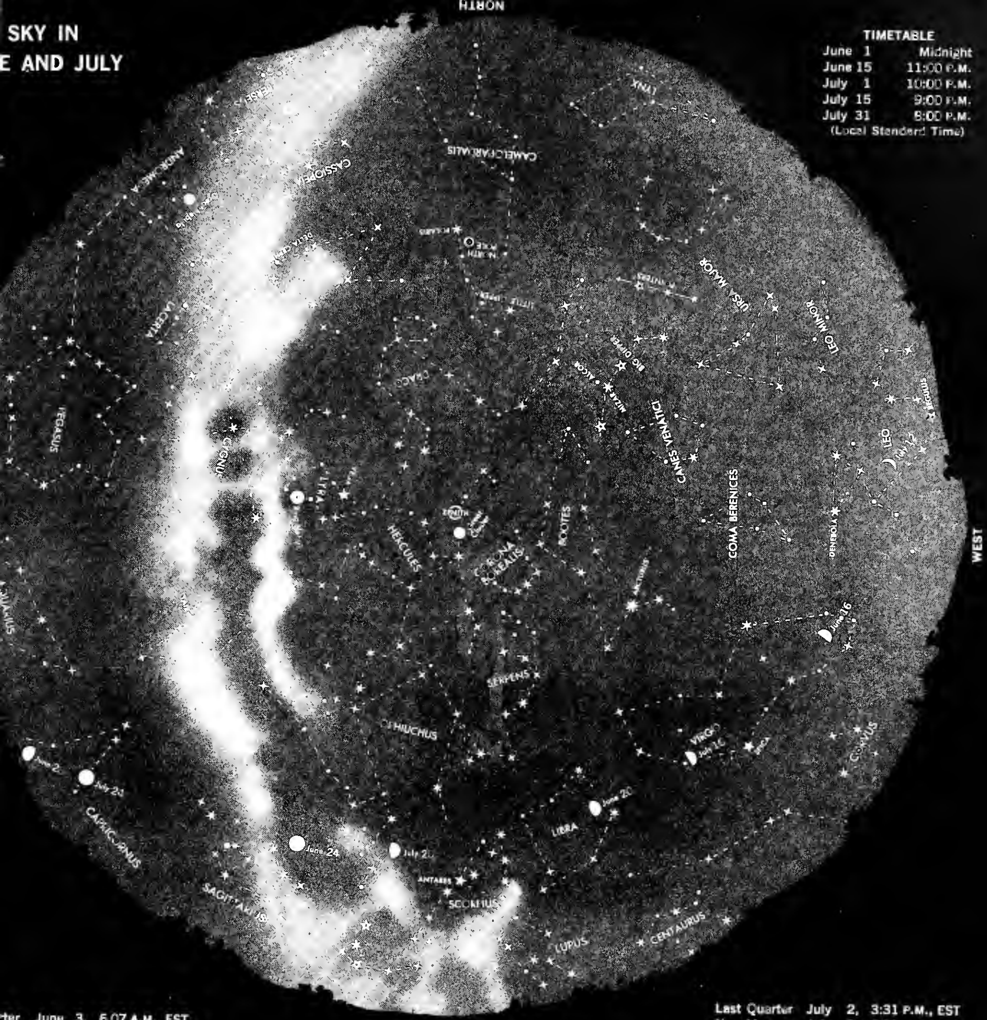
Of course, this might be labeled a very technical cism. Certainly all of the umbral and penum eclipse cannot be observed from the two-thirds to t fourths of the world described above, or from hal world either. The entire umbral phase of the June 24 ec is visible from only about one-third of the world, the total duration of the eclipse (including all phases) be observed from only about one-fourth of the world.

Even the *entire total phase* of the eclipse is visible less than half of the world—47 per cent, to be precise. moon will be visible at some moment or other while totally immersed in the earth's shadow on June 24 about 53 per cent of the world's surface.

To sum up, the moon can be seen from half the wor *any single moment* during the eclipse—as, of course, it be seen at any time, eclipse or not. If the effects of par and refraction are not considered, however, the stater that "half the world can see a lunar eclipse" (implying *all* of the viewing half is able to observe *all* of the phen enon) might be accurate in one limited sense, but bec too generalized to have much practical significance.

Dr. Nicholson is Assistant Chairman, Astronomer, and lecturer at The American Museum-Hayden Planetari

SKY IN
E AND JULY



TIMETABLE

June 1	Midnight
June 15	11:00 P.M.
July 1	10:00 P.M.
July 15	9:00 P.M.
July 31	8:00 P.M.

(Local Standard Time)

rter	June 3,	6.07 A.M., EST
n	June 9,	11:22 P.M., EST
rter	June 16,	6:02 P.M., EST
	June 24,	8:08 P.M., EST

Last Quarter	July 2,	3:31 P.M., EST
New Moon	July 9,	6:31 A.M., EST
First Quarter	July 16,	6:47 A.M., EST
Full Moon	July 24,	10:58 A.M., EST
Last Quarter	July 31,	10:29 P.M., EST

7: Jupiter, prominent in the morning sky, can be seen
and to the left of the crescent moon, and above and to
nt of the moon in the morning sky of the 8th.

9: A partial solar eclipse, visible in Australia, occurs.
on arrives at perigee (nearest earth) shortly before new
The resulting perigee spring tide will bring abnormally
des to coastal areas.

15: Saturn becomes stationary in right ascension and
to move in a retrograde (westerly) direction.

19: Venus, at inferior conjunction, passes between
nd sun and moves into the morning sky.

21: The sun arrives at the summer solstice at 3:57 A.M.,
mmer begins in the Northern Hemisphere.

24: A total lunar eclipse occurs, the end visible from
the United States (see map opposite).

27: Mercury is at superior conjunction and passes
e morning into the evening sky.

1: Mars may be seen in the morning sky as a reddish
gnitude object about six degrees north of the red star
an in Taurus.

7: Venus is becoming prominent in the morning sky,
nd left of the crescent moon before sunrise. Mars is
now fainter and closer to the moon, above and to the right of it.

July 9: The second solar eclipse within a month occurs. This is also a partial eclipse, visible from northern Siberia, Greenland, and North America. It is visible from the parts of Alaska above the Arctic Circle, where it will occur at about midnight of July 8-9.

July 11: Venus becomes stationary in right ascension and resumes direct (easterly) motion.

July 18: Venus and Mars are in conjunction at about 2:00 A.M., EST. They will be close in the morning sky before sunrise, with Mars to the north (left) of brilliant Venus.

July 29: The Delta Aquarid shower occurs during late July and early August, and reaches maximum today. The moon will interfere with late night observations.

Saturn rises before midnight in June, and is visible through the rest of the night, and is in the south by dawn.

In July, Jupiter and Saturn are morning stars. Jupiter rises before midnight by the end of July and appears very bright (magnitude —1.8) in the south by dawn. Saturn (magnitude 0.9) is visible in the southeast after dark and in the southwest by morning. The planet Mercury may now be observed low in the west shortly after sunset as the month comes to an end.

About the Authors

Mr. Luther C. Davis, Jr., the author of "The Amazon's Rate of Flow," is the Assistant Chief of the Foreign Hydrology Section in the Water Resources Division, Geological Survey, United States Department of the Interior. Mr. Davis devotes most of his time to implementing the water resources investigation sector of the U.S. Technical Assistance Program to underdeveloped countries. In 1963, he and three other engineers of the U.S. Geological Survey participated in the hydrologic expedition, on which his article is based.

"Expositions, Exhibits and Today's Museums" is the work of Mr. Gordon Reekie, Chairman of the Department of Exhibition and Graphic Arts at The American Museum. Mr. Reekie, who was born in Barking, England, studied at the University of London, the Southend School of Art, and at the Phoenix Art Institute and the New School, in New York City. Before joining the staff of the Museum in 1953, Mr. Reekie held positions as an art editor and art director.

Mr. Campbell Grant, author and illustrator, prepared the renderings of paintings that accompany his article, "California's Legacy of Indian Rock Art." Mr. Grant is a Trustee and Research Associate of the Santa Barbara Museum of Natural History, a Trustee and Vice President of the Santa Barbara Botanic Garden, and a Trustee of the Santa Barbara Museum of Art. He has written many articles on rock paintings, and is at present extending a museum survey of aboriginal pictographs to include all of California south of San Francisco. Mr. Grant wrote and illustrated *The Chumash Indians and their Rock Painting*, which is to be published this year by the University of California Press.

"Hermaphroditism in Bahama Groupers" is explored in the article by Dr. C. Lavett Smith, Assistant Curator of the Department of Ichthyology at The American Museum. Dr. Smith is also Administrative Co-ordinator of the Lerner Marine Laboratory, in Bimini, the Bahamas, a Museum field station.

Dr. Derek J. de Solla Price, author of "Astronomy's Past Preserved at Jaipur," is Avalon Professor of the History of Science and Chairman of the Department of the History of Science and Medicine at Yale University. He received his doctoral degrees in physics from the University of London and in the history of science from Cambridge University. He has worked as an experimental and mathematical physicist, has taught at the University of Malaya, has served as consultant to the Smithsonian Institution, and was a Donaldson Fellow at the Institute for Advanced Study.

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a, from the arctic to the tropics.

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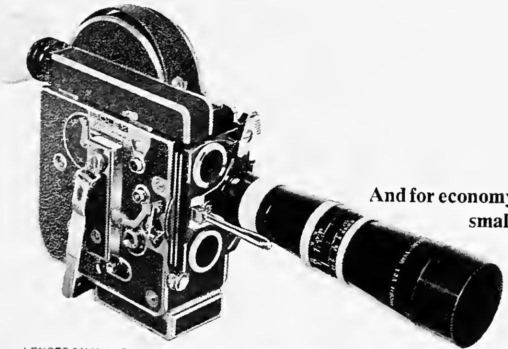

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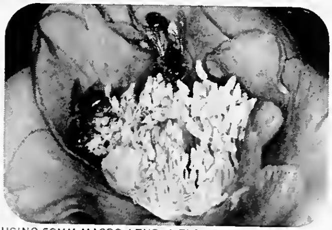

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SCIENCE IN ACTION

Preparing for tomorro

By Perez Malande Olindo

THIS ARTICLE is intended to represent a varied mixture of African outlook on the preservation of wildlife. Ecological variables, social setups, and other environments limit any broad generalities. To gain the support and co-operation of Africans of various regions, suggestions and approaches to wildlife conservation must be restricted to certain specific zones, but can be applied to other areas as mass education in wildlife conservation is enhanced. By virtue of restricted travels on my continent, I have confined my comments, as far as possible, to my homeland—to the Kenya of yesterday and of today and, in places, to the Kenya of tomorrow. I have in no way attempted to outline a governmental policy; I have tried to present a current situation and indicate possible directions.

I was born a few miles from Lake Victoria in one of the most densely populated regions of Kenya. In this area there are very few large game animals today, although we enjoy a great variety of wild birds. Through the stories told in the evenings as part of youth education (storytelling is very much a continuing African custom for passing on information), we learned that once there were many large game animals—lions, elephants, buffaloes, antelopes—but these disappeared as the population increased. This was partly because of the great demand for grazing areas for domestic livestock and the need for land to cultivate.

Lions were a danger to domestic animals adjacent to uncleared areas. (In 1948 I started schooling, and in our first reader was a story of how a lion had devastated an area not too far from our school, killing people and cattle, and of how the invader had been ultimately killed to save the rest of the people.) Other wild game, particularly antelopes, used to invade gardens in great numbers when cultivated beans and peas started flowering. So most of the animals were hunted as they encroached on human interests. To encourage hunting, the people who had killed the truly fierce animals, such as lions, or the big animals, such as elephants, received special recognition. In some ways this enhanced their social status, especially with women. As a result, people in my age group have grown up in an are
prived of the natural beauty and
ness of much of our wildlife.

Conservation Education

WHEN I was a high school sen
began, through a friend, to
respond with Dr. George Petrides, a
servationist and a Professor of Zo
at Michigan State University, who
worked in Kenya and Uganda. By l
Dr. Petrides introduced me to Mr.
Simon, now in Switzerland with th
ternational Union for the Conserv
of Nature, who drew my attentio
publications that would help me u
stand more about wildlife. Withou
knowing it, I had encountered a ch
in my life. I put aside my aspiratio
becoming an engineer or medical do
and decided to study a field in wh

THREE MALE LIONS bask in a game area at the Ngorongoro Crater, which is situated in Great Rift Valley, northern Tanganyika.

ery little but one for which I had ɔed a great interest.

espondence with the United intensified, and after successful tion of high school, I received ad- to Central Missouri State Col- d arrived in the United States in s a private student. Soon after- udge Russell E. Train of the Tax of the United States, who was ·esident of the African Wildlife ship Foundation, got in touch ıe and undertook, through the tion, to finance my education.

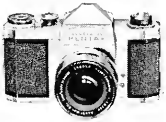
African Wildlife Leadership tion is based on several premises. : For better or for worse, the fu- most of Africa's game country fate of its wildlife resources are hands of Africans;

ıd: Africans themselves must be ound economic reasons for pre- their game resources; and

l: Selected Africans must be ɔd with the know-how required ıe conservation and management.

organizers believe Africans participate in the affairs affect- ɔir own existence—the control, ment, and development of nat- ources in Africa—and have acted swiftly and firmly on these noble premises. The Foundation is paying all expenses for the education of four African students in the United States—three from Tanganyika and myself—including round-trip passages, and hopes to be able to finance others. In this way it is insuring that Africans will be educated to the realization of the importance of wildlife in their own countries. The Foundation has also contributed to the founding of the College of African Wildlife at Moshi in Tanganyika, on the slopes of Mount Kilimanjaro, between the Serengeti Plains and Tsavo National Park. From the college, one is within easy reach of the Amboseli, Mara, Lake Manyara, and the Ngorongoro Crater game areas. From here an eye can be cast on the profile of African game problems. Here, too, carefully selected Africans are being trained in principles and techniques of wildlife management. In the full-fledged move to Africanize our civil service, the replacement of expatriates by untrained, unqualified men would spell disaster for game. The institution has the capacity to expand to become the best of its kind in the world—if it receives the necessary support.

In the United States, the African



Wildlife Leadership Foundation, in co-operation with the Department of the Interior, is providing African student groups with summer orientation and instruction in the national parks and wildlife areas, so that whatever their professions may be ultimately, they will be better prepared to serve Africa and use her resources wisely.

In 1962, I transferred to Michigan State University to study with Dr. Petrides, and in the summer of 1963 I returned to Kenya, where I was privileged to conduct a Conservation Education Program for forty-five high schools and teacher training colleges. This program was organized in co-operation with the Kenya Government and was financed by the Foundation. The topic for the lecture tour was "The Importance of Wildlife to the Economy of Kenya." Knowing that an independent Kenya could utilize as many informed citizens as possible, high school and college students attracted us as the most immediate future policy makers. The teachers, on the other hand, would have a large proportion of tomorrow's citizens under their instruction, and were thus in a very strategic place to influence and shape the future. The lectures were planned and prepared to point out the resources and problems in each local area visited.

Three months is not enough for an educational program such as the one I conducted, so I was thrilled when the director for Swahili radio programs in Nairobi asked me to write a thirteen-part series on wildlife for public information. Although I was returning to the States to complete my education, I agreed to undertake this public service. I recorded three of the programs at Michigan State, and prepared ten other scripts to be read by broadcasters in Kenya. We are now broadcasting the program at the rate of one fifteen-minute segment per week. It is our hope that the timing of this program—before the popular world news—will find many Swahili-speaking people waiting by their radio sets.

The African Heritage

During my lecture tour last summer, I noticed that a shift of values is afoot all over Kenya. One hears such expressions as "Wildlife is our heritage"; "Wildlife is important to our country"; "Wildlife should be saved"; "Wildlife should be preserved." One also hears, "The game department should tell us more about these wild animals and why they are given the land we need to produce crops." Most of the expressions—up to the last one—have
been picked up or learned from a
that have been written about wild.
from declarations by African le
The last one, with others like "Of
importance is wildlife to our cu
background?" or "What is the eco
importance of these animals yo
about to us?" indicates an unde
need for information and educati
the people.

For a long time non-Africans
maintained that if the African g
responsibility to rule his own co
he would have no regard for wild
a natural resource. They were mis

At the World Conference of t
ternational Union for the Conser
of Nature, held in Nairobi from Se
ber 16 to 24, 1963, Kenya delive
conviction in its Wildlife Manifes

"The natural resources of this c
—its wildlife which offers such an
tion to visitors from all over the
the beautiful places in which the
mals live, the mighty forests
guard the water catchment areas s
to the survival of man and beast-
priceless heritage for the future.

"The Government of Kenya, full
izing the value of its natural reso
pledges itself to conserve them fo
terity with all means at its dispo

Ir. Olindo earned his B.A. degree t Michigan State University, where e studied conservation techniques ith Dr. George Petrides. He is now ı Kenya again, beginning a career in ame management and conservation.

We are confident of the cooperation he other Governments of East Africa his important task but, at present, we unable, unaided, to provide the speist staff and money which are neces-. We therefore invite other nations, lovers of nature throughout the ld, to assist us in honouring this mn pledge.

Jomo Kenyatta,
Prime Minister
L. G. Sagini,
Minister for Natural Resources
R. Achleng Oneko,
Minister for Information, Broadcasting and Tourism
robi, 18th September, 1963."

or the first time in the history of ıya, the government had taken a ıd on the question of the future of ican wildlife—a stand that will ren as a reference point from which to ct future policies.

ı many ways we have been chal;ed, but to outline a rigid future pron now would be wishful thinking. vever, as we seek to develop a sensiy to the needs of the animals and to k with the changing environment in ɜr to get the maximum yield of our lable resources, a definite confidence eveloping about the future of Africa. will work together with experts from ɔver the world to insure the survival African wildlife. We wish to guide approach to wildlife education and ıagement by a continued appraisal of ntific findings for every problem that ht confront us. The hardest task may ı out to be that of having the courage lisprove our previous findings when discover our own mistakes.

Reflection

myth of long existence developed the assumption that the approach frican problems inevitably lay in its onal parks. This has not been the , as the program did not have meanand appeal for the people. In Kenya, l co-operation was seldom sought local ideas were ignored. For this on, national parks were interpreted Africans as an exploitation of local ırces by a foreign government that run by strangers. The denial of ac- to family lands was considered a itive measure rooted in the "do-as--are-told-or-else" principle of colo- administration.

ome enlightened preservation ideas ribal game reserves began to appear in 1960, based on a maxim accepted in many countries—that those people living on the land should get the first and greatest benefits from the legal exploitation and from the scientific and sporting aspects of game they live with. A realization is coming into existence that only a proprietary interest at the local level can invoke concern and permanence in wildlife management. New conclusions have grown up in Kenya, wherein the people are increasingly anxious and able to tackle things for themselves—a condition that necessitates a co-ordinated effort between the government and the local councils for wildlife protection elected by the people themselves.

During 1961 and 1962, a new system was developed, intended first to transform the old-style "national reserves." The Kenya plan called for local responsibility for wildlife conservation, directed by the motives of stimulating revenue through employment opportunities, trade, land-use benefits, and prestige. The aim was to use bylaws to protect the habitat under the covering protection of the national game laws. The first reserve to be so launched was Amboseli in Masailand near Mount Kilimanjaro. This was a fine choice, because in 1960 it was approaching a point of land misuse impossible to restore by any amount of knowledge. The Mara was also established in Kenya Masailand. Meanwhile, another African District Council game reserve was being developed by the Meru tribe. This reserve, which has had and is still having a real battle to meet both capital costs and maintenance needs, is about 100 miles northeast of Mount Kenya at an altitude of 2,500 feet. As a game reserve it has a distinctive atmosphere of wilderness and peace. This is the country where Elsa, Joy Adamson's world-famous lioness, and her cubs were living free, and where Elsa is buried. It is a dry-season or dry-year refuge for animals from the wilderness areas to the north and east of it.

The Meru reserve, promoted and appreciated by the people, could be more secure than any other statutory national park, because it is rooted in the understanding and determination of the local people. Such a determination should be reinforced by an appropriate education that would suitably equip more people to manage the resources.

Man has the ability and the capacity to learn many things. He learns to appreciate art and music, and the process of his learning is never complete until he has grasped its underlying significance. This is also the case with the appreciation of wildlife. Yet it has been assumed—and even included in many writings—that the African's use of wildlife and his methods of hunting or collecting the resources were and are by

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You, your school, your organization can help make a dream come true for Cecilia, or some other Indian girl or boy. Just a $10 monthly contribution provides one Indian child with suitable clothing, personal books and a cash allowance for school activities. It is an act of love that will bring you a heart-warming reward. A photograph, the story and letters from the child you help will start off a warm person-to-person relationship. Please give one Indian youngster an even break — and the sense of belonging to the wider world around him.

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"instinct"! If one stated that the American founding fathers went after buffalo or passenger pigeons by "instinct." he would be ridiculed. Everyone must learn in order to be wise.

Semantic Antagonism

ONCE the European was afraid to think of the Africans as people, and so he blamed on them the decimation of Kenya wildlife. On the other hand. the European pioneer into the Kenya highlands was pictured as a man who pushed wildlife peacefully back and cleared the virgin land. In this context. his gun was only a tool to protect the crops and the settlers' families from the menace of the wild jungles. the wild animals. and the savages who were considered to be an integral part of the habitat.

Many books and publications on the problems of African wildlife have made extensive use of such terminology as "tribesmen," "natives." and "primitive hunting methods." which are definitely not appreciated in Africa. and make our people look upon wildlife as an extension of outside humiliation and subjection. In addition there is the current use of the word "reserve," as applied to areas set aside for game; it is also applied to areas that have been set aside by colonial powers as living confines for the African people. Obviously. this is an unfortunate word to be used for game areas. because it has been considered an element of comparison between the two occupants of the reserves.

Kenya's Immediate Needs

To raise living standards. I believe, our agrarian economy must be developed. and emphasized in many ways, including a total re-evaluation of land-use practices. The economic potential of wildlife is not completely known, but its importance is reflected in the contribution of tourism to the country's economy.

Today. through mass media. the government will inform the people of the greatness of Kenya's natural resources—a new idea and a reality that gives the people a new national pride. The Minister for Broadcasting and Tourism has spoken. the Minister for Natural Resources speaks. students and teachers speak, concerned personalities are coming from all corners of the globe to our support. The new drive is part of the nation's march into the new era.

Already our transformation has been rapid. and one wonders whether the world can really understand the inner feeling that illuminates African youngsters with joy and gladness when they realize that they are growing up to take responsibilities with a new destiny! It is the beginning; and we shall make mistakes. which in a way will constitute a practical basis for corrective measures, and a springboard to progress.

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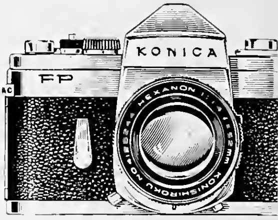

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or H. W. Fairman, M.A., Professor of Egyptology at the University of Liverpool.
Professor C. A. Trypanis, M.A., Ph.D., the University of Oxford.
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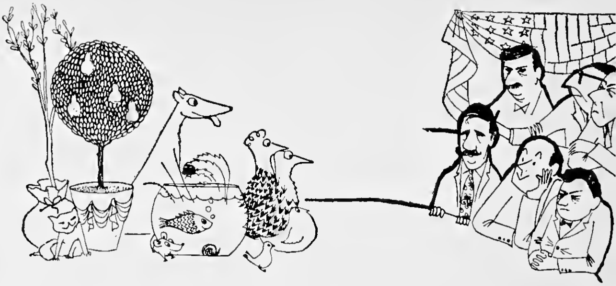


WASHINGTON NEWSLETT

By Paul Mason Tilden

During the spring of 1963 the Supreme Court of the United States arrived at a decision that will surely have a profound effect on the course of human affairs in the arid lands of the southwestern United States—the so-called Pacific Southwest. It will also pose serious problems for conservationists in the United States and, perhaps, in other countries as well.

Little noticed by the public at the time, the Court's decision in the case of *Arizona* vs. *California* triggered the release, less than a year later, of federal plans for one of the greatest water development schemes the world has ever seen—the Interior Department's multibillion-dollar Pacific Southwest Water Plan.

For years, the state of Arizona has claimed that it has been shortchanged in its allotted portion of the 7.5 million acre-feet of water that arrives in the lower basin of the mighty Colorado River during a year of average flow. This is the volume remaining after the states of the upper basin—Colorado, Utah, Wyoming, and Nevada—have exacted their toll for irrigational, municipal, and industrial purposes. Essentially, the decision of the Court awarded thirsty Arizona a larger share of water, leaving equally thirsty southern California, with its sprawling cities and rich agricultural lands, to look elsewhere for that share of the precious mineral it had drawn from the Colorado.

Under the Southwest Water Plan, water would be pumped into the central part of Arizona to open up new lands to irrigated agriculture; to serve the state's booming urban centers and new industries; to relieve the strain on groundwater supplies that, at the current rate of withdrawal, are being depleted far beyond any possible natural replenishment. To compensate for the water lost to southern California farms and cities, the Plan proposes the construction of huge aqueducts to transport additional water from new reservoirs on the rivers of far-northern California.

It is the central Arizona phase
mammoth project that is of most
diate concern to conservationist
many scientists. In order to raise
rado River water and pump it int
rior Arizona, two new high dan
proposed for the already much-da
river in order to generate the nec
hydroelectrical power. These ar
Bridge Canyon and Marble C
dams, the first to be not far abo
already silt-choked headwaters of
Mead behind Hoover Dam on th
zona-Nevada border; the second
miles northeast of the upriver bou
of Grand Canyon National Park.
two, the Bridge Canyon dam and
voir would be by far the most destr
in terms of scientific interest an
tional park system policy.

The reservoir that would form b
Bridge Canyon dam would back
through the entire river-reach of
Canyon National Monument, adjac
Grand Canyon Park on the latter's
ern extremity, and into the sceni
scientific treasure house of the pa
self. Taken together, these two par
tem areas preserve for Americans
for all the people of the world, the
portions of the world's most specta
and instructive example of nature'
sive powers—the Grand Canyon
Colorado. It is not necessary he
dwell at any length on the scientif
portance of the two preservations
fice it to say that the waters of the B
Canyon reservoir would inundate p
a geologic record that presently c
the visitor, casual or otherwise, s
back into the remote history of the
as to confound the imagination—a r
presenting perhaps 2,000 million
of earth building and earth destru

The reaction of conservationists t
phase of the Pacific Southwest
Plan has been sharp. Secretary o
Interior Stewart L. Udall has been c
squarely in the middle of a battle
gives every evidence of becoming a

In the case of the Plan—which, it be said, has political overtones— ecretary will be in the position of ipting to ride two horses, each head- n a different direction.

e of these horses is Interior's Bu- of Reclamation, which has been ;ed with formulating the Plan and ing it to completion if it is approved ongress. The other horse is Inte- National Park Service and its fol- g of conservationists; these latter to enlist the support of laymen and tists, both countrywide and world- if possible, to oppose at least the ;e Canyon dam portion of the Plan. nservationists have pointed out that ectrical power needed to operate the al Arizona portion of the Southwest r Plan can probably be generated xpensively and less destructively by ial power derived from the vast and tapped coal deposits of the Four ers country—that area surrounding ingle geographic point shared by ate boundaries of Colorado, Utah, Mexico, and Arizona. The battle is ted to be a long and bitter affair.

Our Sliding Suburbs

w and again one of those cozy little Cape Cods or split-levels in Amer- uburbia more or less abruptly be- to move downhill—a phenomenon ularly noticeable during the spring melt, or after prolonged summer l rains. An occurrence of this sort is rdinarily understood by the home- , but it presents no particular chal- to the geologist.

at has happened is this: the devel- bulldozer has stripped protective nd plant cover from a geological tion that is particularly vulnerable e softening action of excessive d water — a stratum of clay, per- or a formation of decomposed, aden schist or slate. In the pres- of unusual amounts of water, and a sufficient gradient, the stratum ecome unstable and commence to " With it flows suburbia.

ing note of the ever increasing dis- n of the natural landscape and its lying components in the vicinity of urban centers, the United States gical Survey has initiated detailed s of a number of major American and their satellite suburbs, with to producing geological maps that e interpreted by developers, road rs, industrialists, and others who nake decisions as to the best loca- for their projects.

ssessing suburbia as a whole, it is say that many decisions in the ave been made with more haste ntelligence. Many a suburbanite, ly viewing the mess that only yes- was home, would agree with the geologist who recently said: "Too often important geologic information is not utilized in the planning stage of urban renewal and suburban development."

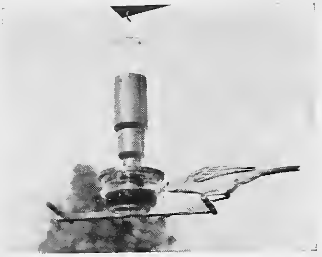
Toward Better Water

Many conservationists feel that one of the more encouraging developments of the past several years has been the increasing congressional interest in problems relating to the pollution of the nation's water resources. This interest centers around major rivers, lakes, bays, estuaries, canals, and other water bodies usually referred to in legislation as "interstate waters" or "navigable waters." Many bills dealing with water pollution either on a broad front or by specific types of offense have been introduced into the 88th Congress.

Typical of the broad-spectrum pollution abatement bill are two similar measures, one of which has already easily passed the Senate; the other, at this writing, is in House subcommittee hearing (S. 649, Muskie and Humphrey, and its companion House bill, H.R. 3166, Blatnik). These bills would amend the existing Federal Water Pollution Control Act to establish a Federal Water Pollution Control Administration; increase grants for construction of municipal sewage treatment plants; authorize issuance of regulations to aid in preventing, controlling, and abating pollution of navigable waters, and, as the short title of many legislative proposals puts it, accomplish "other purposes." The proposals would also establish the post of Assistant Secretary for Water Pollution Control, with jurisdiction over certain parts of the pollution abatement program suggested by the bills. Enactment of these measures during the 88th Congress seems likely.

In the category of "specific offense" bills, might be cited H.R. 4571 (Reuss), which would amend the Federal Water Pollution Control Act to protect navigable waters from pollution by petroleum-based detergents. (A more complete discussion of this subject will appear in a future issue of NATURAL HISTORY.) Some housewives still have the notion that the detergents they buy at the supermarkets are merely a high-powered kind of conventional soap. They are, in fact, no such thing. Many are based on a petroleum-derived chemical, alkyl benzene sulfonate, which, when released into sewers and thence into river or lake waters, maintains its chemical identity over a long period of time. It is, in the language of the technician, not easily "degradable" by water organisms into simple and harmless chemical compounds. Congressman Reuss's measure would set certain standards of decomposability for petroleum-based detergents marketed in the United States.

It is quite likely that this bill will receive no action during the 88th Congress; but it has, at least, served notice



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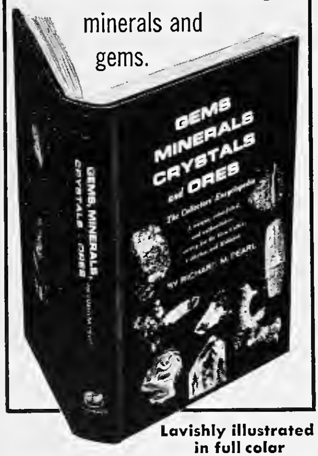

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on detergent manufacturers that their chemists should busy themselves investigating substitute chemicals more susceptible to biodegradation. And, indeed, there appears to be a move by the manufacturers in just this direction—a move that has perhaps been hastened somewhat by bills like H.R. 4571.

There is another kind of water pollution that is far more difficult—perhaps impossible — to deal with legislatively. This is the spillage, accidental or otherwise, of crude or heavy fuel oil off the nation's coasts. Spillage can occur in several ways — through the customary cleaning of a tanker's oil tanks after it leaves port, the pumping of part of a vessel's fuel supply to "lighten ship" after a grounding in shoal waters or on a reef, or by the actual breakup of a ship at sea. A certain amount of pollution from the last-mentioned source is, of course, inevitable.

A serious although hardly necessary case of water pollution by fuel oil occurred recently off the southwest coast of Florida. A British freighter of Liberian registry, carrying a cargo of phosphate, went aground on Pulaski Shoal close to Fort Jefferson National Monument at the tip of the Florida Keys. A rescue vessel from Key West stood by to help pull the freighter free, but its captain refused assistance. The captain requested United States Coast Guard permission to lighten ship by dumping 500 tons of fuel oil overboard. The Coast Guard refused permission. The oil was jettisoned anyway.

Slobbered with heavy oil were the beaches and shallow waters of Bush, Garden, and Long Keys, within Fort Jefferson National Monument. The result was heavy mortality to marine and bird life. Bush Key, incidentally, is the only known nesting site in the United States for both the sooty and noddy terns. Countless species of migrating birds use these islands of the Dry Tortugas as waystops on their annual flights back and forth between North America and Cuba and South America. The shallow waters of the island chain are veritable museums of tropical and semitropical marine life, and valuable breeding and nursery grounds for the commercially important shrimp.

It will take years to assess the total damage done by this one deliberate oil spill, which coated the islands and their tidal flats with gummy, congealing fuel oil. Conservationists were furious, but little, apparently, could be done.

The Standard Approach

Much has been written of late concerning economic depression and poverty in the Appalachian Mountains. The mountain system actually runs from Alabama into Canada, but economists and sociologists have focused their attention on that portion of perhaps 170,000

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TILDEN, a writer and editor in nation's capital, often contributes imns pertaining to government vities and the natural sciences.

ɜ miles that includes southern ylvania, parts of Maryland, all of Virginia, a bit of Ohio, and por- of Virginia, Kentucky, Tennessee, ma, North Carolina, and Georgia. s "Appalachia," so often employed llywood as a type locale for slouch long rifles, bare feet, and illicit —a picture that is, of course, of al accuracy.

erty in Appalachia is an undeni- 'act. The conservation history of of this vast mountain area has been a one. Many of its steep slopes, ed of organic cover by ax and fire, never re-established their original mmunities. Coal strip miners have essly chewed and gouged into the flanks of an essentially valley- dge topography, and the raw s spew forth silt and acids to the narrow bottom lands and poi- ıe streams. Here, one family in lives on an annual income of less 3,000, and here the average rate employment is about 7 per cent. of Appalachia's male inhabitants rought up to be coal miners, but um, hydropower, and mechanized ; techniques have robbed them of ivelihoods.

probably true that a certain per- e of Appalachia's population has be told that it lives in poverty, poverty is a relative condition and is not easily defined, but by stand- mmonly accepted, there is a great Appalachia, both economically ucationally.

y in 1963 the late President Ken- ommitted the federal government ogram of Appalachian economic ıce through establishment of the ent's Appalachian Regional Com- ı, aimed at working with the af- states through the Conference of chian Governors. Thus was estab- a joint federal-state group of ap- ıte bureau heads that, under the anship of Undersecretary of Com- Franklin D. Roosevelt, Jr., was to study of the problems of Appa- and formulate both long- and erm programs for alleviation of sed conditions.

servationists have followed the f the Commission with interest, would appear that there is much ppalachia can do, with a helping om the government, to help itself. : the long history of misuse and of its lands and the pollution of ers, some judicious repair work, the guidance of sound scientific servation principles, could yet do much to salvage the fading economy of an area from which much has been taken but to which little has been returned.

One of the most promising ways of attacking poverty in Appalachia would seem to be to capitalize on its wilderness qualities by cultivating additional outdoor recreational opportunities for the people of more highly urbanized surrounding areas—in other words, cultivating the tourist crop in place of the scanty corn and beans of eroding hillsides. This approach would entail the restoration of a reasonably natural landscape by reforestation and by the enforcement of tough strip-mining laws. Above all, conservationists have hoped that recommendations for ailing Appalachia would bypass the weather-beaten twin remedies to economic ills that have always been so dear to the hearts of federal and state planners as temporary solutions—the big dam and the big highway.

In this hope, the conservationists have been largely disappointed. The Commission's report to the President was recently released, and leading the list of "priority areas of regional investment for the immediate future" in Appalachia was "provision of access both to and within the region." This translates itself from the officialese into a network of highways to lace the area—approximately 2,600 miles of them. Following quickly in the report was "construction of facilities both to exploit and control the abundant rainfall of Appalachia." Again translating, this says: high dams, low dams, big dams, little dams.

One recommendation of the Commission was for another Blue Ridge parkway, a development that caused one Washington wag to observe that it may in the future be difficult to see the Blue Ridge for the parkways. (The Blue Ridge Mountains already have one federal parkway athwart their narrow summits.)

While some of the recommendations of the Commission seemed sound enough, conservationists had hoped for something with a little more imagination.

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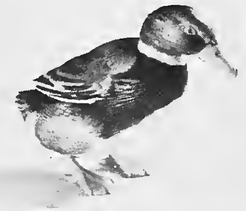

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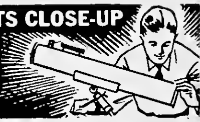

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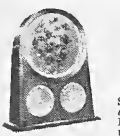

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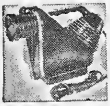

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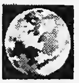

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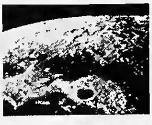

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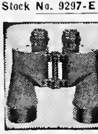

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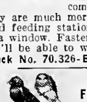

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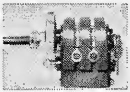

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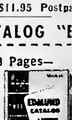

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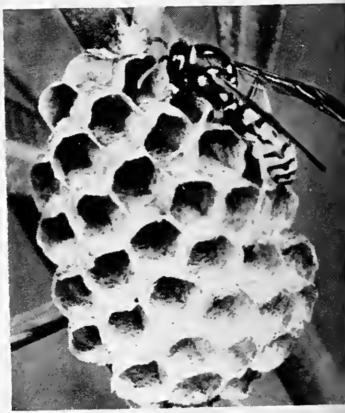

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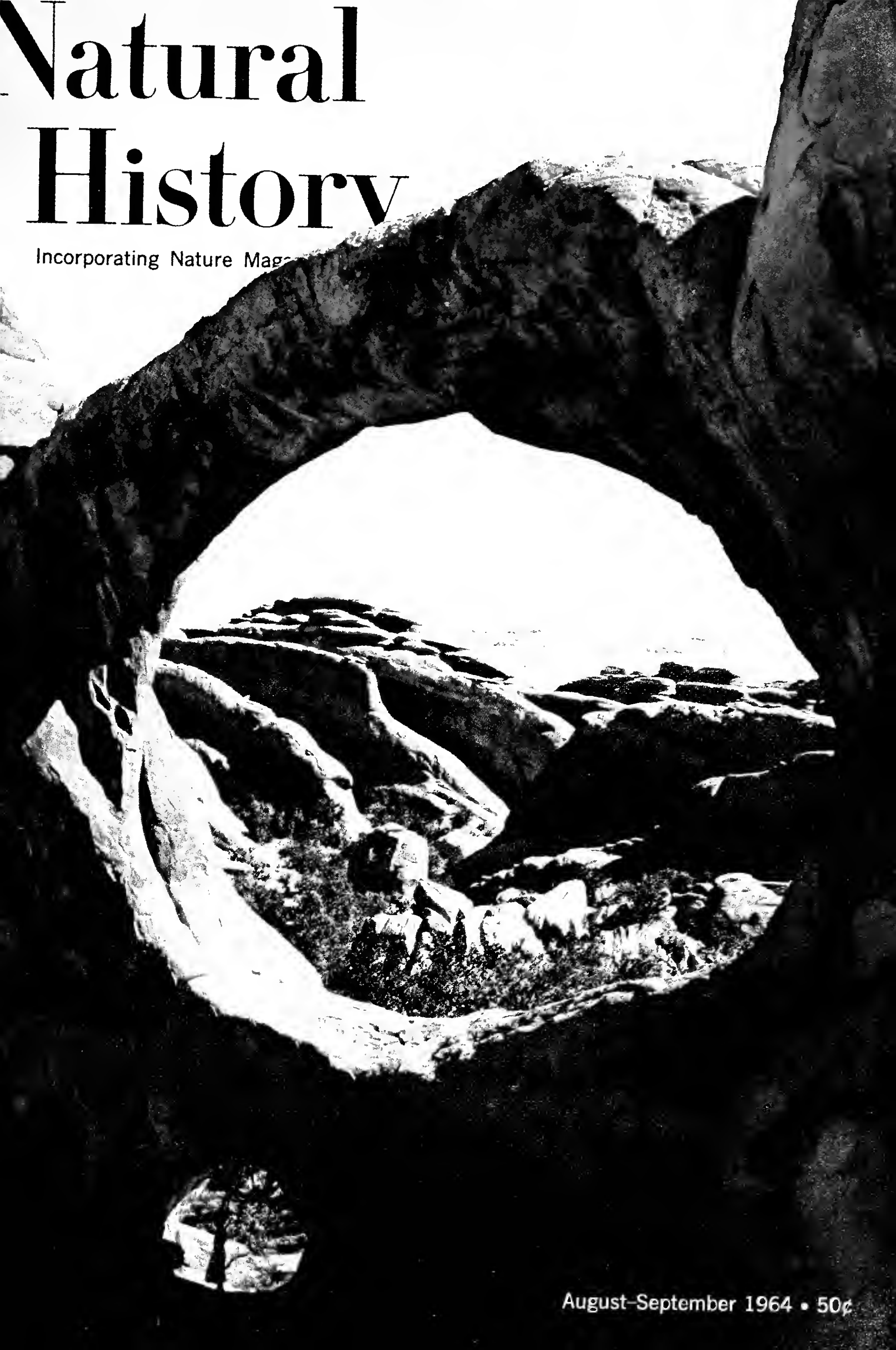

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Vol. LXXIII AUGUST-SEPTEMBER 1964 N

ARTICLES

DEPARTMENTS

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state's red rock country. These massive structures have been formed over
centuries by the combined erosive forces of wind, freezing. and water seep
While many of the arches and bridges are visited by thousands of tourists
year. others are isolated by extremely formidable terrain. In the article
begins on page 42, Willard Luce, a native Utahan, discusses geological asp
of the spans. The author took the cover photo and those accompanying the

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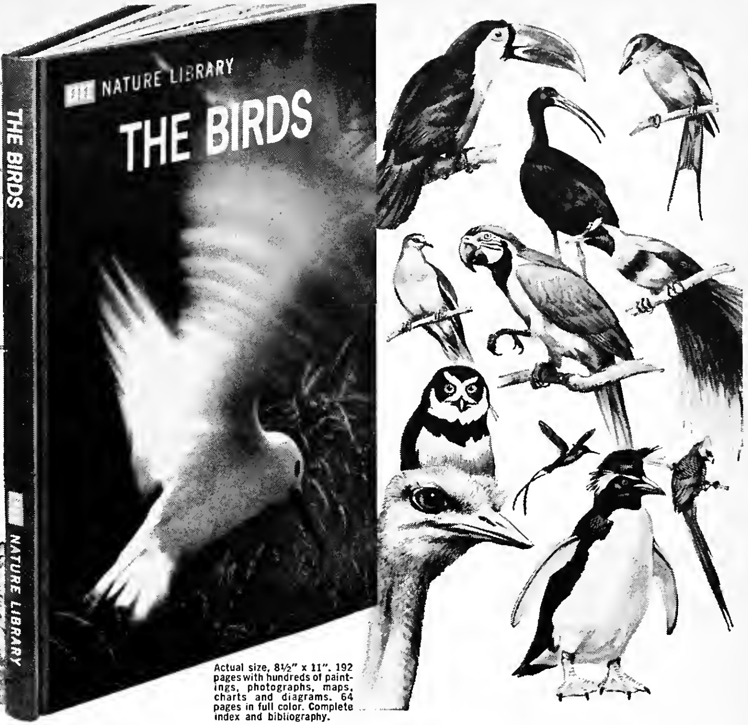

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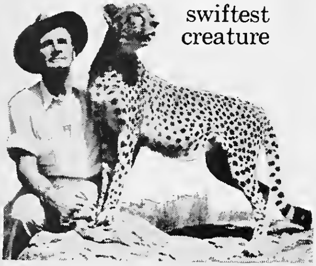


A naturalist's book lis

By Pieter Fosburgh

The Last Redwoods, by Philip Hyde and François Leydet. *The Sierra Club, $17.50; 128 pp., illus.* Politics and Conservation, by Richard A. Cooley. *Harper & Row, $5.00; 230 pp., illus.* Runes of the North, by Sigurd F. Olson. *Alfred A. Knopf, $4.95; 254 pp.* The Long-Shadowed Forest, by Helen Hoover. *Thomas Y. Crowell Co., $4.95; 272 pp., illus.* Animal Life and Lore, by Osmond P. Breland. *Harper & Row, $6.95; 388 pp., illus.* Sundial of the Seasons, by Hal Borland. *J. B. Lippincott, $5.95: 350 pp.* The Great Beach, by John Hay. *Doubleday and Co., $3.95; 131 pp., illus.* Journeys In Green Places, by Virginia S. Eifert. *Dodd, Mead & Co., $4.50; 222 pp., illus.*

In *Walden*, Thoreau wrote: "I long ago lost a hound, a bay horse, and a turtle-dove, and am still on their trail. Many are the travellers I have spoken concerning them, describing their tracks and what calls they answered to. I have met one or two who had heard the hound, and the tramp of the horse, and even seen the dove disappear behind a cloud, and they seemed as anxious to recover them as if they had lost them themselves."

Emerson, Thoreau's neighbor, used to peer curiously at him from time to time, like a boy looking over the backyard fence. He concluded that Thoreau marched to the beat of another drummer, but he readily conceded that the march was purposeful and the drumbeat strong, and when Thoreau wrote of his search for the horse and the hound and the turtledove, Emerson knew exactly what he was talking about.

The mid-nineteenth century produced the best of American nature writing and the most mature thinking. Thoreau viewed nature subjectively, but could project his views brilliantly to make them applicable or at least a matter of interest to all men. The Olympian Emerson, writing with greater detachment, nevertheless acknowledged a deep and personal and unregretted involvement in the natural world. Longfellow wrote of nature with love and gentleness, but it was no mere sentimental journey; when he considered the subject, as he so often did, the mind was with the heart. So it was with Melville and Hawthorne, although their philosophical estimates—or prejudices, perhaps—were radically different from those of Longfellow. Melville was suspicious of nature, suspicious that its beauty was the beauty of a whore, and Hawthorne felt at times its enormous power placed an almos tolerable burden on mere man. M while, Audubon walked through writing and painting with a keen e receptive mind, and a skillful han

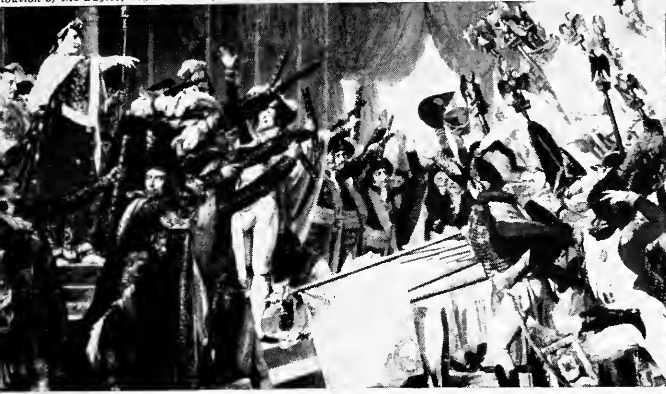
All of these men, and many ot worked at the same time. Although views varied enormously, there w community of spirit and interest tha tablished a great tradition in Amer writing and that compared favor with the brilliant nature writing b done in England at the same time.

All this was a hundred or more y ago. What has happened since in broad field of American nature wri and what have we now? Emerson an contemporaries could look at natur they chose. It was at their doorsteps, beyond lay a vast region of promise they really had no need to explor order to put man in his place. It enough to know it was there. Thoreau, Walden Pond served a springboard for a leap into the unive Emerson, looking out on his backy could write his massive essay *Nat* Longfellow, with little wandering, w a poem with the same title.

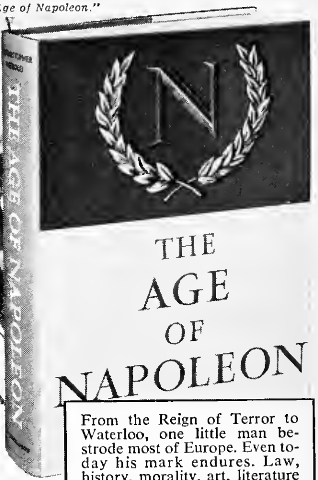
Now, things are different. A sens urgency has come upon us as our civi tion has moved inexorably upon our ural environment, and we fly off on kinds of tangents seeking to ana what is left, trying to discover mean preserving it (conservation in its m ern concept was an unknown word in nineteenth century), exploring new w of using our heritage, and exploring, our rapidly retreating frontiers. Expa ing populations and industries h made our interest in the natural w increasingly practical on the one ha escapist on the other. There seems to little time for, or inclination tow deep thought about nature; perh America today is not the time or pl for it. It would be interesting to see Emerson would write if he were w us now. I doubt if he could be detach

These changes have profoundly fected modern American writing ab nature, and other factors have also b at work. Illustrations, little used in mid-nineteenth century, are now an pectable part of almost any book, merely as decorations but as media carry the story. This is particularly t of photographs, certainly effective properly used, but too often employ these days in what seems to be an eff to relieve the writer of his burden.

ibution of the Eagles," by David. Napoleon presents imperial standards to his troops. An illustration from "The Age of Napoleon."



illes Museum



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Then there is the publishing business, which today does a good deal more than just publish. It seeks out authors, looks for new angles and new means of commercializing old ones, and in general stimulates a vast output of books ranging from how-to-do-its to lyrical descriptive tracts and esoteric biological treatises.

In general, these interests and activities would seem a welcome development. There is money to be made in attempting to satisfy the increasing appetite of the public for outdoor subjects. The field is inexhaustible, and its exploration should be encouraged. Yet if one examines the flood of nature books now on the market, one cannot help concluding that there has been a lack of discrimination by publishers, editors, or both. Many of the new books do not even deserve to be reviewed, but they are published. Perhaps the thought is that the hungry public will devour anything.

Proceeding from the general to the particular, let us have a look at a few of the books that have appeared recently. *The Last Redwoods*, published by the Sierra Club in San Francisco, handsomely combines the old tradition of good writing and careful research with the new techniques of photography dedicated to a purpose—in this case the preservation of *Sequoia sempervirens*. This species of redwood, found on a narrow strip along the northern coast of California, is in trouble, although many of its members, still living and healthy, made their appearance before Christ. Their preservation depends upon the protection of a whole watershed and not just the isolation of scattered stands. The establishment of a Redwoods National Park is projected, and in a Foreword to the book Secretary of the Interior Udall states categorically that this will be done if the public demand is sufficient. It should be, and so should the demand for the book. It contains no silly sentimentality, no overstatement, no purple prose, just facts and reasonable projections on the possible future of *Sequoia sempervirens*, and sensational photographs of what must surely be the most photogenic tree in the world. *The Last Redwoods* is expensive, and for some will be only a coffee table decoration, but John Muir, founder of the Sierra Club, would have been proud of it.

Richard Cooley's *Politics and Conservation* is also a book with a purpose, although it is manufactured on a much more modest scale. The ponderous, even forbidding, title suggests a "heavy" book; it is not. This is the story of the Alaskan salmon fisheries, of their use and misuse since they were first established commercially in 1878, and of the five species of salmon that inhabit Alaskan waters, in some instances all in the same river. When they go to spawn, then to die in the rivers of their birth, salmon
may travel fifty miles a day and the tot
mileage may be as much as two tho
sand miles. Salmon movements are st
a fascinating mystery, and Mr. Cool
writes of them well and carefully.

The burden of his book, however, a
pears to be an indictment of the comme
cial fisheries and of the governme
which has tried to regulate commerci
interests through one federal agency
another. Mr. Cooley contends that in fa
the commercial interests regulate t
government agencies. In the interest
conserving the salmon population—a
with it, of course, the fisheries—the a
thor favors private ownership rath
than the present free fisheries syste
Under the latter, he says, competiti
for an already dwindling resource
stimulated rather than regulated, and t
attitude is to hell with conservation a
the devil take the hindmost. He is su
ported in these views by Alaska's Se
ator Gruening in the Introduction.

The further nature retreats from u
the closer we want to get to it. Boo
help serve the purpose; if we ourselv
cannot experience the pleasures a
stimulations of the receding frontiers,
can at least enjoy them vicariously. Su
books should be very well written, a
not all of them are.

In *Runes of the North,* Sigurd Ols
tells us of the country from Lake Sup
rior to the Yukon. I have consulted se
eral dictionaries and carefully read t
publisher's pronouncements concerni
this book, but I am still not quite su
what a rune is, in this book's conte
If a man goes out to hand dig a well ar
after several failures, finally hits wat
and hangs up a cup nearby so that
can feel the exhilaration of drinki
from his homemade water supply, is th
a rune? In Mr. Olson's book, it is-
whole chapter's worth, in fact. By a
definition, a rune connotes mystery a
magic, and there would seem to be lit
of either in a well-digging operatio
which has been done before by quite
few people.

The mystery and magic are in the a
thor's mind and eye. He seems to be pr
occupied not so much with the face a
facts of nature as with his personal r
actions, which at times are purely se
sual. This is legitimate—up to a poi
But when he writes a chapter abo
catching trout on a wind-blown lake
the Quetico–Superior wilderness,
would be interesting to know just wh
kind of trout he was catching. Then, if
felt it absolutely necessary, he could
on to tell us how he and his son pu
meled each other in their exuberance.

In view of the author's impressi
knowledge of biology and geology, a
his long experience in the country
which he writes, the lay reader mig
expect something more, or at least ho
for it. Subjectivity in reporting about t

l world is all very well if properly ed, but it can be sophomoric.

ther book. startlingly similar to lson's, is Helen Hoover's *The Long-wed Forest.* Here she follows the s in Mr. Olson's north country, es an incredible number of things. personal observations are buoyed th biological notes garnered from nd there, not all of them accurate. g other things, she says this: I surprised a bear, contemplating moval of a suet feeder, a nourish-te before hibernation." Bears, as it ns, don't hibernate.

this is a good and readable book, t gives the reader some insight ie "Changing Seasons in a North-ilderness," which is the book's sub- ut I regret, even resent, the cozi-nd the interpolation, whereby an undertakes to move into the of his natural subjects and speak em with the voice of authority.

unusual book, recently published, nond Breland's *Animal Life and* with well-executed and authentic ations by Matthew Kalmenoff. s not really a reference book, as the her suggests, but rather a collec-f notes and paragraphs on subjects g from mammals to mollusks. , however, are carefully indexed, a result the book does indeed have reference value.

author undertakes to dispel many myths and fallacies in current ation. Do snakes commit suicide? gles carry off young children? Is such a thing as the "bear hug"? oles blind? What animal can open ster? What was the manna of bib-imes? What mammal has the dis-n of being man's worst enemy?

these and many, many more make fascinating bedside reader, ex-ly well written, with careful atten- fact. It has no real sequence, al-h mammals, mollusks, insects, and are each discussed in separate s. The book can be opened at ran-nd read with considerable pleasure enefit.

s last statement also applies to *al of the Seasons*, by Hal Borland, s here, as always, a competent and ive writer. Its subtitle, "A Selec-f Outdoor Editorials from *The New Times*," adequately suggests what eader will find, but there are in-rable pleasant surprises. Mr. Bor-as is his custom, roams through the al world, looking at nuthatches, g the December wind, and sensing ysteries of twilight. Nothing, be it as the weather or as small as a , is beyond his range.

a matter of convenience, perhaps, lso to give his musings a sense of uity, Mr. Borland follows the sea-There are 365 essays in this book, one for each day of the year. and each is dated. But there is no need for the reader to follow consecutively; he may skip happily from August's moon to January's snowbird, and nothing is lost.

But what has happened to Thoreau's turtledove? Are there any who have seen it? Perhaps there are. John Hay, in *The Great Beach*, writes of the outer coast of Cape Cod, and he does it extremely well. There is no escapism in this book, only sound observation and thought, which even admit to the presence of beach buggies on what might otherwise have been a tranquil scene. There is no resentment at the intrusion of man and mechanism, only resignation and adjustment. "The Cape," writes Mr. Hay, "is caught up in the human scheme of things. and we can hardly avoid looking at it with modern eyes, for good or ill." Mr. Hay's eyes are modern in the best sense of the word, and what he sees he writes about without any of the clumsiness. carelessness in fact, or projection of self that characterize so much of our modern nature writing. He is modest, restrained, and thoughtful.

Virginia Eifert, in her *Journeys in Green Places*, writes of the shores and woods of Wisconsin's Door Peninsula, which she describes as "a long finger of limestone and sand thrusting into northern Lake Michigan." This is country she knows and loves well, and this shines through clearly. When she finally finds a calypso orchid after years of search, the reader shares in her excitement.

Mrs. Eifert writes very well, and she has the further advantage of being a competent geologist and botanist. In addition, she seasons the scientific approach with such descriptions as one of an old man who "liked to wander about the country, looking at the mountains and rivers and oceans that the Lord had made. Since the Lord had gone to all the trouble of making them, he thought the least a man could do was go and look at them." "I, too," the author states, "feel that this is the least I can do."

She does a lot more. In fact, it is quite possible that she and Mr. Hay are rarities among our modern writers. They may have seen Thoreau's turtledove disappearing behind a cloud. At least, they are looking for it.

Mr. Fosburgh is a free-lance nature writer who frequently contributes to these pages. His latest book, published by Macmillan, is "The Natural Thing."

A HISTORY OF DOMESTICATED ANIMALS, by Frederick E. Zeuner. *Harper & Row, $12.00; 560 pp., illus.*

THIS is the only extensive book on domesticated animals now available in English. The book is divided into two parts: the first discusses the origins and evolution of domestication; the second deals with domesticated animals under subdivisions concerning preagricultural domestication of mammals, early agricultural domestications, mammals domesticated for transport and labor, mammals used as pest destroyers, various other mammals, and domesticated birds, fishes, and insects. A twenty-nine page bibliography and twenty-page index conclude the work. The book has numerous photographs and drawings.

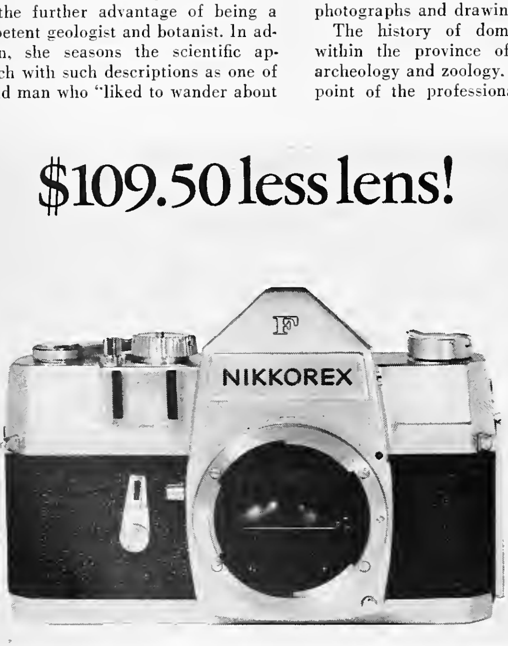
The history of domestication falls within the province of two sciences, archeology and zoology. From the viewpoint of the professional or advanced amateur archeologist, this book provide most useful source material. the taxonomic zoologist or geneticis is more of a nightmare. The auth himself an archeologist, seems to aware of the genetic concept of spec tion, but also seems unable to incor rate it into his writing. Some of his tematic revelations state that the coy and domestic dog are unable to hybrid and that the "hyaena dog" (cape hu ing dog, *Lycaon pictus*) is "a mem of the hyaena family, and not a do Both of these statements will surp mammalogists. Another shortcoming the book is that there is no definition exactly what a domestic animal is.

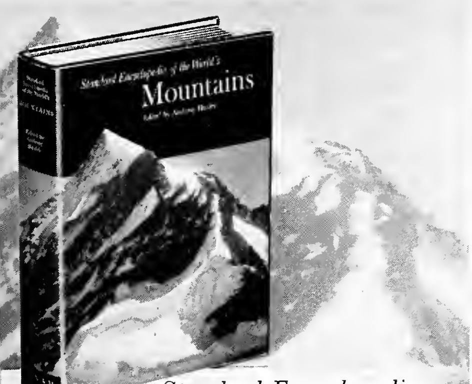
Although technical and well do mented, the book is quite readable its shortcomings may, hopefully, stir late research into this fascinating fie

RICHARD G. VAN GEL
The American Muse

BIRDS ON A MAY MORNING (12-i L.P.), $5.00; *recorded by Droll Yank Incorporated.*

USUALLY it is more fun to observe field taping of bird songs than listen to the recorded results. The sp produces many a paraphernalia-la monster questing in the woods—inte stealthy, but somehow able to step dry branches at the rate of thirty minute and to somersault into m gullies. Oddly enough, even at the stant of the worst fall imaginable, a b begins to sing, and as soon as the m ster can stand up, he hoists his mic phone, presses the button of his t recorder, and for a wild moment observer is reminded of one of th sinister creatures of fiction that Jan

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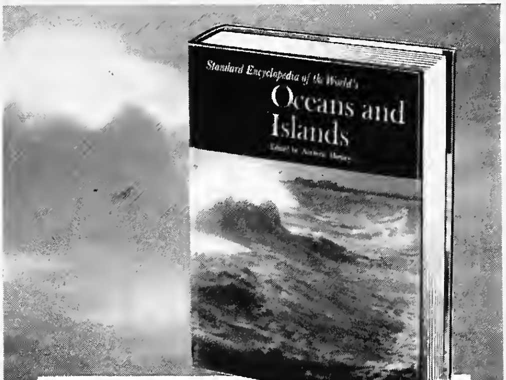
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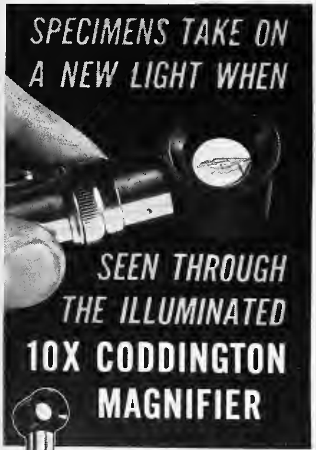

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The present one, by Droll Yankees Inc., takes the listener to the farm of Richard E. Dana in North Pomfret, Vermont, where a bird concert commences with the crowing of a Plymouth cock. The other artists are thirty-six undomesticated species from field, orchard, woods, and swampy places. An instructive human voice identifies them with some reverence on Side A, but only the birds themselves are heard on Side B. Thus a sagacious statement on the album jacket suggests that "the record may be used as a guessing game, to learn the bird songs, or simply to bring back the joyful sounds of a May morning." Most listeners won't quibble with that. Although somewhat boring, the record is technically adequate, and the Audubon Societies of Rhode Island and Massachusetts have endorsed it.

William George
The American Museum

Troy and the Trojans, by Carl W. Blegen. *Frederick A. Praeger, $6.95; 240 pp., illus.*

Professor Blegen—a modern successor of Heinrich Schliemann, whose remarkable deductions first unearthed Troy—led an expedition from the University of Cincinnati to the site of Troy. There, in seven meticulous campaigns, the results of Schliemann's excavations were tested and refined (1932-38). After the Trojan enterprise was finished, Blegen undertook the excavation of Nestor's Pylos, a Homeric site untouched by Schliemann, which has since become famous as the location of Linear B archives. This discovery gave the impetus to the decipherment of the earliest form of written Greek.

At Troy, Blegen applied a system of strictly scientific and unsensational digging. Little seemed left to be excavated when the Cincinnati expedition started, but with the aid of small tools, patience, and keen observation the prehistoric record was read in minute detail. The new book on Troy gives an abbreviated but straightforward account of the findings. The description of the growth of the citadel of Troy is developed from its earliest stages (about 3000 B.C.) to the time of the Trojan War (here dated about 1260 B.C.) and its brief aftermath.

As a sample of methodical archeological reporting the new volume is excellent. It demonstrates how a strict separation of material facts and theoretical speculation can be maintained. Many new insights resulted from the observa-

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JAMES STOKLEY, Michigan State University

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ɩf data previously neglected. The of animal bones and vegetable re- may be referred to here as an ap- iate example. Much was learned agriculture, hunting, fishing, diet, ven warfare from these sources of ice, and interesting changes in en- nent are now apparent. The horse uddenly introduced at the begin- ɩf Troy VI, soon after 2000 B.C., by who archeologically are marked vcomers to the site. These new in- nts, as is pointed out in the inter- ive section, were probably related earliest Greeks, who entered their homeland at about the same time. orse must have been of strategic tance in the successful movements immigrants.

volume is well illustrated and lue respect to the previous genera- ɩf Trojan excavators. It should be ıs a modern, unbiased account of at a famous prehistoric site.

MACHTELD J. MELLINK
Bryn Mawr College

'REASURE OF THE GREAT REEF, by r C. Clarke. *Harper & Row, $4.95;* ., *illus.*

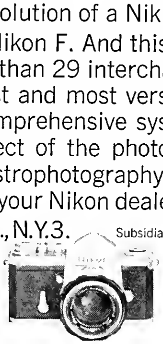
the ingredients for an exciting lventure tale are here: exotic lo- Ceylon); a true treasure hunt off gerous reef; legends of lost ships; tic marine creatures; and an in- crew of skin divers. Combine elements with the fine storytelling of the versatile Mr. Clarke, add ous photographs, and settle down evening's entertainment.

t of the action takes place near eat Basses reef off the southeast of Ceylon in what is literally a ard of lost ships. In addition to rrative of the recovery of sunken re (including a bronze cannon), ok rambles into all manner of re- ubjects: the history of wrecks and recovery; observations on the be- of sharks; the legal problems of water archeology; movie-making; ques for the preservation of re- d objects; giant squid; and, above in diving.

WILLIAM N. TAVOLGA
The American Museum

GY, by Peter Farb. *Time, Inc.,* *192 pp., illus.*

a glance, this volume in the "Life ature Library" appears to be one n the recent spate of lavishly illus- nature books. The numerous il- tions—both full color and black hite—are well chosen and repro- ; many have lengthy captions. The deserves more than casual perusal the author's chapters, which run or less parallel to the pictures and



their captions, set a high standard in popular science writing. Themes include: biotic communities, energy flow as exemplified by food chains, adaptations of various sorts, biological rhythms and cycles, parasitism, beneficial mutualization, predation, competition, population fluctuations, extinction, and so on. The complexity of interrelationships within the biota is reiterated or implied constantly, and there is a steady undercurrent of conservation attitude. The latter, especially, dominates in the concluding chapter on man versus nature. Again, the examples are familiar—water and air pollution, radioactive fallout, biocides, the population explosion, and other aspects of our present "predicament of being a ruler over the earth without knowing the [ecological] rules." There is a vacant ecological niche for this book on many a bookshelf.

Ralph S. Palmer
Univ. of the State of New York

Fish-Shape Paumanok, Nature and Man on Long Island, by Robert Cushman Murphy. *American Philosophical Society, $3.00; 67 pp., illus.*

This book is a graphic account of the rise and fall of the flora and fauna of Long Island, and constituted the 1962 Penrose Memorial Lecture at the American Philosophical Society. Dr. Murphy's account rests on his detailed knowledge of conservation as he, among few, has learned it at the font—by observation and study. His research is profound and the evidence is written with clarity, accuracy, and forceful logic.

Few books have been written on historical themes from the viewpoint of the trained scientist and conservationist. Dr. Murphy's short essay stands with Aldo Leopold's *A Sand County Almanac* as an example of great scientific literature. The author is an outstanding scientific prophet of our democracy.

The period covered in *Fish-Shape Paumanok* extends from the time of the last retreating glacier to the crowded plazas of modern supermarkets and beyond to the heritage, if it may still be called that, of future residents of Long Island. Glacial formations, the establishment of the original flora and fauna, and the vagaries of wind, weather, and tides are presented in an introduction to the island. Introductions of other sorts then follow. These include Algonkin Indians and the early English and Dutch settlers. The latter introduced a chain reaction—slow and long extended—that led to a complete alteration of the Long Island scene.

The sequence of historical events presents the tragic effects of inept farming, overhunting, and the resultant depletions of plants and animals, even to extinction —locally and completely. It dramatizes bounty systems, fires, and the systematic removal of forests to supply both sl and shore. Human appearances and partures are aptly considered, too.

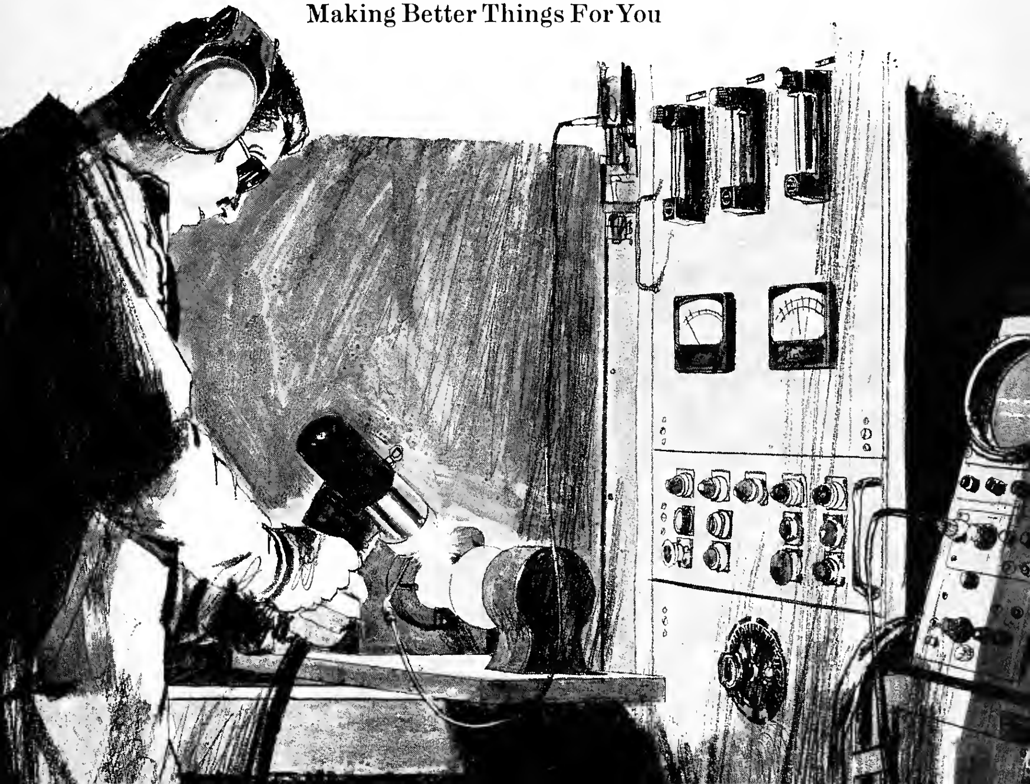
This theme of flux is extended to clude the changed ecology of the Lo Island landscape caused by introductic of exotic plants, pollution by deterge and chlorinated hydrocarbons, the r ages of suction dredges, bulldozers, a land developments. And the end is yet, what with the filling of ponds, dil and fills on wetland savannas, and mi of concrete slabs leading from here nowhere. Dr. Murphy sounds a clear c for immediate federal ownership of tl wilderness area still existing on the F Island seashores. All told, the story o fauna and flora has probably never be presented in better perspective. The bo is profusely illustrated with sketcl by nineteenth-century artist William Mount, supplemented with photogra and paintings of past and present scen The bibliography is excellent and quotations from Walt Whitman are and nostalgic. This is a masterful p sentation by an eminent scientist a conservationist.

Edwin P. Creaser,
Hofstra Univer

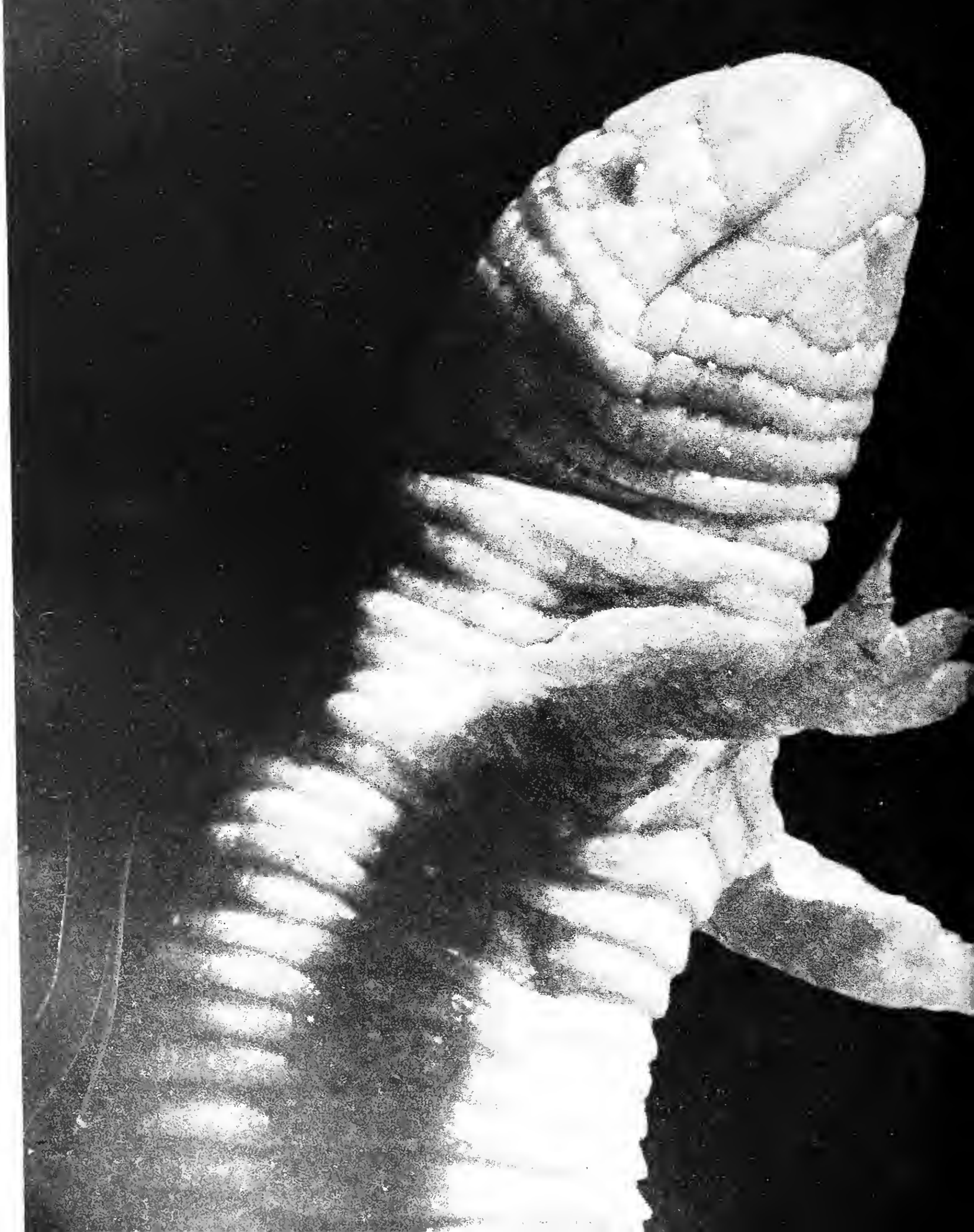
Wasp Farm, by Howard Ensign Eva *The Natural History Press, $3.95; pp., illus.*

In the overlap of the fields of scie and literature, I have often felt t there are primarily two groups of p ticipants—competent scientists who c not write well and competent writ with a limited knowledge of scier There are exceptions, but they are few. Consequently, when a scientist w writes with ease appears on the sce we are indeed fortunate, and when t scientist is one of the leading authori in his field and has a skill with his that rivals his scientific acumen, th is reason to rejoice. Rejoice we m then, in the abilities of Howard Ens Evans as demonstrated in *Wasp Fa* This small book treats with gentle hu and sound philosophy the behavior, pecially the nesting activities, of a v ety of wasps that Evans encounte when he lived on an eight-acre "W Farm" near Ithaca, New York. Infor tion about the ways of the fascinat wasps is augmented by data gai through the author's studies of the sects in various parts of the Wes Hemisphere and through the investi tions of others. I cannot say whet you should read this book because of scientific content or because of its lightful literary style, but in any ev I urge you (be you scientist or layma to read it if you are seeking an evenir enjoyable enlightenment.

Jerome G. Rozen,
The American Muse



"Little Snake With Hands"



Amphisbaenids are a taxonomic enigma

By Charles M. Bogert

At the southern part of the peninsula of Baja California, Mexicans working in the fields occasionally unearth a small, nearly blind, burrowing animal they know as the *axolote*. On the mainland of Mexico, roughly a thousand miles to the southeast in the state of Guerrero, a similar creature inhabits sandy areas bordering the Balsas River. In Guerrero, the natives call it a *culebrita con manitas*, literally a "little snake with [little] hands." The animal does resemble a snake in having a forked tongue and no ear openings or movable eyelids. Its serpentine appearance is further heightened by a slender, pinkish-lavender body, little larger in diameter than a pencil. Despite these characters, each of the short, stout limbs behind its head terminates in five-clawed digits.

Detailed examination of these seemingly preposterous reptiles reveals traits that they share with a blind, limbless burrower restricted to Florida. No less astonishing, they more closely resemble other blunt-tailed, superficially wormlike, limbless reptiles known from subterranean habitats, principally in Africa and South America. Approximately 130 species of these reptiles have been discovered. All have features in common with those in Mexico and the one in Florida. For this reason they are placed in one family, the Amphisbaenidae.

No other family of reptiles has a distribution quite so bizarre. Among snakes and lizards a few large families are widely and more or less continuously distributed in two or more, but seldom in all, continents. At the other extreme, a few families—perhaps once somewhat more diversified—have dwindled to a single species. Such lone survivors as the earless monitor (Lanthanotidae) of Borneo or the tuatara (Rhynchocephalidae) of New Zealand are restricted to one island, a few islets, or a tiny fraction of a larger land mass. Occasionally two or three species of a family, the footless lizards (Anniellidae) of California and Baja California, for example, are adjacent in one small portion of a continent.

It is sufficiently mystifying to find relatives of the iguana in Madagascar and the Fiji Islands, when all other members of the family are in the Americas. What is more surprising, amphisbaenids are distributed on parts of five continents, although the majority of the species are concentrated in two clumps on opposite sides of the Atlantic. Nowhere else are amphisbaenids so abundant as they are in the tropical and subtropical portions of Africa and South America. They inhabit several islands bordering the Caribbean, but these populations are essentially outposts of those in the South American center. The West Indies species, however, nearly outnumber the few that seem at first to be haphazardly distributed in warmer portions of the northern continents.

All of these are found on peninsulas. The map *(page 19)* shows that in North America there are four species. Three inhabit areas bordering on the Pacific—two on the mainland of Mexico, a relatively narrow southern extension of the continent, and one in Baja California, a slender strip of land flanking the northwest coast of the main peninsula. To the east one species is restricted to peninsular Florida. The one in Europe occurs at the southern end of the Iberian Peninsula. The few species east of the Mediterranean in Asia Minor inhabit either the Arabian Peninsula, or Turkey and Iran, both of which are bordered on two sides by water.

Perhaps peninsular climates, which are less rigorous than those characteristic of regions farther inland, account for this distribution. Seasonal changes are less pronounced because the more stable temperature of the adjacent water exerts its effects on the land. In other words, environmental conditions on peninsulas more nearly approximate those prevailing in the habitats of amphisbaenids in Africa and South America. The ancestral amphisbaenids conceivably adopted subterrestrial habits in order to avoid the adverse conditions on the surface, where temperatures fluctuate more rapidly and exceed the extremes encountered in the soil.

The amphisbaenids in western Mexico are the most isolated group in the family. They are exceptional in one other respect—retention of the front

Two legs ending in five digits (not all show in photograph) are typical of *Bipes biporus*, also known as *axolote*.

Lateral undulations of body propel Florida sand skink under surface. Sand falls in tunnel, marking sinuous trail.

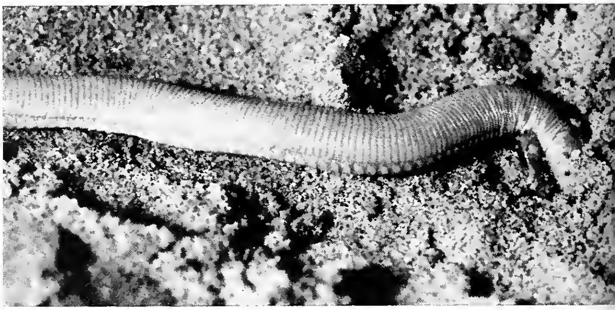
limbs. Like the limbless amphisbaenids found outside Mexico, they have remnants of hip bones. We can assume that the Mexican species arose because of the geographical isolation of one assemblage of similar individuals at an early stage in the history of the Amphisbaenidae. This population perhaps became separated from its relatives before many of them had parted with one or both pairs of legs.

The fossil record shows that lizards arose in the Jurassic Period, possibly 150 million years ago. As the dinosaurs and their relatives declined, the lizards began to flourish. They branched out as they exploited unoccupied habitats, and their form and habits changed. By the time the ruling reptiles faded from the scene at the close of the Cretaceous, lizards were advancing on several fronts. Those in one line followed a trend leading toward the loss of limbs, of ear openings, and of movable eyelids, and became snakes. These peculiarities, among others, suggest that snakes evolved from lizards adapted for life underground. It is possible, even probable, that amphisbaenids were exploiting subterranean habitats before the snakes appeared. Remains of the oldest indisputable snake, from the Upper Cretaceous, antedate by a few million years the most ancient amphisbaenids thus far recovered. But these are from the Eocene (45 to 55 million years ago), and by that time the amphisbaenids were highly specialized burrowers differing little from those today.

Paleontologists are likely to be pleased, rather than surprised, therefore, should fossil amphisbaenids eventually be found in rocks older than those containing snakes. With fossils no older than those of the Eocene, however, amphisbaenid ancestry is as obscure as that of the man who told Carl Sandburg, “I don't know who my ancestors were, but we've been descending for a long time.”

Certain it is that amphisbaenids have been descending for a long time, literally. Selection resulted in their becoming increasingly streamlined. The elongation of the body and the loss of limbs facilitated their progression through the soil. They dispensed with the eardrum along with ear openings—a source of friction to an animal moving in an underground environment. The detection of airborne sounds was then no longer an asset,
although amphisbaenids retain
inner ear and the bone (extraco
mella) that once transmitted sou
waves from the eardrum. Other mo
fications may enhance the reception
sound waves transmitted through
soil. Although snakes, too, lack
openings, they are sensitive to sou
of low frequency—100 to 700 cyc
per second—as investigators at Prin
ton have shown. Bone conduction
counts for their reception of both s
borne and airborne vibrations wit
this range. Hence, this may also

Front end of *Bipes* plods on short limbs, steering trunk. When reptile burrows in sand, *below,* it holds l
against body and pushes head do



of amphisbaenids. Amphisbaenid
protected with a transparent cov-
; derived from a "window" in the
r lid that fused with the upper,
d little friction when the head was
st through the soil. With no pre-
n on vision under such conditions,
ver, the eyes deteriorated. Their
ges are discernible in some spe-
or deeply buried in the most
mlined, where they can be seen
in the translucent hatchlings.

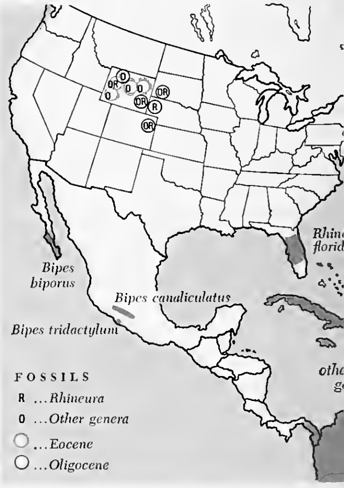
ptiles foraging on the surface
see, hear, or smell their prey, or
oy such specialized organs as
red (heat) receptors to locate
ith few exceptions, subterrestrial
es depend largely upon scent—
possibly sound—to locate their
Beetle larvae, termites, or earth-
s may produce enough noise
feeding or squirming through
oil to be detected by an amphis-
d. The British naturalist Hans
w found the *culebritas con mani-*
ving in patches of moist alluvial
along the Balsas River, where
left tunnels at least a foot below
urface that could be followed
ny direction." When Hobart M.
n reached the Balsas in 1932, a
shower had preceded his arrival,
he found amphisbaenids nearer
urface. Several were under large
s, often near the bases of trees
rubs, where the soil remained
. Tunnels readily identified as
of the two-legged amphisbaenid
ed that several had worked their
o the undersurface of rocks.

veral of the *culebritas* Smith cap-
had been eating small beetles.
ntly a foraging amphisbaenid
ocate and devour insects or simi-
rey without coming to the sur-
It is equally probable that in-
or their larvae gain access to
unnels amphisbaenids create as
move about. An amphisbaenid
Florida, *Rhineura floridana,* was
n a gallon jar of moist sand and
ved sporadically as it worked its
along the side of the container.
eptile often left tunnels in den-
patterns, as though it had ex-
d various areas in the jar. When
tes were added to the jar, how-
it became evident that it was
than luck that led the animal to
rey. Shortly after the termites
released on the surface, most of
crawled into a fissure in the
at the edge of the jar. Almost
diately the *Rhineura* headed toward them, vigorously pushing its head into the soil and momentarily retreating while it thrust out its forked tongue. Leaving a somewhat sinuous tunnel in its wake, the worm-shaped reptile nevertheless veered little from the course that led to its prey, and within a few moments was rapidly seizing and swallowing termites.

However, the performance of the *Rhineura* did not reveal whether it was hearing or smelling its way to the insects. Repeated use of the tongue strongly suggests that it was being used to sample the ambient air. Odorous particles adhering to or dissolved in the film of mucus on its forked tip were being carried to paired receptors in the roof of the mouth. Snakes and some lizards employ the forked tongue in a similar fashion. When the tongue is withdrawn the tips are thrust into a pair of depressions that lead to chemoreceptors, or specialized organs of smell, in the palate. By creating tunnels, amphisbaenids may well provide avenues for the transmission of both sound and scent. Amphisbaenids from Baja California, at least those kept in moist sand in the laboratory, occasionally come to the surface. The small holes they leave as they re-enter the sand, usually by backing into the burrow, probably prove inviting to insects or insect larvae seeking shelter.

LIMBLESS amphisbaenids, although once looked upon by Europeans as rather quaint serpents from the Mediterranean region, have been known since ancient times. The Aztecs, whose interest in natural history led them to maintain zoological and botanical gardens in their capital, were probably aware of the two-legged reptile in Guerrero. No specimen reached Europe, however, until more than two centuries after the Spaniards had conquered Mexico. An amphisbaenid with limbs, described as a *reptile bipède,* was first depicted in 1789 in a French encyclopedia. For almost another century the creature remained nearly as mythical as the unicorn and the griffin, although it had acquired a scientific name, *Bipes canaliculatus.*

LIMBLESS and near-limbless lizard distribution in N.A. is shown, *above.* Bottom map plots living and fossil Amphisbaenidae in the Americas.

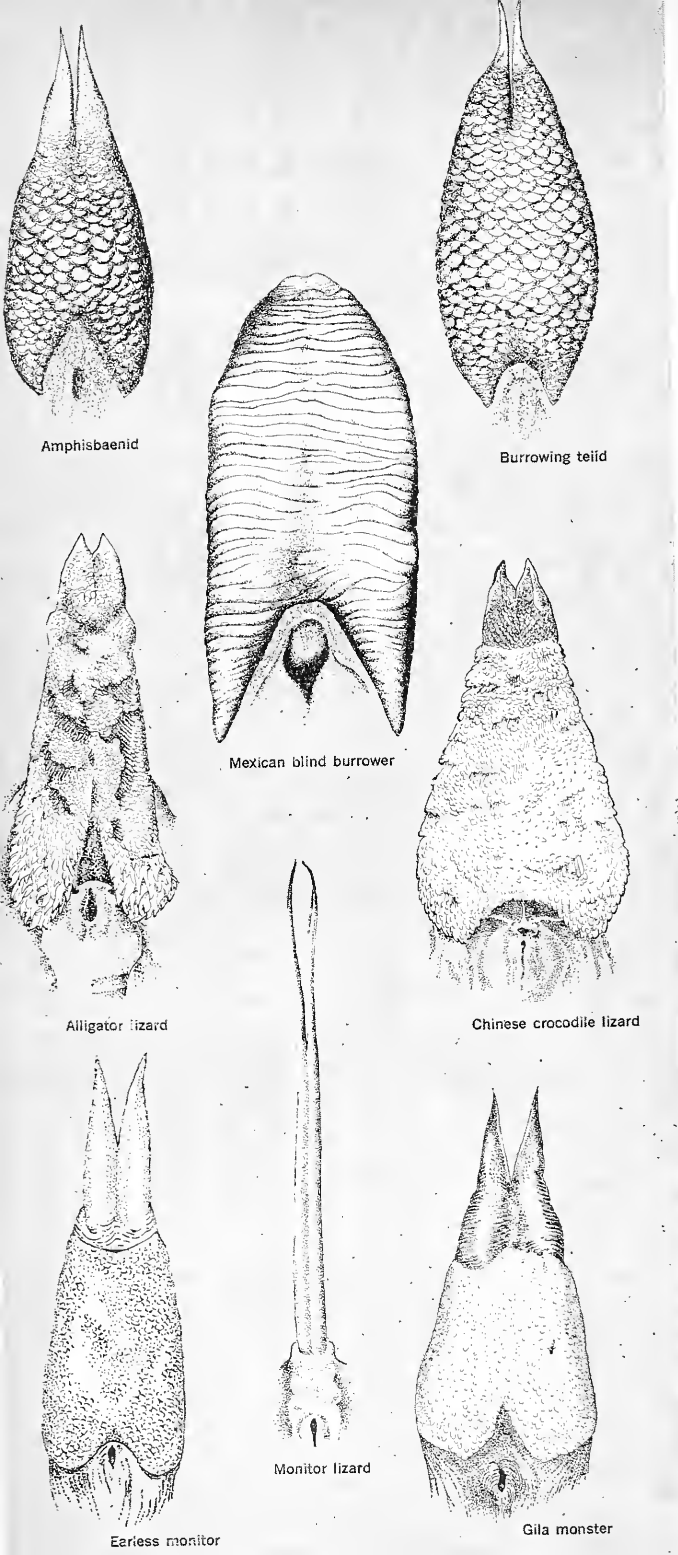


Two-legged amphisbaenids were not rediscovered until the latter part of the nineteenth century. The first to reach any serious student of natural history came from the Balsas Valley. Similar reptiles were found in 1875 near La Paz in Baja California. Nearly two decades afterward, in 1894, a Mexican naturalist, Alfredo Dugès, received specimens taken near the Balsas River. Another was sent to him from Tecpan de Galeana, a town on the coastal side of Guerrero, a few miles to the northwest of Acapulco. Dugès noted that this specimen differed from the others in having but three digits. Furthermore, those from inland localities along the Balsas also had tails proportionately twice as long as the one from Tecpan.

Dugès was reasonably sure that this one belonged to a species unknown previously. To verify his belief he sent the specimens, along with his notes. to Professor E. D. Cope in Philadelphia. Cope agreed that the short-tailed, three-toed individual was not *canaliculatus*. and for it he used the name *tridactylum* that Dugès had proposed. But examples of the two species from Guerrero proved to diffe from those obtained in Baja California, which Cope recognized as a thir species. It resembled the one inhabiting the Balsas Valley in having fiv digits and a tail about twice th length of its head. Whereas specimen from the Balsas had six pores near th base of the tail. those from Baja Cal fornia had only two. Cope also note peculiarities in the scales on the hea but to call attention to the more obv ous character of the pores, he name the species *biporus*. Unlike the specie in Baja California, the three-toed sp cies had four pores.

Such pores are not invariably di cernible on amphisbaenids. Althoug pores of the sort are retained by a three species of *Bipes*, some of th limbless members of the family lac them. These structures are not indi pensable, therefore. nor are they co fined to burrowing reptiles. Simil pores are found in many terrestri lizards of distantly related familie and in some species are confined males. Hence, they may play sor obscure role in pairing or courting a tivities, but field and laboratory inve tigations of mating behavior in lizar have failed to reveal their functio

ALMOST nothing has been learn about the courtship of amph baenids. Relatively few of the 1 species that might be studied und controlled conditions in the laborato are easily found, and they are n widely distributed. Thus far, *Bi* *tridactylum* has been so extraordin ily elusive that doubts arise conce ing the source of the specimen Du obtained. The two five-toed species a seldom encountered far from the t or three Mexican sites where ea first became known. But not one ad tional three-toed specimen has b



Amphisbaenid

Burrowing teiid

Mexican blind burrower

Alligator lizard

Chinese crocodile lizard

Earless monitor

Monitor lizard

Gila monster

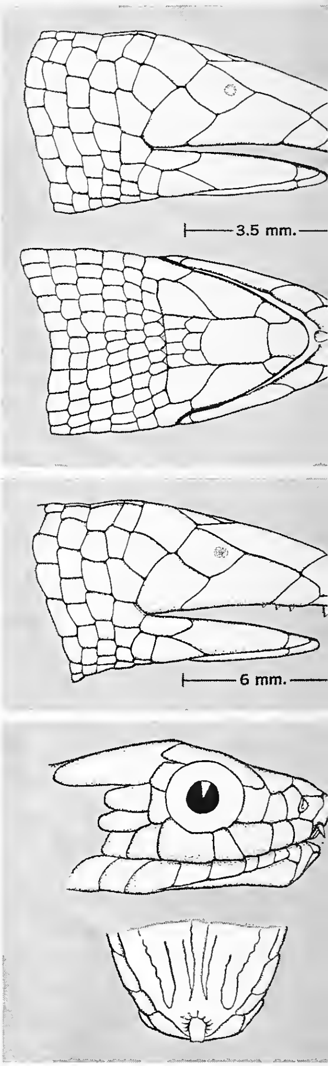
SIMILARITIES and dissimilarities in tongues of lizards are of interest to taxonomists. Tongues of amphisbaenid and teiid. top. display such striking resemblance that it reinforces belie they descended from common ancestor orted since Dugès described the cies 70 years ago. The only speci- n that Cope or anyone else has seen probably shipped from Tecpan de eana, as Dugès reported. But per- s it was found elsewhere and ely mailed from that town. After over half a century additional cimens surely should have been dis- ered, if only by accident, in the e area. Nevertheless, when the na- s of Tecpan and the surrounding ntry are asked if they ever uncover *britas con manitas* they merely surprised. Should they be asked ther the *animalitos con dos pies* le animals with two feet) are found hiding beneath rocks in area, they may glare suspiciously. e questioner inquiring about *enan-* , or trolls? Does he expect a serious y to such questions?

nanito, or troll, would be little appropriate than "two-handed rowing snake," a name used in 4 for the *Bipes* in Baja California. vas supplanted by "mole lizard" "two-footed worm lizard," neither which is much better. Anyone who erves an amphisbaenid crawling, vever, first might suspect that it has e in common with an earthworm n the habitat they share. Despite functional limbs, *Bipes* is more mlike than lizard-like in appear- e. When unearthed with sand ad- ng to its body, it usually remains ionless. Gradually the coiled body nifests signs of life, and the limbs in a sort of overhand stroke, as ugh the creature expected to swim. front end soon plods along pur- efully, but the rest of it, two-thirds more of the body, inches along hworm fashion. The head and bs seem to steer rather than drag trunk, which more often progresses alternately advancing the skin and n pulling the body forward inside When *Bipes* re-enters the sand, how- r, it holds the limbs flush against its ly, thrusts its head down at an an- and pushes it beneath the surface. Vere it not for the vestiges of eyes the head, its appearance would be re deceptive, but no more so than vernacular name. This was not in- ded to convey the impression that "worm lizards" are worms. But y may not be lizards, either. The blem of deciding what they are is old and as cumbersome as the fam- name Amphisbaenidae. This is de- ed from the generic name *Amphis- na*, the Latinized version of a Greek term meaning "to go at both ends." Although it has been suggested, it is questionable whether Linnaeus selected the name in 1758 because he realized that the burrower could move backward or forward with equal facility. The probability is greater that Linneaus chose *Amphisbaena* because it had been used since ancient times for a fabulous serpent with two heads. Moreover. Linnaeus had obtained specimens from Brazil. where the name *cobra de duas cabeças* or "snake with two heads," is still in use as the vernacular name for a large amphisbaenid possessing a rounded snout, well-hidden eyes, and a blunt tail. Brazilians apply the same name to the slender, limbless amphibians now called caecilians (NATURAL HISTORY, October, 1962). Linnaeus would not have brooded over this confusion, for he himself had classed caecilians, amphisbaenids, and miscellaneous limbless lizards as snakes.

UNTIL naturalists made detailed studies of the structure of the animals they classified. such deficiencies were inevitable. But, faults and all, Linnaeus' work provided the impetus for more intensive studies of structures and relationships in both plants and animals. When his successors made increasingly better use of such information. it became evident that caecilians bore more resemblance to salamanders. Amphisbaenids, correctly recognized as reptiles much earlier, posed no problems. but only because no one asked why they had been called snakes. The limbless lizards were not satisfactorily distinguished from the snakes until 1841, when Sir Richard Owen devised a classification that incorporated numerous improvements. Notwithstanding his advanced ideas, he still maintained that amphisbaenids were snakes.

Various students, notably Professor E. D. Cope, questioned Owen's conclusions. Pointing out that several of the limbless lizards resembled the amphisbaenids in one way or another, Cope maintained that they, too, should be regarded as lizards. But Cope also noted that the amphisbaenids might have arisen independently from the common ancestors of snakes and lizards. If the amphisbaenids arose earlier than the snakes, as Cope's statement implies, and both share features with the subterranean lizards, their resemblances can be attributed to convergence. In other words, all characteristics they share are not those of a common ancestor. Snakes, burrowing lizards, and amphisbaenids are somewhat alike because each group at some time in its history became adapted to the same sort of habitat. Nevertheless, Cope preferred to regard amphisbaenids as extremely specialized lizards.

Within recent years Cope's views



EGG TOOTH jutting forward beneath a West Indian amphisbaenid hatchling's snout, *top*, is replaced in the adult, *center*, by a curved-back median tooth. Egg tooth of snake hatchling, *bottom*, is lost and not replaced in the adult.

have been accepted with growing skepticism. If amphisbaenids are lizards, they are far enough removed from any normal lizard to be aptly described as outlandish. There is no doubt, however, that they should be grouped with the lizards and snakes, the only other reptiles that have paired copulatory organs. Moreover, the amphisbaenids gain their release from the egg by slitting the leathery shell with an egg tooth in precisely the same fashion as snakes and lizards. Although the hatchling sheds the egg tooth shortly after emerging, it is a real tooth of dentine covered with enamel. Such teeth are not found on turtles, crocodilians, and the tuatara, whose hatchlings escape from the egg by breaking the shell with a caruncle. This is a horny outgrowth of the skin on the snout, the same sort of egg-breaker used by birds.

Although egg teeth are peculiar to snakes, lizards, and amphisbaenids, once more the amphisbaenids prove to be nonconformists. They not only have a strikingly different egg tooth but also a distinctive feature associated with it. In snakes and lizards the egg tooth is near the end of the bone supporting the snout, just outside the mouth. When the egg tooth is shed it is never replaced, even in the lizards and the few snakes with teeth at the front of the upper jaw. The egg tooth of amphisbaenids, however, is attached inside the mouth, but curves forward so that the chisel-like tip extends underneath the snout beyond the lower lip. This alone would not be so remarkable, but in amphisbaenids the egg tooth is replaced by a stout tooth, which is nearly always the largest one at the front of the jaw. This tooth, sometimes feebly cusped, curves slightly inward, wholly different from its predecessor.

It is exceptional for reptiles to have a tooth centered under the snout. Lizards of one family, the geckos, have paired egg teeth, which they shed but never replace. Whatever teeth mammals have at birth are commonly replaced by somewhat different teeth later in life. Nearly all snakes and lizards replace teeth or fangs almost continuously throughout their lives. The replacement teeth invariably conform in shape, but, keeping pace with growth, they are progressively larger than their predecessors. Amphisbaenids are unique in having the egg tooth replaced by a completely different kind of tooth in the same socket.

The median tooth, perhaps with some peculiar advantage to a reptile seizing its prey in the confines of its burrow, presumably arose from the egg tooth. As an earlier innovation the egg tooth appeared in the ancestral lizards before they branched out into family groups and gave rise to snakes and amphisbaenids. The lizards and their offshoots have continued to be the innovators—the reptiles that invaded new habitats, essayed new modes of reproduction, and penetrated new regions. Species with offspring having the egg tooth are now twenty times as numerous as those whose young emerge with a caruncle, which might well serve as the hallmark of the conservative minority.

IN structures, habits, and habitats the turtles, crocodilians, and the tuatara differ little from their venerable ancestors. All these reptiles, and there are scarcely 350 species, live on land, in the water, or divide their time between the two. A few turtles and crocodiles are marine, or partly so, and some turtles tolerate desert environments. Otherwise their adaptabilities are limited. None of them lives in trees, shrubs, or on cliffs, and while one turtle inhabits crevices, none of these reptiles has dispensed with limbs and become fossorial. Not one has switched from laying eggs to giving birth to its young. In contrast, numerous snakes and lizards and at least two amphisbaenids bring forth fully formed young. Other members of family deposit eggs in their burro but what the majority of the amph baenids do, no one knows.

Obviously, however, their adap bility did not come to a standstill o they were specialized for life und ground. They have become furt specialized in shape, size, and me of progressing in subsurface envir ments that vary from humus to sa soil or rocky terrain. Species resist to desiccation tolerate relatively environments, although most of th are restricted to moist soil.

If amphisbaenids were advan burrowers by Eocene times, they have staked their claim to subter nean habitats a hundred million ye ago. Conceivably the primitive sna had barely begun to exploit the adv tages of living underground when t encountered amphisbaenids. Comp tion with more advanced burrow may not have affected the snakes, certainly some of them returned to restrial habitats. Back on the surf the primitive snakes could get al without external ears or functio limbs. With light once more an ment of their environment, howe vision was advantageous. Terrestr snakes re-elaborated their partly generated eyes, but the eyes contin to deteriorate in snakes that adhe to dark, subterranean habitats. might hazard the guess that the bl snakes, *Typhlops* and relatives, more widely distributed than amp baenids, but scarcely more numero descended from a primitive snake gained access to regions the amp baenids failed to reach.

Meanwhile, terrestrial snakes, fr of the restrictions that their erstw fossorial existence had impos branched out and advanced along li that led in some instances to spe of fairly gigantic proportions. Fos found in Eocene deposits in Eg and Patagonia reveal that snakes attained lengths in excess of thi

Typical traits of amphisbaenids are median tooth, at left, stout teeth, and a compact skull (four times life-size).

The conservative amphisbaenids ined relatively insignificant.

HATEVER their place of origin, they managed in one way or an- to circumvent barriers. Some million years ago amphisbae- were fairly widespread in North ica. Fossils found in Oligocene its in Wyoming, Colorado, and e Dakotas closely resemble the es *Rhineura floridana*, now iso- in Florida. As noted earlier, the nce of relict populations of am- aenids in warm regions as far le the Tropics as Turkey and the ern part of the Iberian Peninsula haps attributable to the less rig- climates on peninsulas.

ch climatic conditions once ex- at least sporadically, in portions e world that are much cooler . It is reasonable to infer that mphisbaenids penetrated such ns as Wyoming during periods the terrain, the climate, and features of the environment ap- mated those prevailing today in da. At best, locomotion through or soil is laborious and time ming. Hence the dispersals of isbaenids must have been pain- slow. As Hans Gadow observed years ago, an amphisbaenid pop- n might expand its distribution rate of, say, ten feet per year, a continuity of suitable terrain.

If this is a fair guess and the shift was in one direction, the range of the hypothetical species would have expanded less than four miles since the beginning of the Christian Era. In Gadow's words, "this is a mere nothing in point of time." It would have required 125,000 years for the species to extend its distribution a little more than 200 miles. "To round out this fanciful calculation to a quarter of a million years," Gadow continues, "100.000 years may then be allowed for hitches on the journey, such as waiting for sandy patches to join. Idle dreams? Not at all, since our calculations afford an insight into what can be done in time by a slowly spreading kind of creature."

Gadow wisely avoided detailed discussion of the complexities of dispersal. It will suffice to note that on very rare occasions land-dwelling animals accidentally reach distant outposts on natural rafts or other objects on which they are carried to land masses otherwise inaccessible. It seems highly improbable that amphisbaenids reached Africa from South America (or traveled in the opposite direction) in this manner, but can we be sure that something of the sort does not happen, say once every ten million years? Had the two continents drifted apart, numerous other family groups would be distributed in a similar manner. Instead, other families on both continents are, or were, more nearly worldwide in distribution.

We need not assume that the amphisbaenids crossed an expanse of salt water as wide as the Atlantic, however, if they were once extensively distributed. Negative evidence, where the fossil record is concerned, does not preclude the possibility that amphisbaenids once inhabited much of Asia. It is no strain on the imagination to assume that they existed in North America much farther to the northwest than Wyoming during the Eocene or later. If so, amphisbaenids might have moved from one continent to the other at the same time that camels, horses, and other land mammals were en route between Asia and North America.

WHATEVER explanation is acceptable, if the amphisbaenids expanded their distribution no more than 1.600 miles every million years, as Gadow suggests, they have had ample time since the Eocene to spread over every continent. Presumably they encountered insurmountable barriers in some parts of the world. More to the point, we might infer that the distribution of the group has been contracting, rather than expanding, during the last ten to twenty million years. Gaps in the range of the family suggest wide extinctions of populations, if not of species, in several areas.

Much like amphisbaenids, the limbless or nearly limbless lizards now inhabiting North America tend to avoid the more extreme climates in the interior of the continent. Two closely

Bone structure of *Bipes biporus* is shown in X-ray, but its vestigial rear limbs are too small to see in picture.

related footless lizards of one genus of *Anniella*, are confined to warm areas in California and northwestern Baja California. An odd little relict, *Anelytropsis*, with relatives in the Philippines, New Guinea, and Malaysia, is found only in a narrow strip along the eastern edge of the Mexican plateau. Three reptiles of the genus *Ophisaurus*, known as glass lizards because of their slender, fragile tails, inhabit Florida. The distributions of two of these extend to portions of the coastal plain, but the third is the exception. Its range extends as far north as the Great Lakes and west to eastern Texas, and individuals are occasionally found near the Caribbean coast of Mexico as far south as Veracruz.

One other North American lizard, not yet limbless, but with the limbs greatly reduced, is confined to Florida. This is the Florida sand skink, *Neoseps*, a burrower with a single digit on the front limbs and only two on the hind limbs. Where the family is more abundantly represented, particularly in Africa and Asia, a few skinks have become limbless. In both these continents skinks exhibit virtually all stages in the reduction, from five digits to none, and in some there is no external sign of limbs. When vestiges of both pairs of limbs are present on skinks, however, there are fewer digits on the front limbs. Furthermore, remnants of the hind limbs persist after the forelimbs disappear; the hind limbs never disappear first.

THIS is true of other families, with one notable exception—lizards in the family Teiidae. Relatively few of these inhabit North America, where only the whiptails, *Cnemidophorus*, are widely distributed. In South America, however, the family is extraordinarily well diversified. The family includes the tegus *(Tupinambis)*, lizards large enough to prey upon small mammals and birds, but there are also a number of tiny burrowers in the group. The limbs are reduced in several of these, in some instances to bud-like remnants. Curiously, in this family the hind limbs are in more advanced stages of reduction. In some species retaining forelimbs, the hind limbs are missing completely.

In this respect, therefore, they resemble *Bipes*, the two-legged amphisbaenids of Mexico. Nearly eighty years ago a Belgian herpetologist, George A. Boulenger, employed by the British Museum (Natural History), observed that the scales, skull structure, and worm-shaped body of some teiids were similar to those of amphisbaenids. E. D. Cope ascribed this to convergence. Others who held similar views may not have compared the tongues of teiids and amphisbaenids. Comparisons reveal a startling resemblance. Tongues of burrowing teiids conform closely to those of amphisbaenids. On each the fleshy base is covered with scales arranged like shingles, and the forked tips are similar. This resemblance might be attributed to convergence, but were this so, other fossorial lizards should share the peculiarity. Obviously they do not, however, for the tongue of the Mexican burrower *Anelytropsis* closely resembles that of its Asiatic relatives in being covered with transverse plates and grooves instead of the superficially fishlike scales.

Consequently there is little likelihood that the tongues of teiids and amphisbaenids are alike because of convergence. Burrowing proclivities account for the reduction or loss of limbs. The extraordinary tendency of species in both groups to retain f limbs after losing those at the rea less readily explained. Coupled peculiarities of the tongue, this trait lends support to the belief amphisbaenids and teiids descen from a common ancestor.

It need not be disconcerting to characteristics of snakes combine amphisbaenids with those of liza Several fossorial lizards are snake and a few primitive snakes re vestiges of the hind limbs, occasion with other features of the ance lizard. The amphisbaenids, howe have their own peculiarities. They tain features of the lizard and also resemble snakes, but they are readily confused with either. The rowing teiids parallel the amphis nids, and appear to retain the ance tongue. But they have not advan far enough along similar lines to licate other characters. Only the phisbaenids have a soft skin for of numerous rings, each compose flat, square plates. No other re replaces the egg tooth, and few oth for that matter, have a median t in the upper jaw.

Several less conspicuous pecu ities point to an extremely anc separation of the amphisbaenids. much easier to bridge the gap betw the snakes and lizards with an a of burrowers than it is to link the phisbaenids to either group. It mains to be ascertained whether t reptiles antedate the snakes, but phisbaenids have been amphisbae for well over fifty million years. W impeccable logic, those who call phisbaenids lizards can argue these reptiles could spend even m time in subterranean habitats with finding a place in the sun. But criterion is not their antiquity: i the extent of their divergence. On basis, amphisbaenids warrant reco tion as a distinct group, apart f the snakes and lizards.

Since they are not lizards and tainly not worms, they also deserv vernacular name more appropr than worm lizards. *Culebritas manitas* has erroneous implicati too, but what is more descriptive *Bipes* than a "little snake with hand

OVERHAND MOTION of legs, *left*, i characteristic of *B. biporus*' "wa *Bipes* has vestigial eyes, *right*, probably finds prey by sound or sm

Management of Wate

Technology alone cannot solve problems

By George H. Davis

One of the greatest hopes for coping with the world population explosion is by expanding food and fiber production in the "underdeveloped" lands of the arid zones. Most desert soils are rich in mineral nutrients, and in much of the arid zone the climate would permit year-round cropping. This fortunate combination permits tremendous production per acre when such soils are irrigated. Parts of the arid southwestern United States have seen intensive development of irrigated agriculture, especially the San Joaquin and Imperial valleys in California and the Salt and Gila river valleys in Arizona. Experience in these areas—the failures as well as the successes—can point the way to similar intensive development in other arid parts of the world. The following discussion is based largely on experience in Arizona and California, and in the San Joaquin Valley particularly, although the antecedents of irrigation date back to prehistory.

Remains of the works of ancient lost civilizations in arid lands throughout the world—Babylon in Mesopotamia, the Roman irrigation works of the oases of the western desert of Egypt, the Hohokam Indian ruins of the Salt River Valley in Arizona, to name but three—are mute reminders of man's inability to manage water resources successfully. In these areas disruption of the existing social order by invasion or by some natural disaster, such as drought, may well have played an important part in the destruction of a culture based on irrigated agriculture, but there is evidence that in all three cases man failed to cope effectively with a water problem.

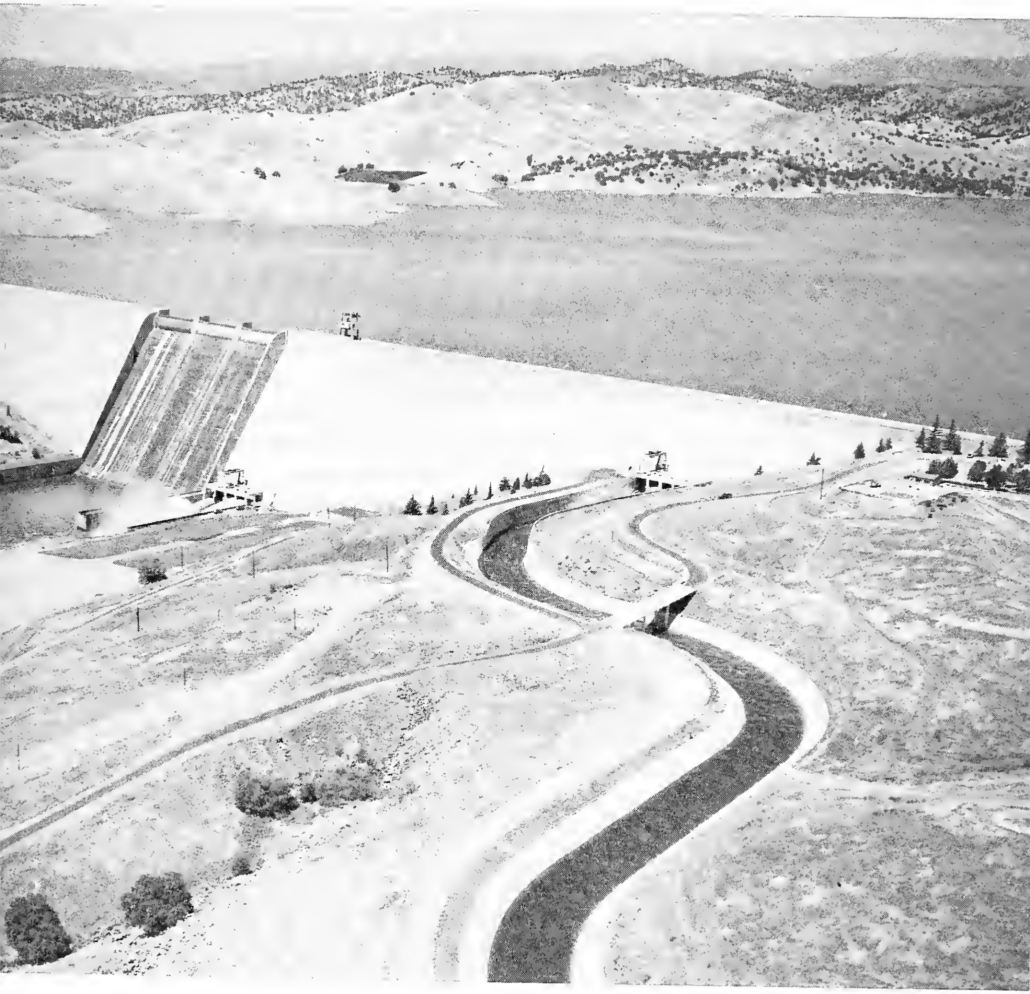
In Mesopotamia there is widespread evidence that the productivity of the soil declined owing to salinization—the concentration of salts in the soil zone as a result of inadequate drainage and surface evaporation. In the oases of the western desert of Egypt shrinking of the irrigated area was caused by a decline in the flow of wells as the natural pressure that raised the water to the surface of the land was depleted. In some of the oases, Roman wells dug to an artesian aquifer (one that contains water under sufficient pressure to raise the water above the top of the permeable, water-yielding deposits) flowed at relatively high topographic levels in a series of isolated valleys. The flow made it possible to irrigate lower-lying lands by gravity flow from the wellheads. But the flow exceeded replenishment, and the artesian head was reduced until the wells ceased to flow. Rows of Roman wells may still be seen along several stages of canals, each built to replace a higher system as the artesian head declined. By the close of the Roman period the head had dropped so low that only small oases in the bottoms of the valleys could be irrigated with flowing wells.

The Hohokam culture flourished in the Salt River Valley at the present site of Phoenix, Arizona, from about the beginning of the Christian Era to about A.D. 1400. The Hohokam people disappeared before the arrival of Europeans, and little is known of their relations to other Indian groups. There is some evidence that the Pima Indians are descendants of the Hohokams, although the Pimas speak of the Hohokams as a vanished race; in fact, the term Hohokam means "those who have gone" in the Pima language.

Diversion of the waters of the Salt River into large canals made possible the irrigation of tens of thousands to perhaps a quarter of a million acres. The longest canal was 12 miles long, and a total of 175 miles of Hohokam canals has been mapped. Some of the main canals were as much as 30 feet deep and 75 feet wide—large even by modern standards. The Hohokam canals were not fixed systems; several were built, each upslope from its predecessor. Evidently this was because of progressive waterlogging — drowning of plants by continuous saturation of the root zones—and accumulation of alkali in the soils of the lower lands. The solution of moving upstream with successive diversions could not be carried above rock outcrops in the bed the Salt River. Thus, the Hohokam inability to cope indefinitely w waterlogging and salinization brou their culture to an end.

In the so-called underdevelop modern countries, many of which arid. great benefits may be realized developing small water supplies human or stock use. This is relativ easy, and involves studies to locate adequate source of drinkable wa

n Arid Lands



Water is sent to thousands of acres in San Joaquin Valley via a diversion canal carrying runoff from Friant Dam.

elatively unsophisticated engi-
g works to move the water from
irce to where it is to be used.
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ind pumps to lift ground water
surface, and pipelines or ditches
ivey water overland from a
, stream, or small surface reser-
an drastically alter a primitive
ıy. Where the environment and
ıy are favorable for irrigation,
chnology is equal, for the most
part, to the task. Basically we are still building dams, wells, and canals as did the Romans and Babylonians, although, of course, our construction techniques are far more sophisticated.

The most complex problems in water supply in arid zones relate to the proper management of the supplies. For example, although evaporation may impose a practical limit on the storage of water in surface reservoirs in arid basins, this does not mean that we have exhausted all possibilities of further water development. Data from current research suggest that evaporation from reservoirs can be drastically cut by the use of thin films of chemicals (such as cetyl alcohol) that float on the water surface but have no effect on the quality of water. Another promising method of evaporation reduction

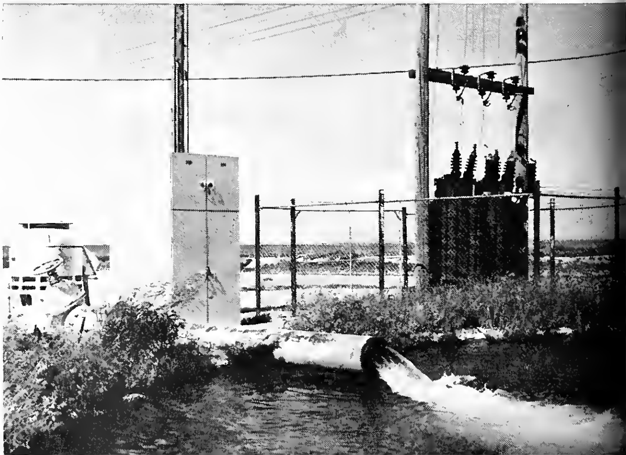
involves the use of submerged bubbler devices, similar to the familiar fish bowl aerator that brings cool water to the surface. Evaporation from open water surfaces increases as the water temperature increases. Thus, the constant circulation of cool water to the surface reduces the evaporation rate. With adequate knowledge of the geohydrology of arid basins, it would be feasible in many places to store tremendous quantities of water underground in the irrigated area. This would involve putting surface water underground when surpluses were available and pumping it out when the surface supply was deficient.

Of all water management difficulties in arid lands, salinization may well be the most frustrating, and has plagued irrigators for 3.000 years. Even today it is not controlled beyond the primitive technique of washing the accumulated salt out of the soil by applying excess water. Much the same could be said of waterlogging. In many areas we continue to apply surface water for irrigation so liberally that the water table rises to the surface and literally drowns the very crops that we are attempting to grow.

The damage from waterlogging is twofold. Most crops cannot survive a long period of saturation of the root zone: however, this is only a short-term damage that causes crop loss until the water table can be lowered. Salinization is much more serious. The mineral content of the soil moisture increases whenever evaporation or transpiration can occur—for example, after an application of water for irrigation. Where the water table is several feet or more below land surface, the soil solution is normally diluted a flushed by succeeding applications water, and the dissolved salts are ca ried away or become concentrated the ground water. On the other har where the water table is so close to la surface that evaporation of grou water takes place, there is no oppo tunity for residual salts to esca downward. Moreover, dissolved sa are brought to the surface in t evaporating ground water, and i crease the soil's salt content.

This concentration of salts is oft doubly damaging. First, it is toxic

Irrigation well, often used in arid western U.S., uses much electricity or fuel and requires skilled maintenance.



Commonplace windmill pumps often can revolutionize local economies in many of the underdeveloped arid lands.

s. Second, if the solution has a
percentage of sodium in relation
lcium and magnesium, soils con-
ng even a small amount of clay
be rendered virtually imperme-
because of the swelling of the clay
cles. Crop yields decrease as per-
ility decreases, until further cul-
on is unprofitable.
e best time to control waterlog-
and salinization is before exten-
damage has occurred. In most
it is possible to maintain the
: table at a safe level by keeping a
ıce between the local ground
water that is pumped and the irrigation water that is brought in from outside the irrigated area. In places where ground-water levels cannot be controlled by pumping for irrigation—for example, where the quality of ground water is too poor for irrigation or where wells cannot be developed economically—deep surface ditches may be the most inexpensive solution.

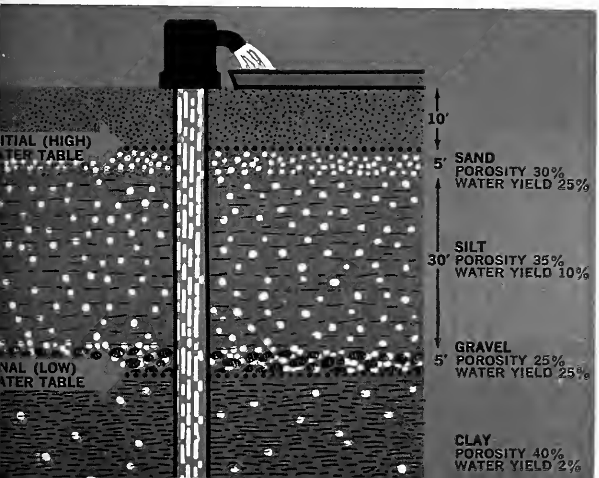
A problem unique to arid lands, which has only recently come to light, is the severe compaction that takes place in many soils during the early days of irrigation. In humid climates, rainfall exceeds evaporation and plant demand; consequently, excess water can percolate through the soil and replenish the saturated zone of ground water. In arid lands, the sparse rainfall either evaporates or is used by hardy desert plants, which are capable of reducing the soil moisture far below the level at which water will percolate downward by gravity. Thus, after a long, dry summer the soil-moisture deficiency may be such that 3 to 4 inches of water would have to be supplied to the soil before any could move downward. In many arid areas this soil-moisture deficiency is never met, and infiltration can occur only where water concentrates, as in stream channels.

Stream flow in arid lands is commonly in the form of flash floods, and often the flow could be better classified as thin mud rather than water. Much air is entrained in deposits of this origin and, when dry, such soils may contain up to 50 per cent air space. Small amounts of clay can give sufficient dry binding strength to preserve the initial frothy structure, even under loads of several hundred feet of overlying sediments. However, when wetted, the clay slakes, the air is squeezed out, the deposits compact, and the land surface subsides.

This phenomenon, termed hydrocompaction, was first observed on a large scale in the early 1950's in the western San Joaquin Valley when large areas of virgin land were put under cultivation and irrigated with ground water. Compaction caused the land surface to sink, and within a year or two irrigation ditches that originally were 3 feet deep and 5 feet wide had become broad swales 15 to 20 feet deep and 50 feet wide. As the ditches became deeper they had to be abandoned because they were below the level of the lands that were to be irrigated. The sinking was accompanied by cracking of the soil, which ruptured pipelines and caused structural damage to roads, wells, and buildings.

Even more severe was the effect of soil compaction on what had been nearly level irrigated fields. Wherever water accumulated—at a slight depression in a field or where a ditch or pipe leaked—the surface sank. This situation was constantly aggravated as excess water found its way to the ever deepening depressions. Releveling of the fields only alleviated the condition temporarily. Within a few years the originally level valley floor had been changed into a hummocky prairie.

A government test plot that was kept continually submerged sank 10 feet within 19 months, and sinking continued even after the water supply was cut off. During the test a cumulative depth of 129 feet of water had infiltrated. Continuous observation of the surface sinking, coupled with tests of the subsurface deposits, showed that compaction of the deposits and the resulting settling took place as the water moved downward toward the water table, locally 300 feet deep. Computations based on the slowing of the rate of advance indicated that five and a half years would be required for water from a constant source to reach a depth of 200 feet, and it could take several



Molecular attraction holds water in sediments and is greatest in such fine material as silt. Gravel drains freely.

Hydrocompaction test plot shows ten-foot drop after previously level land was subjected to 17 months of flooding.

decades for water applied at the surface to reach the saturated zone. Ultimate stabilization of the land surface could not be expected earlier.

Similar compaction phenomena have since been reported in many places in some arid western states—Nevada, Utah, Arizona, and Colorado. Comprehensive studies of the geology and hydrology of the San Joaquin compaction by an interagency committee of federal and state organizations have revealed the causes and predicted future effects. This knowledge is vital in planning major structures such as highways and canals that must cross the compactible soils. The only practical solution so far has been to plan for compaction in the hope of minimizing financial losses. Steel pipelines have replaced leaking ditches and the less flexible concrete pipelines, and irrigation by sprinklers has replaced irrigation by gravity from ditches. Research now under way offers some promise for hastening the ultimate soil compaction by speeding infiltration through such means as drilling numerous, closely spaced holes in canal bottoms. If this proves feasible, water could be introduced into the abnormally dry deposits at various depths, and in this way the wait for natural downward movement could be greatly shortened.

Probably the most severe single hazard stemming from arid-land irrigation is deterioration of the quality of water through use. The principal economic use—growing crops—invariably results in a concentration of dissolved mineral matter in the outflow from irrigated areas, and municipal and industrial uses usually add undesirable chemicals to the water. In irrigation the difficulty is uncomplicated but unavoidable; plants use water for temperature regulation and to form carbohydrates, but they remove little of the dissolved minerals. Moreover, most soils in arid climates characteristically contain much natural soluble salt, because of lack of leaching by rain water.

In arid lands water commonly is used many times in its trip from the point where it falls as rain or snow until it finally reaches the sea. For example, in the South Coastal Basin of California, which includes the Los Angeles area, use of water is so effective that only 8 per cent of the supply to the area annually wastes to the ocean. Yet, in each cycle of use some of the water discharges to the atmosphere and thus the remaining water becomes more mineralized. With ground water, each cycle of pumping and replenishment results in a more concentrated blend of water and dissolved minerals.

In the early development of arid lands, as in our own West, the problem of increasing mineralization grows gradually, and it is only in recent years that it has become critical in major streams. For example, in 1960 the summer flow in some reaches of the San Joaquin River exceeded 3,300 ppm. (parts per million by weight) dissolved solids, and was unsuitable for irrigation of certain crops and for some other uses. Many specialists consider irrigation with water that exceeds 1,500 ppm. dissolved solids to be harmful to the soil, and feasible only under the most favorable combination of soils and drainage. The deterioration of the water of the San Joaquin River has grown progressively more serious because of the great expansion in irrigated acreage since 1946, and the resulting increases in mineralized drainage returned to the streams. Much of this additional acreage is on the drier western flanks of the San Joaquin Valley, where the soils typically contain abundant gypsum (calcium sulfate) and other salts. Some drainage waters from the irrigated lands contain nearly as much mineral matter as sea water (35,000 ppm.), although calcium and sulfate compounds predominate over those of sodium and chloride, which are more harmful to plants.

Fortunately, engineering solutions are possible in the San Joaquin Basin.

reas now affected are in the lower of the basin. Plans are under way tercept the highly concentrated age water and convey it in canals lewaters beyond irrigation diver- , thus restoring the quality of the m waters so that they are suitable rigation of downstream lands.

ery water user contributes dis- d mineral matter to the streams, many downstream users are ad- ly affected. The required waste sal systems are far beyond the of individuals or even of local agencies, just as sewage disposal ity is beyond the resources of in- ual homeowners. The obvious way pose of irrigation waste waters is regional or basin-wide system.

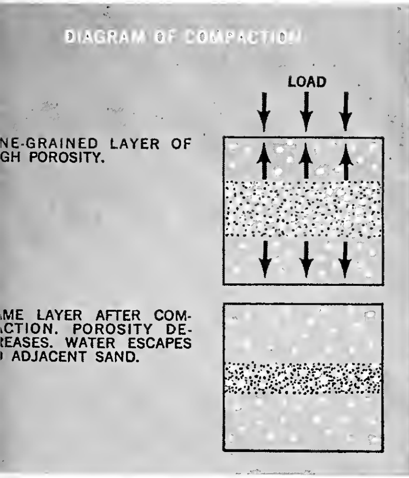
other pressing problem of the logy of arid lands is overdevel- nt of the water supply. Where the is irrigated from streams, farmers monly place more land under irri- n in wet years than the stream upply in dry years. The principal in this situation are in low crop in dry years and consequent loss pital investments. However, with turn of wet years the system may stored.

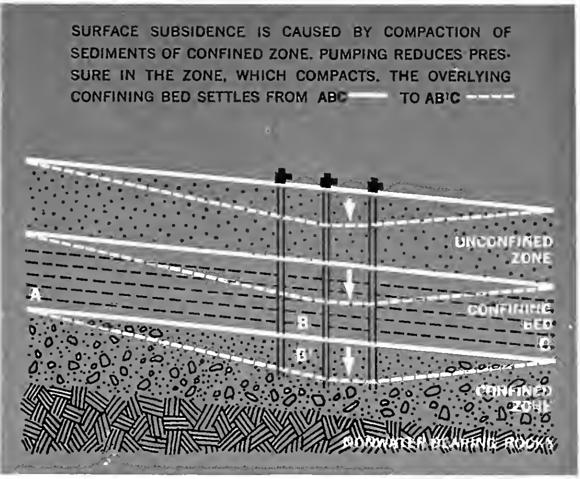
ere ground water is the irriga- supply the situation is much dif- t and the losses may be much severe. Ground water generally is ned from wells that tap saturated -yielding deposits—granular ma- s such as sand and gravel that in water in the irregular openings en the grains. In sand and gravel openings commonly comprise 20 per cent of the total volume of material. In finer materials. such as silt and clay, the percentage of openings, termed porosity, often is from 30 to 40 per cent of the total volume. but such materials release their water slowly. Furthermore, the finer the grains the greater is the proportion of water retained by molecular attraction when the material is drained. Thus, a dry desert valley may contain, within a hundred feet of land surface, sufficient water to cover the area to a depth of 20 to 40 feet. For example, hydrologists estimate that the ground-water storage capacity of the San Joaquin Valley (surface area 10.000 square miles) in the zone from 10 feet to 200 feet below land surface is 93 million acre-feet (1 acre-foot = 43.560 cubic feet). This is ten times the normal annual flow of the streams into the valley and more than three times the capacity of Lake Mead, behind Hoover Dam on the Colorado River, the largest surface-storage reservoir in America. Moreover, this estimate is based only on the water that would drain from the sediments by gravity, and deliberately ignores the even greater quantities held indefinitely by molecular forces in the fine silty and clayey deposits.

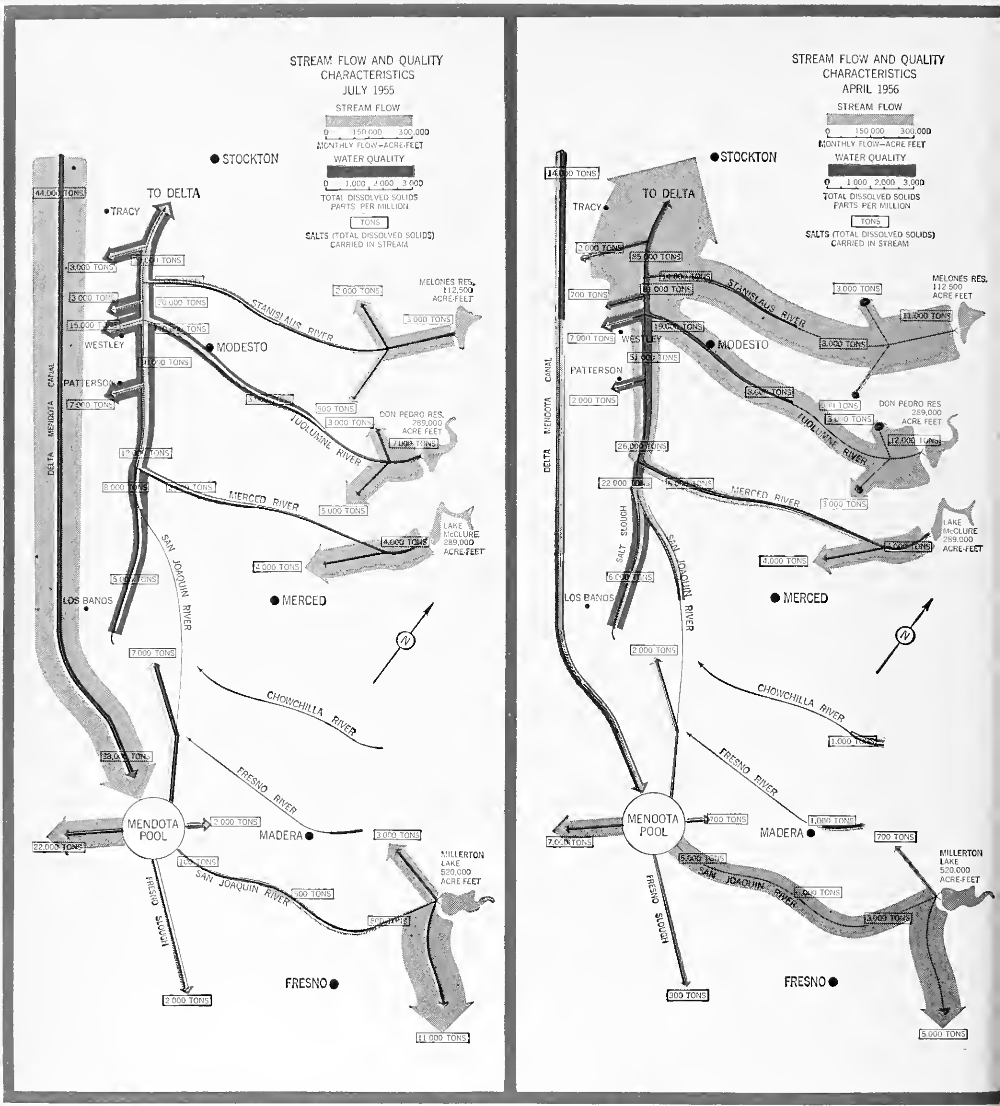
NATURALLY, recharge to the groundwater reservoir is vital. When wells are pumped for irrigation some of the water applied, commonly as much as half, returns to that reservoir. This, together with infiltrating rainfall or stream flow, makes up the recharge. When the average long-term discharge exceeds recharge, however. the basin is overdrawn, in much the same sense that a bank account is overdrawn when checks consistently exceed deposits. To carry the analogy further, we generally start ground-water development with a full bank account. When the drafts exceed the deposits, we are reminded each month by a bank statement: in the ground-water reservoir this has its parallel in the hydrologist's report of recession of water levels.

Overdraft of ground water can end in complete depletion of the saturated zone in shallow basins or, more commonly, in the lowering of water levels to a depth at which further pumping becomes uneconomical and enough land goes out of irrigation to bring the withdrawals into balance with recharge. The economic effects on water users are painful, to say the least. As water levels recede, large investments are required to chase the supply downward. For example, wells must be deepened, pump bowls lowered, and power plants enlarged. And the cost of all these must come out of the income produced by the use of the water.

One of the more lasting effects of overdevelopment of ground-water supply in dry climates is the compaction of the water-bearing deposits that takes place with the decline of water pressure in artesian aquifers—those in which the water is confined under pressure by relatively impermeable, overlying deposits such as clay and silt. The water pressure helps to support the overlying load. When the pressure is reduced by pumping, the effective load on the water-bearing deposits increases. The materials then compact to compensate for the water removed, and







Relative quantity of stream flow and salt load of San Joaquin River system in its high and low stages is shown in the widths of the gray and green lines.

the land surface settles. Such subsidence is not evident to the casual observer and generally is detected only by precise surveying.

In the western San Joaquin Valley the maximum settlement due to pumping has been as much as 25 feet. Similar overdevelopment of artesian aquifers has resulted in as much as 11 feet of subsidence in the Santa Clara Valley, California, and several feet at Las Vegas, Nevada. Known areas of subsidence exist in other arid or humid parts of the United States.

The damages from such compaction are subtle. Well casings collapse prematurely, canal gradients change and disrupt water-delivery schedules, river gradients change, resulting in aggravation of flood hazards, and in the Santa Clara Valley there has been extensive inundation by the salty waters from neighboring San Francisco B

Compaction usually is irreversib restoration of artesian pressure d not cause expansion of the materi Thus, the reduction in ground-wa storage represented by the compact is a permanent loss, in the same se that siltation of a surface reservoi a permanent loss of capacity.

What, then, can be done to m the most effective use of water in a lands? The answer is that there is simple cure-all. Rather, the soluti in wise management of this most ic natural resource for the greatest d of all the people. Such considera- ns as hydroelectric power genera- , flood control, irrigation, dilution astes, maintenance of fisheries and llife, and recreation facilities must valuated in adequate planning.

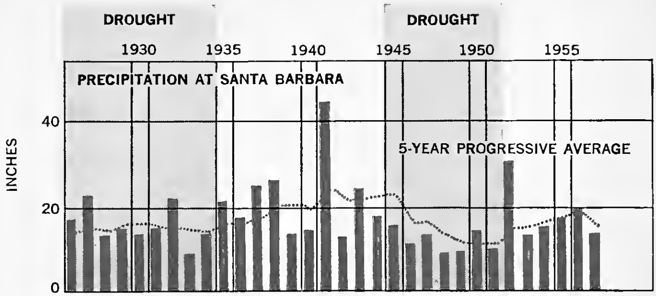
ive major categories that require ntion are: (1) regulation of stream by means of reservoirs and water- l management; (2) improvement maintenance of water quality ugh adequate control of pollution contamination; (3) proper use of erground storage; (4) increase in efficiency of water use through ination of wasteful irrigation prac- s and the substitution of crops low water requirements for those high requirements; and (5) in- se of fresh-water supplies by such ns as desalinization, weather mod- tion, and importation of water areas of water surpluses.

esearch fields that offer great pos- ities in increasing efficiency of er use in arid lands include: reduc- of water use by wasteful plants; ction of canal seepage and of oration from reservoirs; water- lity management; forecasting river s; saline-water conversion; im- ement in re-use of water; and ap- ations of nuclear energy.

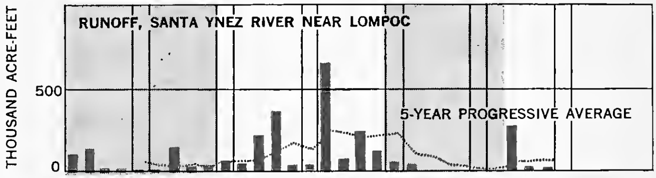
NE other matter that cannot be overemphasized is the need for sion of conflicting and often un- istic state and federal laws govern- water to make them consistent and gruent with our present knowledge ydrology. Unfortunately. discus- s of water rights have been noted e for discord than harmony—wit- those of India and Pakistan over Indus River, and Israel and Syria the Jordan. In most arid areas of world, where water means the dif- nce between a prosperous life or survival, probably the most im- tant objective is to get water users ork together for the greatest long- good for society. Our knowledge ydrology is adequate, for the most , to meet the technical problems arise; the greatest difficulties lie he fields of law, of sociology, and conomics.

TOR'S NOTE: This is the third in eries of articles that will describe wide-ranging research activities of United States Geological Survey.

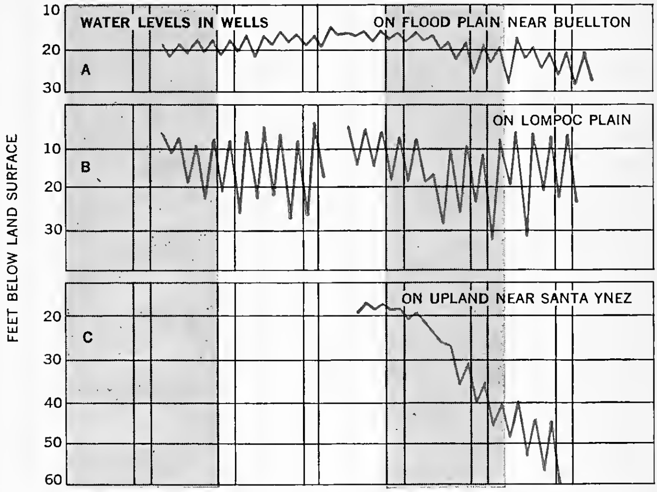
HYDROLOGIC TRENDS IN SANTA YNEZ RIVER BASIN



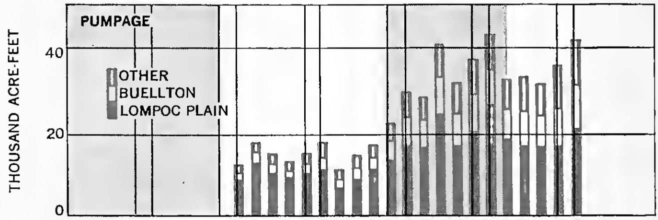
BARS on graph show the annual rainfall at Santa Barbara. Dotted line is five-year progressive average, on which the low points represent drought periods.



RUNOFF of Santa Ynez River supplies water for the city of Santa Barbara. Note way fluctuations are accented, in particular during periods of drought.



GROUND WATER near a stream fluctuates most in droughts (A); irrigated areas fluctuate more (B); marked overdraft is evident in irrigation pumpage (C).



GREATLY EXPANDED irrigation through pumpage of ground water followed World War II, and is typical of many western states, including California.

In January, after high waters from rainy season have begun to subside, turtles arrive on islands in Orinoco to lay eggs.

Groups of females, after basking in the sun for several day move over the sandy beaches, searching for adequate nest site

Pilgrim of the River

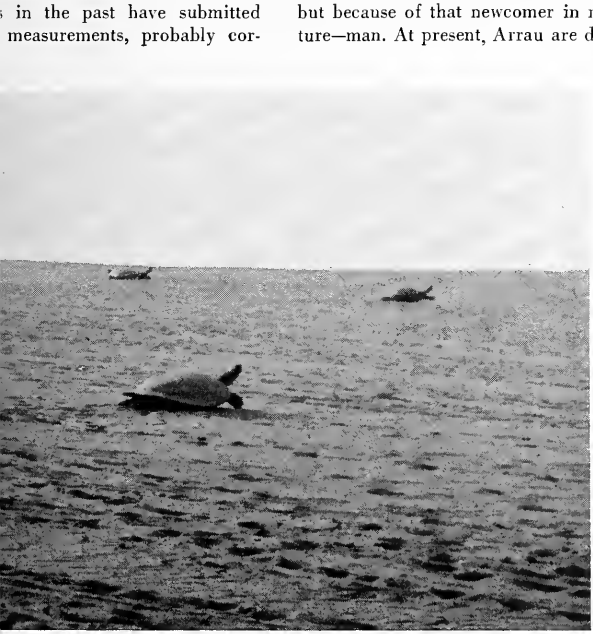
e cycle of the Orinoco turtle has many unusual features

By Janis A. Roze

EZUELAN INDIANS call the Orin-
o River "Father of All Waters."
ke any good father it has been
surprises for its children—the
is, and every explorer, past and
t. Our story is about one of
surprises—the Orinoco River
Arrau *(Podocnemis expansa)*,
life cycle presents some extra-
ry features. For long months the
feed in the Orinoco and its
ries, but from January to April
urney to a few isolated beaches
central Orinoco. There, thou-
of determined creatures creep
he sandy beaches, lay millions
s, then travel back again to their
l feeding grounds.

Arrau is the largest New World
ater turtle, a little smaller than
en sea turtle *(Chelonia mydas)*,
has a worldwide oceanic dis-
on. Our record measurement
carapace of a female was 89
eters (nearly 3 feet), although
erage is about 2 feet. Some ex-
in the past have submitted
measurements, probably correct, for it seems that the largest members of any animal species disappear and their total number diminishes as soon as man starts hunting them. The weight of the female Arrau averages 45 to 55 pounds, and some captured specimens have weighed more than 100 pounds. The males are smaller; their almost circular shells are about one and one-half feet in diameter.

If one is to look for mystery and drama in nature, it can certainly be found with this animal. Arrau is a species of what is probably one of the oldest groups of living turtles. Its immediate ancestors have been traced back to the Age of Reptiles (Mesozoic Era). It survived when the dinosaurs became extinct, lived during the development of many of the recent animals, including man, and now, ironically, is itself in danger of extinction. This is not because it could not succeed in the evolutionary struggle, but because of that newcomer in nature—man. At present, Arrau are distributed throughout tropical South America, but it is in the Orinoco River that they are particularly abundant.



During the rainy season, the Orinoco and its tributaries cannot hold all the water supplied by the tropical rains, and they overrun the river beds, invading adjacent savanna lowlands, called *llanos* in northern South America. For months these extensions are Arrau feeding grounds. They eat fruits, flowers, roots, and soft vegetation. When the rains diminish and the waters slowly retreat into their river beds, so also do the Arrau. Then they start their long pilgrimage to the sandy beaches, which at that time are covered by more than thirty feet of water. The large and small tributaries of the Orinoco are the roads on which the turtles travel, sometimes for more than a hundred miles, in ever increasing numbers. Once they reach the Orinoco, they continue either upstream or downstream, sometimes fighting strong currents, sometimes passing violent rapids and other obstacles. They stop eating, and the whole life activity from this point on is directed to reaching the beaches. The males seem to be the first to arrive at the *remanso* (tranquil, protected waters) near the sandy beaches, where the eggs will soon be laid: a few days later the females arrive, and mating takes place.

AFTER the mating, each step of the cycle is well marked, as are most well-established rituals in nature. The water level is still dropping, increasing the size of the many sand beaches around the island, when on an early morning in late January the water's edge is adorned with a row of shiny, wet bodies of Arrau females. They have started the first step—basking in the sun. In the early days there are only a few of them, but soon many parts of the water's edge are covered with dark clusters of turtles; sometimes there are up to six thousand basking in the fiercely hot tropical sun. They do not fight with each other—

there is no aggressive competition among them. When all the available places are occupied, other females wait patiently in the water, their heads extended like periscopes, until one basker decides she had enough sun or is frightened off by, perhaps, unusual noises or a predator. All the others follow as she backs into the protective water. After about five minutes they all return and slowly reoccupy the water's edge.

Their resistance to sunshine is remarkable—some females bask almost uninterruptedly for six or more hours. Others retreat after an hour or so and reappear later. The excessive heat raises the metabolism in the females' bodies, which are loaded with maturing eggs. The first date of basking varies from year to year, probably depending on the end of the rainy season and the time at which water in the river begins to recede. Because rains have their own regulations, it is impossible to predict when in a given year the reproductive activity will start.

IT is somewhere between the 11th of January and 25th of February, while water is still dropping and the sun is bright in the sky, that the second step in the ritual takes place. After sunset the turtles retreat to the water, but only for a few hours. If you near the water's edge when the moon is dark or clouded over, you can sense the thousands of Arrau present in the *remanso*, or hear the dry, hard sound when two large female bodies clash together, so full is the *remanso* of females eager to start egg laying. Then they begin to emerge from the water, usually in groups. The first night is generally used for exploring the beach, and only twenty or thirty females appear. Some begin to lay eggs at once, while others, after long walks all over the beach, postpone this activity. The next morning their trails are found in the otherwise undisturbed sand, and by following their steps it is possible to register their behavior. After a few days several hundred or even several thousand Arrau climb out of the water and the high season has begun.

While thousands of turtles appear year after year on the same sandy beaches, hundreds of humans do the same, easily removing many eggs and baby turtles, and a good part of the female turtle population. The story of turtle hunting far antedates the white man's discovery of the Americas, but in latter years, with the advance of our civilization, the destruction has become more effective, and the turtle has begun to show signs of diminishing. The Venezuelan Government, worried about the situation, offered generous research funds for our School of Biology of the Universidad Central de Venezuela to make an ecological and economic study of this renewable natural resource that provides means of living for many *ribereños* (people who live on the river banks), be they Indians or *criollos*, who are the descendants of the Spanish.

For the last four years we have established, during the reproduction period of the Arrau, a temporary biological field station on abandoned, isolated Cuba Island, located in the middle of the Orinoco near the Venezuelan-Colombian border, to study the reptile. The island is about five miles long and two miles wide and its beach, Playa del Medio, is one of the main arenas for egg laying. Within fifty miles are three or four more beaches where the yearly pilgrimage ends.

To obtain as precise data as possible we spent many sleepless nights on the sandy beach of Cuba Island observing —or, it might be said, feeling—our way with our hands toward some kind of knowledge in the darkness. The turtles come out of the water in groups. Some four or five move ahead, then stop and listen: meanwhile some from behind pass them and walk for a while, only to stop after a few yards to listen and observe. They, in turn, are overtaken by others, and so it goes until the group has reached some of the highest elevations of the beach. There they begin to dig nests, and there other groups mix with them. During the walk, a female stops from time to time and throws sand on her back with her front legs as if she is trying the quality of sand. Their approach can be heard from some distance by a typical "gurc, gurc" sound. This is particularly loud on the final nesting sites, and it seems that it has to do with some characteristic of the sand—perhaps a higher concentration of salts or other minerals. We could produce the same type of sound on other turtle islands in the Orinoco by walking over the sand. Curiously, sands from beaches that are not used by turtles usually do not produce this distinctive noise.

Sometimes we arrived on the nesting sites early in the evening, fell asleep, and awoke to find turtles all

TURTLES dig small holes to recei
their eggs at the bottom of the larg
holes they dig first, *above* and *righ*

s in one square meter of ground dug up and the eggs counted. The ge per nest was from 82 to 85.

around us—moving, digging, or laying eggs. The first night we did not know how to pass unnoticed and make the needed observations. Since it was almost impossible to see anything, we walked among them, but soon found out that the turtles rightly took us for strangers and returned, running, to the river. So we crawled on our bellies. The observation was much more difficult, but at least the Arrau did not run away. On occasion, to reassure the turtles, we extended our hands laterally and, first with one hand and then with the other, we threw sand on our backs as the females were doing—and it did the trick.

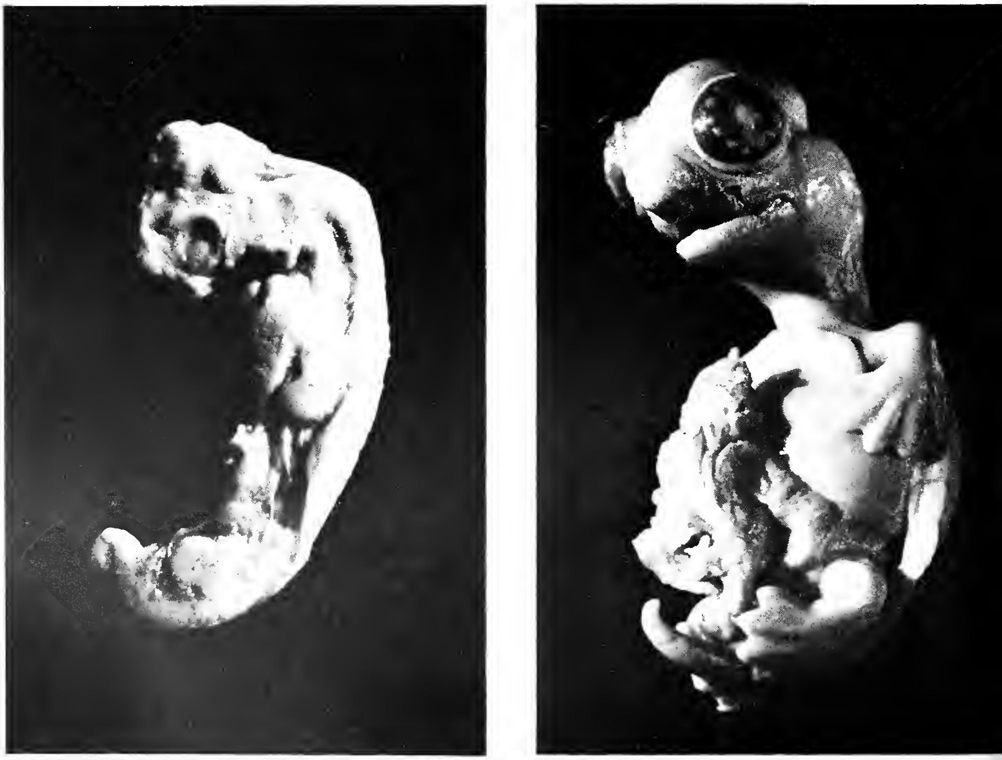
When a female decides she has found the right place, she starts digging immediately, using all four legs. First, there are strokes with front legs that throw the sand to the posterior; then, one at a time, the hind legs finish the job, throwing the sand laterally four or five feet away. When the legs on the right side tire, the female uses the legs on the left side until a hole about three feet in diameter and almost two feet deep is produced. This is a difficult task, for the sand is dry and the walls fall in repeatedly, but the female goes on until she is finished, although from time to time she relaxes for a few seconds.

When the large hole is dug she uses her hind limbs to scoop out a smaller hole—about twelve inches deep and ten inches wide—in the bottom. This is the spot where the eggs will be laid. The wet sand starts at that depth, and both during and after digging the female irrigates it with her cloacal liquid to facilitate egg laying and to contribute to the firmness of the nest walls. When the nest is carved large enough she makes a last, quick move, throwing her body backward to cover the nest hole completely with the carapace. From this moment on she is unmovable. Earlier, any suspicious sound or movement could frighten her away. Once the egg laying starts, however, we discovered we could move around freely. We could touch her head or legs or body, throw sand on her—nothing could force her to budge. We capitalized on this behavior by opening one side of a nest and, with our hands inside it, feeling the eggs actually falling and the turtle using her tail to distribute them in the nest. For about twenty minutes nothing is heard but a peculiar moaning. The eggs come out at intervals of four to fourteen or more seconds. At first, two or three are laid at once; later, one by one. When the egg laying nears its end, a curious gargling sound is heard, as if air is coming from the cloaca. By this time, the stupendous effort has filled the female's eyes with tears that roll down her sand-covered face. But the job is only half-done.

Immediately after finishing the egg laying, and without lifting her body, she starts closing first the nest, then the large hole. It is a good hour's activity, as she not only covers the hole, but smooths over a surrounding area about twelve feet long and five feet wide. One end of this area, as far as possible from where the eggs are buried, she does not cover completely but leaves a small depression in the ground. This gives the appearance of a recently covered nest, and may be designed to confuse predators. Completely exhausted, with wet eyes, bloody hind limbs, and a tired body, she returns to the river. The following year, on the same beach, the pattern will be repeated.

Sometimes egg laying starts early in the morning. The first rays of t sun heat the sand beaches so rapid that on more than one occasion have found exhausted females wl have died before being able to rea the saving waters. While the egg la ing is in full swing at night, ma females go on basking during the da time until their time to lay has com and this most intensive activity m last up to two months.

To obtain data about the product ity of our beach we made a tra sect, opened one square meter ground every ten meters, then dug o and counted all the nests and the nu ber of eggs in them. The number eggs varies greatly; the average around 82 to 86, although young males, called *lechonas*, lay only 50 60. The record number obtained fro a single nest is 150. The eggs are so shelled, elastic, and almost round. T native boys play ball games with the



EMBRYONIC DEVELOPMENT of *Podocnemis expansa* takes about 45 days. In top photograph, two- or three-day-old embryo is easily visible through the thin egg membrane. Before hatching, the caruncle—a beaklike projection—forms on the snout ju below the nostrils. This is used to break the shell, and th the turtle begins its struggle up through sand to the ligh

the middle of April all the fe-
have gone. The incoming rains
he water level rise quickly, and
ach is abandoned except for
eds of predaceous birds, which,
the egg-laying period, hunt for
ished or badly closed nests to
fter the departure of the fe-
however, the birds wait for the
ngs to come out of their safe,
round nests. Among the most
nt birds are vultures, like the
o *(Coragyps atratus)* and Cari-
aracara plancus), or the tallest
American flying bird, the
Bird *(Jabiru mycteria)*, and
od Ibis *(Mycteria americana)*.
well-protected eggs continue to
at an almost constant under-
temperature of 31 to 32 de-
entigrade. After three days of
tion the embryo can be seen
, and after ten days the unmis-
shape of a young turtle is
through the thin membrane.

However, the development continues for at least forty-five days. Then the hatchling breaks the soft shell and starts to struggle upward to the light. The sand above is soft, but it takes two or three days for them to reach the surface. When those uppermost tire, the ones below overtake them, the strongest reaching the surface first.

Near the surface the intense heat of the sun, which has raised the sand temperature to over 60 degrees centigrade, repels the young turtles; so it is only late at night or in the early morning hours that the hatchlings break the surface and start running toward the water. We have called this journey the "death race," for as soon as the two-inch, one-ounce creatures appear, all the vultures and other birds begin a fantastic banquet. The baby turtles run as fast as they can; they scurry, stop, and then race off again. But soon the beach is covered with empty shells —the bodies have been eaten out by vultures. The larger birds swallow the turtles whole. Sometimes the tiny racers do not seem to know where the water lies, and they run down the first slope they find. Many times, certainly, it leads them to the river, but at other times the inclination leads them toward the center of the island. The birds swoop down to kill the first several thousand hatchlings, but as more keep running among the dead bodies of their brethren, the birds have some difficulty in distinguishing which is dead and which is a live turtle that has hesitated for a moment.

For the young turtles who reach the water, the calamities are not over. Large and small fishes, like the Valenton *(Brachyplatystoma filamentosum)*, Cajaro *(Phractocephalus hemihopterus), or Pavón (Cichla* sp.*)*. as well as the Orinoco crocodile *(Crocodylus intermedius)* or the South American caiman *(Caiman crocodilus crocodilus)* are waiting to swallow the unfortunate creatures, and the death race continues until the relatively few fortunates—perhaps 5 per cent—have reached the turbid Orinoco waters.

Nature sometimes plays a tragic trick; the rains start earlier than usual and the waters rise so fast that many nests are inundated before the young have hatched. The year 1963 was a particularly bitter one; several million eggs and newborn turtles never reached the surface. It was a sad occupation to open nest after nest and find lifeless young or grayish eggs with their rotting embryos.

Toward the end of May the river rises over the beaches, leaving visible only a tiny, vegetation-covered portion of the island. Even this is sometimes overrun by the violent waters. But the Arrau will return again as long as there is an opportunity, and if man does not wipe them out entirely.

In 1800 Baron von Humboldt, the German explorer-naturalist, provided good descriptions of some aspects of turtle exploitation by Indians. Although they captured the females for meat, they much preferred the eggs. Von Humboldt speaks of about 33 million eggs laid on one beach in one season, and his calculations include 100- to 120-thousand nests. The Indians, who frequently worked for Christian missionaries, collected millions of eggs in their baskets, washed them, and then threw them in *curiaras* (small, canoe-like boats), and squashed them. Then they were left until an oily substance from the "whites" floated on the surface. This was collected and used as fuel for lamps. There was a time when turtle eggs supplied most of the oil for lamps throughout northern South America. Turtle oil is still used for cooking. Even now, turtle eggs, fresh or dried, are considered a delicacy.

At one time Indians who attempted to catch the females had to compete with jaguars, which were then abundant. The animals knew how to flip a female onto her back so they could eat her at leisure. Another great enemy of the turtles was the Orinoco crocodile, and records show that in a single night the Piaroa Indians killed eighteen large crocodiles during the turtle-nesting season. When a demand developed for crocodile skins for export, they were hunted eagerly, and soon became scarce in the main stream of the Orinoco; thus, fashion helped to rid the Arrau of at least one enemy.

During the May to December feeding period, the Arrau is caught in several ways. The *criollos* use a blunt hook baited either with a mango or a *topocho*—a variety of banana—while the Indians use bows and arrows or harpoons, but in either case the Arrau are fierce antagonists. Their legendary resistance was confirmed by a female we caught on the beach. She had a rusty arrowhead in the middle of her brain; the reptile had lived with it for years, judging from the state of the iron. To honor the resistance of this Arrau, we solemnly marked her, and the *ribereños* acceded to our request that she be released.

The great respect that the natives hold for the Arrau is shown by the many legends told from generation to generation. For instance, no woman
is permitted on the turtle islands. E
those who approached had to stay
their boats and away from the bea
When questioned about this, an Ind
answered: "Why, certainly. That's
cause of the Turtle Lady." The bel
is that during the daytime, when
sand is sizzling hot, the Turtle La
appears. She is a tall, beautiful, bla
haired woman in a white, diaphan
gown. She walks among the baski
rows of turtles, encourages them, a
shows them the best areas in wh
to bask. She orders away the ones t
have stayed too long in the sun, a
points out the highest beaches wh
hatchling survival is best. In short,
Turtle Lady protects the female turt
in all ways, but she is jealous of a
other woman, and will harm her a
guide all the turtles to other beac
should one approach. In addition,
will injure any man who is on
beaches when she is there. This et

LOCAL PEOPLE on the Orinoco catch turtles on their breeding grounds and pen them before shipping them to market.

TRACKS of females seeking nest sites cover the beach. Wavy lines between the footprints are made by turtles' tails.

ision—and many Indians swear
ave seen her walking among the
s like a nature spirit—has more
r to protect the Arrau than all the
nment laws put together. The
are disobeyed readily, even
enforced by National Guards-
Needless to say, we agreed that
urtle Lady should be respected!

ring the darkest nights—so goes
er story—when the females are
ided and confused about where
t what time to start egg laying,
lbador (the Whistler) appears.
histler is a huge male turtle, and
istle guides the females straight
nesting grounds that were indi-
during the day by the Turtle
The Whistler can see on the
st nights, and sometimes he can
e so that no human ear can hear
he female turtles hear him,
h, and his magic call is obeyed
of them. When the Whistler is
on the beach, he warns the females of danger, including the approach of men. The turtle collectors, therefore, have always tried to catch the Whistler before attempting to capture the turtles, but so far they have been notably unsuccessful. Also, there are many nights when turtles lay eggs but the men can find none in the darkness. This, too, is arranged by the Whistler.

In myth and reality, then, the Arrau is an integral part of the lives of the Indians, who cherish the other's existence. The Indians do not "possess" the Arrau—or anything else that lives in the Father of All Waters—as we possess, or think we possess, our houses, streets, sometimes even our wives and children. They sincerely share their lives with the turtles, attempting to outwit them by an honest competition in which man is armed with his intelligence, and the Arrau is protected by its instinct and its mystical allies.

RUSTY arrowhead, apparently carried for years, is lodged in this turtle's skull.

Arches and Bridges

# of Stone

by WILLARD LUCE

THE STATE OF UTAH has the greatest collection of natural arches and bridges in the world, many of them now in three national monuments: Arches National Monument, Natural Bridges National Monument, and Rainbow Bridge National Monument.

In Arches National Monument near Moab, Utah, there are eighty-eight known natural arches. Some are no larger than small windows, while one, the 291-foot Landscape Arch, is considered the longest natural span in the world. A good many others have openings large enough to serve as railroad tunnels, and one, Delicate Arch, could curve up and over a three-story building. The rocks of the Monument are primarily of Entrada sandstone, although Carmel formations and Navaho sandstone are also present. Entrada is a brown or reddish-brown, fine-grained sandstone with subordinate, interbedded siltstone and claystone. The Entrada is

Sipapu Bridge, above, is located in Natural Bridges National Monument. It has a 261-foot span.

Double Arch, left, resulted from the effect of wind, frost, and water seepage on Entrada stone.

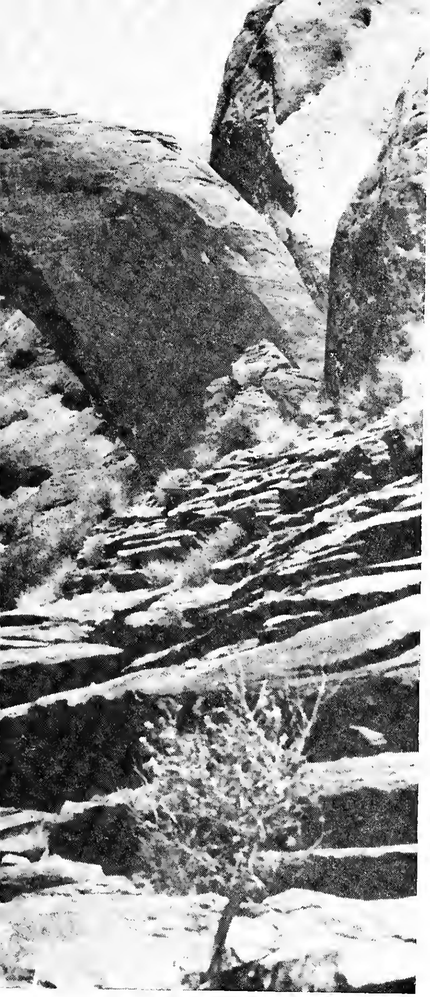
probably of a combined water and wind origin; it exhibits sections that are typically deposited in water, while others, strongly cross-bedded (cross-stratified), were probably dune or wind deposits. On the basis of stratigraphic position, Entrada is assigned to the Late Jurassic Period.

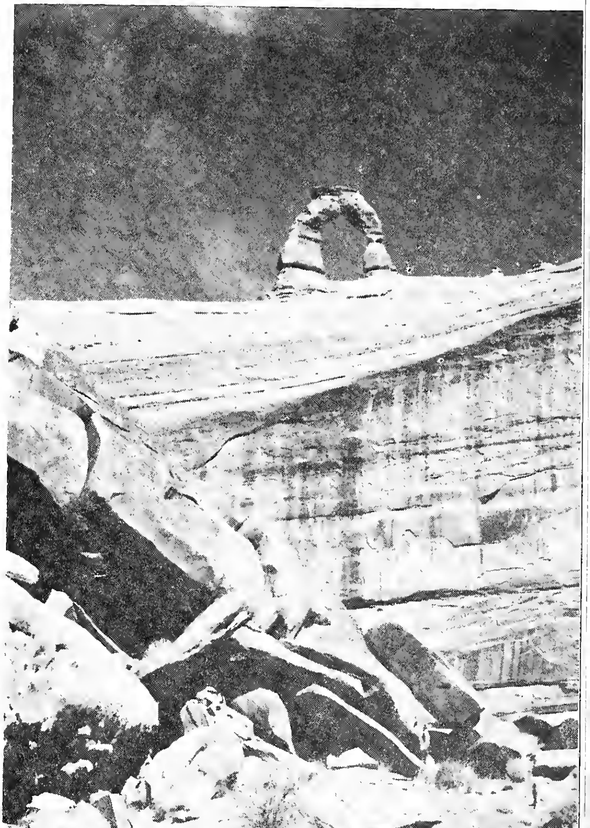
Utah's red rock country has been affected by various geological processes. In some instances, an intrusion of salt forced the rocks upward into huge anticlinal folds or domes. The pressure from underneath and the upthrusting caused a warping and finally a cracking of the Entrada sandstone. Joints, or cracks, ran parallel to each other and to the axis of the anticline. The upward movement of the anticline also hastened the erosion of the post-Entrada material. Erosion continued, eating down into the parallel joints and into the secondary cross-joints that ran at right angles. Soil collected between the fins, and plants grew there, sending roots into the tiniest cracks. Freezing and thawing helped widen the space between the fins.

While such intrusions did alter the surface and texture of rocks, they were not responsible for the formation of arches. Water, wind, and frost played the major roles in this phenomenon. As these three forces gradually ate away at the rock slabs, undercutting started, and the softer material was washed or blown away. This occurred in the Entrada sandstone, but it happened far more rapidly in the Carmel formation, which is of a soft and crumbly nature. Because the wind is seldom still on the high Colorado Plateau country, sandblasting became a continuous process. Slowly, holes were worn through the fins, and arches were born.

Looking-glass Arch, below, rises symmetrically in the South Moab area just east of U.S. Route 106.

Rainbow Bridge, right, is most famous in Utah. It spans 278 feet, curving 309 feet above Bridge Canyon.





Grosvenor Arch, seen at left, towers above Kodachrome Basin, just a few miles south of the Bryce Canyon Park.

Delicate Arch, located in Arches National Monument, could encompass a three-story office building within its arc.

At other locations, seepage of water formed alcoves, or caves, by dissolving the cementing material and washing it and bits of sandstone away. Potholes formed on top of the sandstone ledges, gradually becoming deeper, until finally a large hole formed in the top of the cove, in some cases causing the whole roof to collapse. The Double Arch is a product of both these processes. Coves working in from two directions finally perforated the slab of sandstone, while potholes working down from the top caused the roof to collapse. Two girders were left, reaching out from one apex to form one of the most unusual structures in Arches National Monument.

The most obvious difference between a natural bridge and a natural arch is that a bridge spans a watercourse, although the watercourse may be dry most of the year. For example, the canyons of Natural Bridges National Monument, in the southeast corner of the state, are usually free of running water, but during spring runoffs and flash floods, they sometimes carry a huge volume of water mixed with sand, trees, and even boulders.

Running water also plays an important role in the formation of any natural bridge. Slowly, over eons of time, a stream bed wears down into rock. Twisting and turning, the water digs an oxbow channel deeper and deeper into the thick layer of sandstone. As it continues wearing downward, the moving water also pushes and churns against the side of the channel until finally it wears a hole through the oxbow and takes a shortcut. This is the beginning of a natural bridge, and the size of the hole is one guide to estimating its age. A bridge that has a small opening, with a thick slab of stone above it, is considered to be more recently formed than one with a large opening overhung by a thin girder.

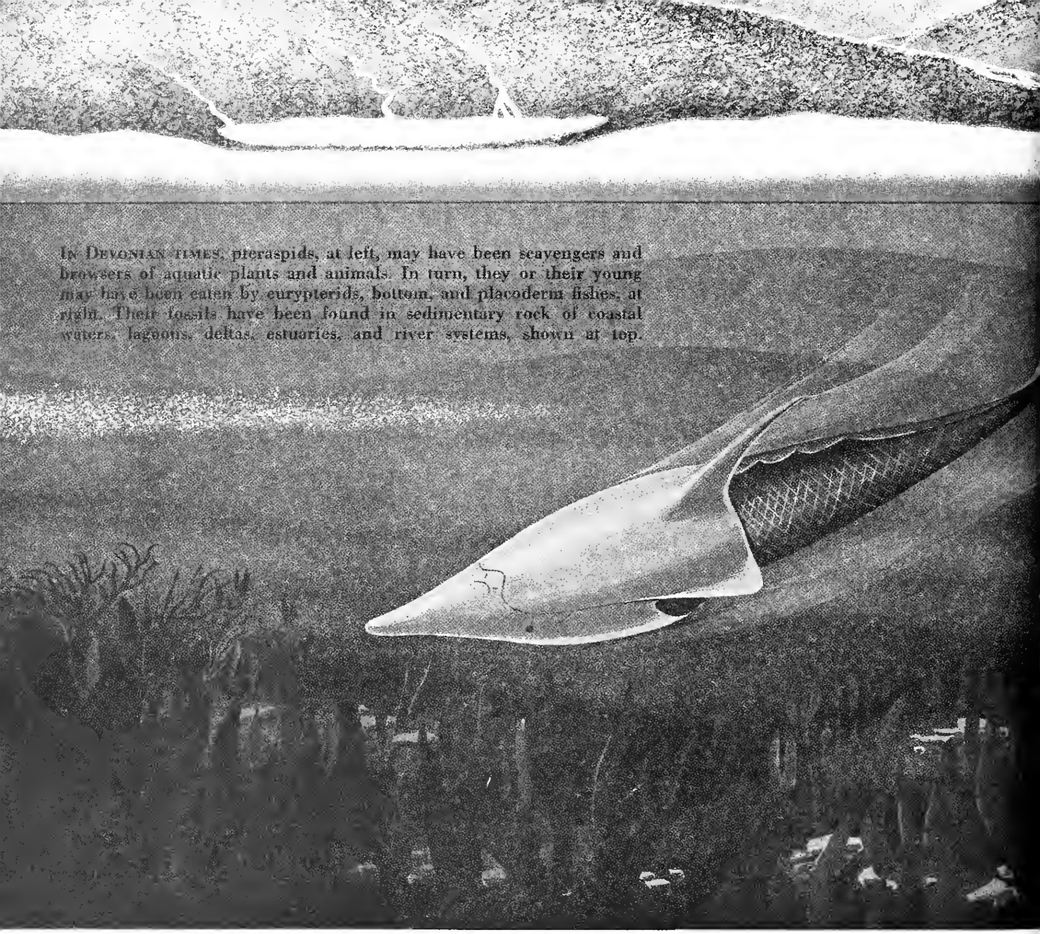
On this basis, the three White Canyon bridges of Natural Bridges National Monument may be classified as "young," "middle aged," and "old." Kachina Bridge, the youngest, has a span of 206 feet, but curves only 98 feet above the canyon floor, while the sandstone arc above the opening is 107 feet thick. Sipapu Bridge is middle aged. It is also the largest and most beautiful of the three. It has a 261-foot span, and its 56-foot-thick beam of stone curves 166 feet above the canyon floor. The Owachomo is the oldest. Its thin, 11-foot-thick girder is 97 feet above the canyon floor and spans 200-foot-wide Armstrong Canyon.

Rainbow Natural Bridge, itself a national monument, is the largest, most colorful, and certainly the best-known of all Utah's natural bridges. It is located in one of the most inaccessible areas in the United States, Alaska excluded. Within a radius of fifty miles there are only two improved roads, neither of them heading for Rainbow Bridge. To reach it by land requires a fifty-mile drive over a primitive road that ends fourteen miles from the bridge. From then on there is only a winding trail through the red rock canyons. It fights its way from one canyon to another, always creeping deeper and deeper into a desert of barren sandstone. Rainbow is much easier to reach from the Colorado River, and as waters from the recently flooded Glen Canyon Dam continue to back up into Aztec and Bridge canyons, boats will be able to reach almost to the bridge. Unlike other bridges in the state, Rainbow's spanning beam arches gracefully and symmetrically up and over the canyon beneath it. This is why the Navahos call it *Nonnozoshi*, or Great Stone Arch, and the Utes call it *Barohoini*, The Rainbow. But neither of the names prepares the visitor for its tremendous size. Its arch is 278 feet across and 309 feet above Bridge Canyon, and there is room enough beneath it for our National Capitol.

In addition to the natural arches and bridges described in this article, there are others scattered throughout Utah's red and white rock country. Many are in the area that soon may become Canyonlands National Park, which would be near the junction of the Green and the Colorado rivers.

The North Window, one of many smaller arches near Moab, is 65 feet high. Its beam measures approximately 130 feet.

This fortress-like structure has been aptly christened Turret Arch. It is located in Arches National Monument.



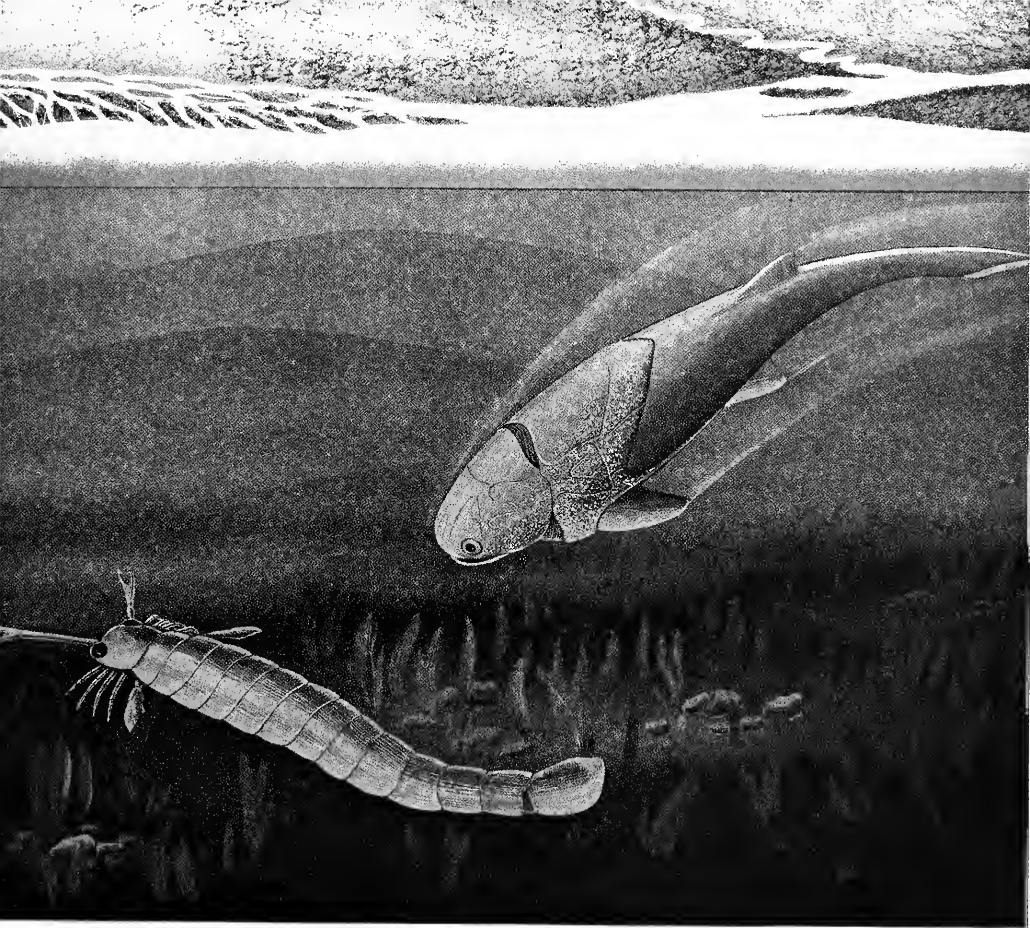
IN DEVONIAN TIMES, pteraspids, at left, may have been scavengers and browsers of aquatic plants and animals. In turn, they or their young may have been eaten by eurypterids, bottom, and placoderm fishes, at right. Their fossils have been found in sedimentary rock of coastal waters, lagoons, deltas, estuaries, and river systems, shown at top.

Armor-plated and Jawless Devonian Fish

Fossil record is clue to pteraspid habitat

By DAVID L. DINELEY

AMONG the most curious anim
ever to appear in the waters
the Northern Hemisphere were
ostracoderms, an ancient group
jawless, armor-plated fishes, many
which may have looked rather l
giant tadpoles. Most of them were
tween four and twenty inches long, l
a few grew to larger size. Their
mains are most often found in ea
Devonian rocks, deposited betw
380 and 400 million years ago,
though they apparently existed duri
earlier Ordovician times. By the e
of the Devonian Period they beca
extinct, yet there remains the pos
bility that our modern agnathous,
jawless, fishes—the lampreys and h
fishes—may be descended from ost
coderm ancestors. In recent ye
there have been some very detailed d
cussions of the affinities between th
two agnathous groups. These affinit

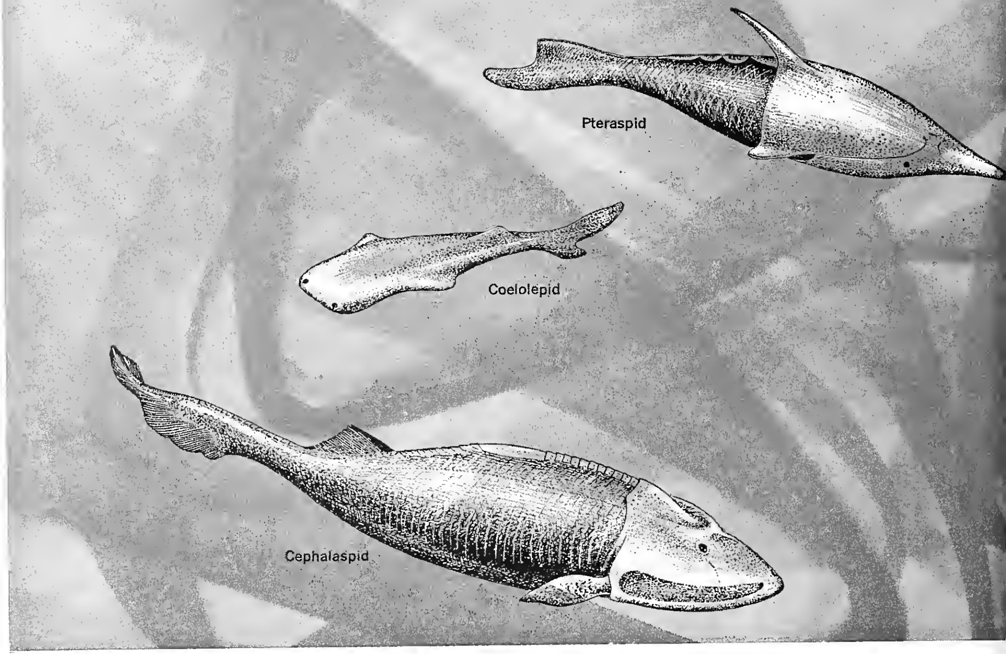


wide scope for conjecture, be- e only the bony armor and scales e ostracoderms remain, while the ern lampreys and hagfishes possess no comparable hard parts.

tracoderms were entirely aquatic ures, with varying amounts of armor about the head and body. They lly lacked paired fins and they n by waggling a stout tail. In place ws and teeth, some had a structure irecting or scooping up food into mouth; others may have had er-like "lips." Basically there were kinds of ostracoderms—those that a head skeleton largely comprising single complex shield of bone Osteostraci), and the more varied p (the Heterostraci), in which the and body were encased in separate ony plates. Although we have yet nd an ostracoderm with any sort ny "backbone," there is no doubt that those animals were true vertebrates, and were among the first to leave traces of a specialized mode of life.

The pteraspids were perhaps the most successful of the heterostracans, and their fossils are sufficiently numerous to provide us with a fairly detailed picture of their natural history. At the turn of the century, six or seven species of *Pteraspis* had been described; the number of valid species today is six times greater, and as many yet-undescribed, related types are known. Geological studies by various workers, including the author, have helped to give an idea of the environment and the changing conditions in which these animals lived.

Pteraspids were rather trowel-shaped and flattened little creatures, usually a few inches long, and with strong tails with the lower, finlike lobe larger than the upper. This lower part of the tail served to keep the creature's nose down as it swam. The snout was a more or less elongated, solid, single bony plate. Just behind its lower hind margin lay a narrow, transverse mouth. The eyes peered forward and sideways and were relatively small. The nasal cavity probably opened into part of the mouth. A pineal organ was present between the eyes. Over the central part of the back and belly were large, symmetrical median plates, or discs, while slender, somewhat bowed branchial plates ran along the shallow sides of the body. At the hind end of these branchial plates lay the branchial, or gill, openings from which water was expelled after it had passed over the gills. Beyond these, cornual plates formed the hind "corners" of the carapace. From the center of the hind margin of the dorsal disc projected a spine, which, together with the



cornual plates. may have helped to stabilize movement through the water. While the plates forming the top and sides of the carapace were often found fused together, the ventral disc always seems to have fallen away after the animal died. and it possibly never coalesced with the other armor.

Only very rarely has the delicate assemblage of small plates about the mouth been preserved. The oral plates, hinging down from their posterior ends. formed an apparatus rather like a mechanically expandable scoop or shovel. Clearly. such slender structures were not used for biting or crushing. None has been found to be worn or abraded. and presumably they were covered by or linked with an epidermis that allowed them to splay out forward and downward. One can picture this device being used to scoop up mud or food from the bottom.

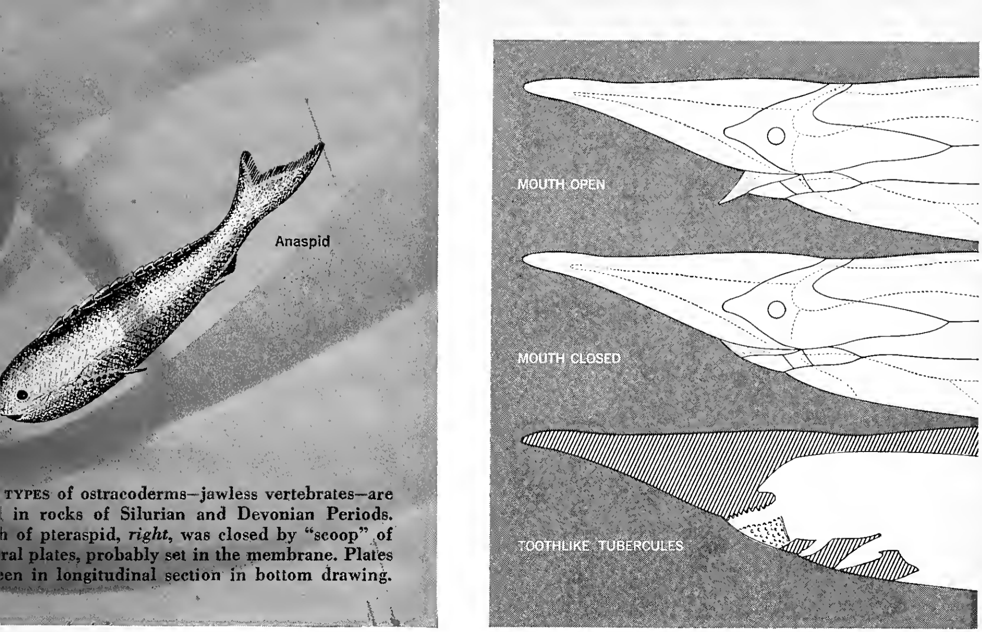
Behind the animal's flattened and boxlike front part. the rear half of the body was laterally compressed and covered with bony scales that were overlapped. thick. and regular. The largest were on the flanks. and occasionally two scales seem to have fused to form curious "double scales."

Both the plates and the scales have the same remarkable. three-layered structure. Outermost is a layer of dentine. which bears an ornamentation of "ribs," tubercles, and so on. In the middle is a cellular or spongy bone layer. which is the thickest of the three. On the inner side is smooth. laminated, bony tissue. The sensory canal system runs through the middle layer and connects with the outside via small pores.

All of the features described above are very typical of the pteraspids. especially the fine ribbing seen on the plates of the carapace. On the interior of the carapace is a remarkably constant arrangement of impressions that gives a clue to the disposition of organs within the body.

From the impressions inside the dorsal shield we can reasonably suggest that a pair of small nasal capsules lay just above and behind the mouth. with the nostrils opening into the mouth. and behind these lay a prominent pineal organ. two semicircular canals. and gill chambers in pairs. Supporting the various soft tissues. respiratory system. and so forth. was possibly a mass of cartilage. We have never yet discovered fossils in which this cartilage had become ossified. and possibly no pteraspid ever developed a rigid bony endoskeleton. Seven or more pairs of gill sacs or chambers were present. and may have been similar to those of modern jawless fishes. They must have been connected with the mouth and. either directly or via a common canal. with the branchial openings. which lay close to the hindmost sac. Water, taken in at the mouth, passed into the pharynx and throug a small connection into each g cavity. What kept the water moving not easy to see. The rigid box of a mor prevented "breathing" mov ments—contraction and expansion— the head and body. It is thought ve unlikely that currents produced by t waving of cilia, little hairlike proje tions from the gut wall, could ha been strong enough to propel an ar mal as large as *Pteraspis*. Profess D. M. S. Watson of London has su gested that the water was kept movi by muscular tissue that "squeezed" along the system, as in hagfishes t day. He thinks that in at least o heterostracan this tissue was a stro sheet attached to the ventral surfa of the brain case not far behind t eyes and just in front of the first pa of gill sacs. The fact that the ventr disc resisted fusion with the oth plates suggests that it may have be hinged by tissue and moved by t respiratory activity going on above

In common with other primiti aquatic vertebrates. the ostracoder possessed a sensory, or lateral li system. This was a network of fi canals that ran along the sides of t body and formed a complex patte over the head. similar to that of t modern lamprey. In the pterasp carapace. as we have seen, it involv a system of canals running throu the middle layer of the plates a



TYPES of ostracoderms—jawless vertebrates—are in rocks of Silurian and Devonian Periods. h of pteraspid, *right*, was closed by "scoop" of ral plates, probably set in the membrane. Plates een in longitudinal section in bottom drawing.

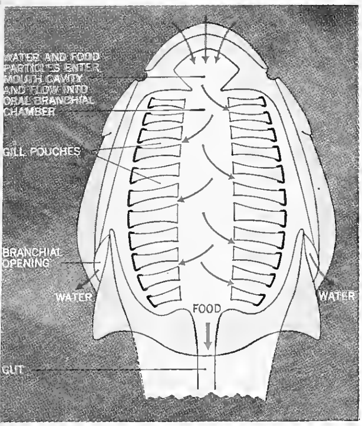
ng the exterior through numerinute pores. It has been recently sted that, as in certain modern the lateral line system may have oned as an "echo-sounder," lo- objects by measuring the re- vibrations set up by the swimmovements of the animal itself. rk or turbid water this would been particularly useful.

RT from the anatomical interest ffered by these fishes, we have absorbing problems concerning geological and geographical dison, life history, and habits. of the ostracoderms are known from isolated or fragmentary and scales. Many of the first pid fossils to be discovered were omplete that they were regarded remains of mollusks, sponges, er invertebrates. The true chorature of these fossils was eventestablished in 1858 by T. H. y in London. Complete speciare still very rare. Only in 1935 detailed account of newly found ete fossils published by Dr. E. I. of the British Museum. Pteras-however, are now known over wide geographical area. Origidiscovered in Britain and Ger-they have since been found in and Belgium, Poland, the ne, and Spitsbergen. In North ca they have been found in Nova Scotia, the Canadian Arctic Islands, Ohio, Colorado, Wyoming, and in the Canadian Rocky Mountains.

Most frequently the pteraspids are found together with various other ostracoderms and placoderms ("plate-skinned" fishes with primitive jaws) in sandy formations often called the "Old Red Sandstone" in Great Britain. These deposits are usually and essentially non-marine—the sediments of deltas, lakes, and flood plains. Often the ostracoderm remains occur in isolated pockets and segregations, as though swept together by streams and currents. Here, at least, the impression is gained that the pteraspids and other ostracoderms lived in inland waters. Occasionally they are found in marine sediments and this, together with their distribution on each side of the Atlantic, prompts the question of whether or not the animals spent at least part of their life in the sea. Many of us who have searched for the earliest ostracoderms have produced evidence to show that they originally inhabited marine waters and, indeed, the majority of pre-Devonian specimens have been recovered from marine deposits. During the Devonian Period, however, the animals seem to have migrated to fresh-water habitats (where they eventually suffered extinction). What were the reasons for this change of habitat and was it, in fact, as complete as the fossil record suggests?

So similar are the faunal successions on both sides of the Atlantic that there must have been communication between the now widely separated regions, with ostracoderms migrating or dispersing from a common center. I recently found that the pteraspids in Nova Scotia, for example, appear to have been very closely related to, and contemporary with, those in Britain. If continental drift is not invoked, the distances over which the dispersal occurred amount to more than 2,000 miles, even if the center of dispersal lay midway between the Old World and the New. If the continents are grouped together in a manner acceptable to the proponents of the drift hypothesis, the distances, while considerably reduced, are still large.

Although the majority of pteraspid occurrences are in beds of Old Red Sandstone type, it is becoming obvious that these fluvial, lacustrine, and deltaic environments were in direct connection with the open seas. This can be seen in the geological successions in Germany, southwest England, and eastern North America. Since pteraspid migration across dry land was impossible and dispersal was unlikely to have been very extensive in fresh waters, this connection with the sea assumes great importance, for it presents a way in which the animals may have migrated over wide areas. We believe that very probably these



Food and debris may have entered gut, as water, squeezed from gill pouches, left the body via branchial openings.

ostracoderms spent part of their life cycle in the sea, especially the shallow coastal waters. As they were bottom-dwelling creatures, it is likely they never moved far from the shallows, and may have spent part of their cycle in the ancestral home of the vertebrates, later moving into fresh waters. The most numerous of the earliest pteraspid types seem to have lived in Spitsbergen, and it may well be that the migrations of successive groups of ostracoderms began somewhere in the northern Arctic.

Pteraspis and its relatives lived in times of great geological and biological change. Mountain-building movements on a wide and drastic scale were in progress, affecting not only geography, but perhaps the climate as well. ("Dinosaurs of the Arctic," NATURAL HISTORY, April, 1964.) No doubt these, in turn, exerted much influence on pteraspid history and, indeed, on the development of all the vertebrates.

PERHAPS we are now in a position to outline something of pteraspid life history and mode of existence. Nothing is known of the reproductive mechanisms in these ancient jawless fishes, but possibly large numbers of eggs were laid at each breeding season. These may have been deposited on sandy or shingle bottoms in the sea. Here food particles would have been plentiful, and the young may have spent some time lurking in, or feeding on, the bottom sediments. The larvae were probably active swimmers, capable of rapid and widespread dispersal. At this stage in its existence the creature lacked the armor plates and bony scales of the adult, and it is not surprising that so far we have not found it in fossil form.

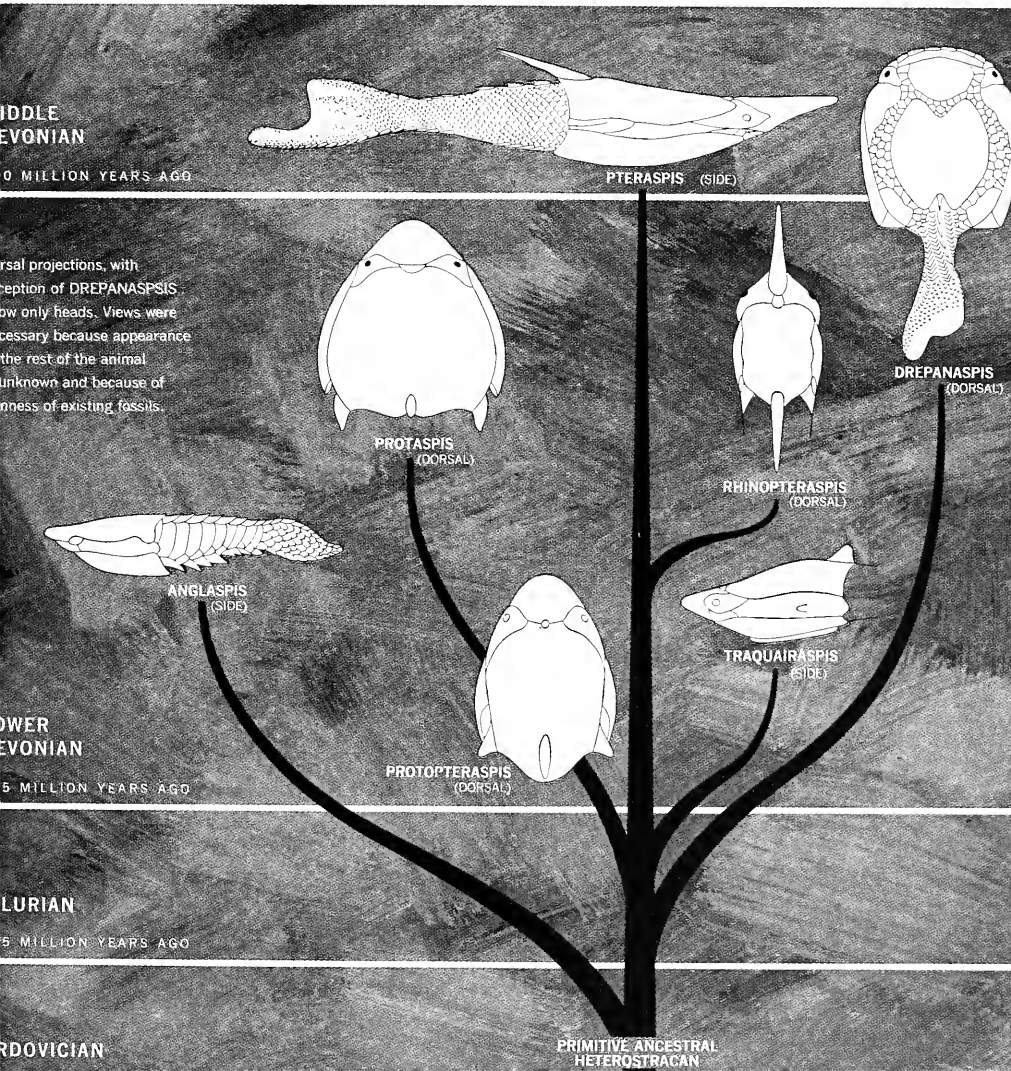
One worker has suggested that the rigid adult carapace originated in a fusion of scales—perhaps a result of tension and compression forces—over the head and trunk region of the pteraspid ancestors in early Paleozoic times. The scales coalesced around their adjacent growing edges, and tended to attach themselves around dorsal and ventral nuclei to form discs. During late Silurian and Devonian times the ossification in the scales of many ostracoderms set in around both dorsal and ventral disc centers and at other points that were the sites of the paired plates. In some types, scaled areas persisted between the major plates, and apparently the scales were never completely absorbed by the larger units. Around the margins of many plates there is a somewhat different kind of ornamentation, indicating the most recently formed part, where bony material was deposited as a rim around the nucleus of fused scales. Once the carapace formed a complete, rigid, boxlike structure, no further growth was possible.

We see *Pteraspis* as a specialized type of agnath, successfully adapted for its mode of life, despite its rather clumsy appearance. Although perhaps poorly equipped as far as sight and hearing were concerned, sensory canals may have provided it with a means of registering other stimuli. The mouth apparatus seems to have been an excellent mechanism for bottom feeding or for scooping up food as the creature swam. From this it seems that the food was essentially of soft, small particles, with tiny plants or animals or even decaying matter forming the bulk of it. Forms with long snouts may have used them to probe and stir mud and bottom debris; the blunt-nosed, broad pteraspids may have merely passed across the surface of the substrate or over fronds and patches of weed with open mouths. It is more than possible that the animals were "mud-eaters" that took in mud and digested the organic matter in it. It has also been suggested that tentacles about the mouth, like those of catfish, might have been present to assist in probing debris on the bottom. Some Russian ostracoderms have been
thought to have been plankton-feed
sucking in floating microscopic a
mals and plants, but such a feed
method is not likely among pterasp
Food particles (and perhaps mud) a
water taken in, perhaps in gulps,
the mouth would have been pas
back into the pharynx, where some s
of filter mechanism may have sie
out the food and other solid parti
and directed them into the aliment
tract while the water passed into the
sacs. This filtering system was pr
ably of soft tissues only, for we h
no fossil trace of it. It may have c
sisted of sticky surfaces, rather t
the comblike system of baleen wha
While food particles were digested
the gut, mud and sand may h
passed along to the anus. In the b
known species, *P. rostrata*, the a
was small and close to the carapa
suggesting a small, short gut, proba
not designed for mud feeders.

ONE of the interesting aspects
ostracoderm life that I have
vestigated in recent years is that of
range of environments and the ecol
involved. Pteraspid remains, like th
of most ostracoderms, usually (
though not always) occur as conc
trations in sediments that show si
of current action. Nevertheless, fr
the way in which numbers of th
fossils occur together in the rocks
seems highly probable that the anim
lived together in small groups
schools in the Old Red Sandst
lakes and deltas and that they a
occurred near, if not actually in,
open sea waters. Very often they m
have inhabited some environme
with other ostracoderms and even w
small placoderms, many of which w
active predators with snapping ja
Some of these other creatures h
much the same mode of life and wou
have been attracted by the same fe
ing opportunities, although it is int
esting to see that the pteraspids, on
established, seemed to have crowd
out almost every other sort of het
ostracan from the area. The conte
porary, possibly predatory, placoder
do not seem to have been large enou
to prey on the adult pteraspids,
though they may have fancied t
young. Of the other inhabitants
the ostracoderms' environment—ost
cods, pelecypods, miriapods, and e
rypterids—only the last would ha
constituted any hazard. With the
pincer-claws they could have ma

work of the small ostracoderms.
at we have discussed above ap-
o the pteraspid group of ostra-
ns as a whole, but we must re-
er that they were among the last
ostracoderm groups to appear
at they had a fairly long evolu-
y span—at least throughout all
ver Devonian times (15 million
. During this period they
ned out into many different
each no doubt adapted to a
ılar environment and mode of
nce. Generally speaking, the
t types were small and blunt-
later pteraspids were either
long-snouted species or big, broad-nosed types. The biggest of all, known in southwest England, approached six feet in length and was a relative giant. From what we can tell from the rather metamorphosed rocks containing it, it seems to have lived in a coastal lagoon environment.

Inevitably we must ask what caused the extinction of this peculiar group of animals and, of course, there is no simple and obvious answer. It was probably a combination of geographical, geological, and biological circumstances. Sluggish in movement, poorly provided with senses to warn of impending danger, and having little but their armor for protection, the later pteraspids may have fallen prey to placoderms. In their larval and immature stages they may have been especially easy victims of other vertebrates or large invertebrates. Changing climatic conditions, possibly with extensive desiccation, could have been fatal. By Middle Devonian times pteraspids had virtually disappeared. Other ostracoderms persisted longer by adapting to new modes of life and perhaps by shedding their armor. It is possible that our modern lampreys and hagfishes are descended from these, but here the fossil record is completely lacking. We are allowed conjecture, but have few facts after the Devonian.



rsal projections, with
ception of DREPANASPSIS
ow only heads. Views were
cessary because appearance
the rest of the animal
unknown and because of
nness of existing fossils.

SKY REPORTER

Moon's face—first wonder of our sky

By Thomas D. Nicholson

THE FACE OF THE MOON, acclaimed as the most beautiful and impressive sight that a telescope can show the human eye, was selected by astronomers at The American Museum-Hayden Planetarium as the first of seven celestial objects to be featured in "The Seven Wonders of the Universe," the summer program for this year.

The identification of seven wonders follows a tradition dating from antiquity, when travelers in the ancient Greek world selected from among the artistic monuments erected by man the seven that were most spectacular in their beauty and grandeur. The earliest known list of objects, called the Seven Wonders of the World, was made by Antipater of Sidon in the second century B.C They were the pyramids of Egypt, the hanging gardens of Babylon, the statue of Zeus at Olympia, the temple of Artemis at Ephesus, the tomb of King Mausolus at Halicarnassus, the Colossus of Rhodes, and the great lighthouse (Pharos) at Alexandria. The reputation of these seven wonders remains today, although thousands of years have elapsed since the last was built and little, if anything, is now left of their former glory.

The ancients never explained why exactly seven wonders were named, although the number seven has always had a special mystical meaning. There are seven days in the week, named after the seven wandering stars in the sky (five visible planets, sun, and moon), and some of the best-known groups of stars in our universe (Orion, the Big Dipper, the Pleiades, the Northern Crown) each contain seven stars of exceptional brightness.

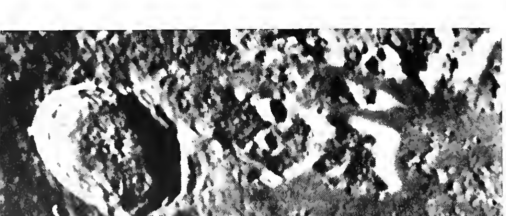
The choice of celestial objects to be included among the Seven Wonders of the Universe was a great challenge. It was decided, first of all, that each of the seven wonders should be a real, physical object that we can see or photograph, rather than a concept or a physical law, such as the expanding universe. Second, we decided to base our selection upon the celestial objects visible from earth, even though some of the choices might appear quite different or even insignificant from another place in the universe. Third, each of our seven wonders should be unique—either the only one we know or the most impressive of a class of similar objects. And, finally, each should relate in some way to our plan of showing, through seven objects, the design of the universe. Our choices met these criteria admirably.

The face of the moon, for example, is unique because it is the only celestial body on which we can clearly see the features of a solid surface. On only one other world in space, the planet Mars, can we observe anything at all of the solid surface, and that very indistinctly. The moon itself can hardly qualify as one of the greatest celestial bodies. Neither in size, in mass, in distance, nor in the role it plays in the universe does it match other awe-inspiring objects in our sky. It is merely a satellite, an attendant of a planet, one of thirty-one such satellites in the solar system, and by no means the largest of those. But its remarkable face is certainly a wonder of our sky.

On the face of the moon we can observe tens of thousands of individual markings or objects, some thirty thousand of which have been

IN COMPOSITE PHOTO of moon, south is at top, west left, as in an observatory telescope view. Dark areas are plains.

Large crater at left center, *above*, is Posidonius, sixty-two miles across with walls up to 6,000 feet high. Inside, several straight clefts intersect at a small central crater.



Both Eudoxus (upper) and Aristoteles craters, located in northern area of moon, have steep, terraced walls that rise about 11,000 feet. Aristoteles is sixty miles across.

Dr. Nicholson, the regular author of this column, is also
Chairman of **The American Museum-Hayden Planetarium.**

identified and named. We can see mountains and valle
and great, flat, dark plains; we observe crater-like form
tions, from tiny pits a quarter-mile across, to mountai
walled depressions over a hundred miles in diameter;
find long and tenuous ridges marring the level plair
straight and narrow trenches extending a hundred mil
and more, and bright, splashlike rays fanning out fro
some craters as far as halfway around the moon.

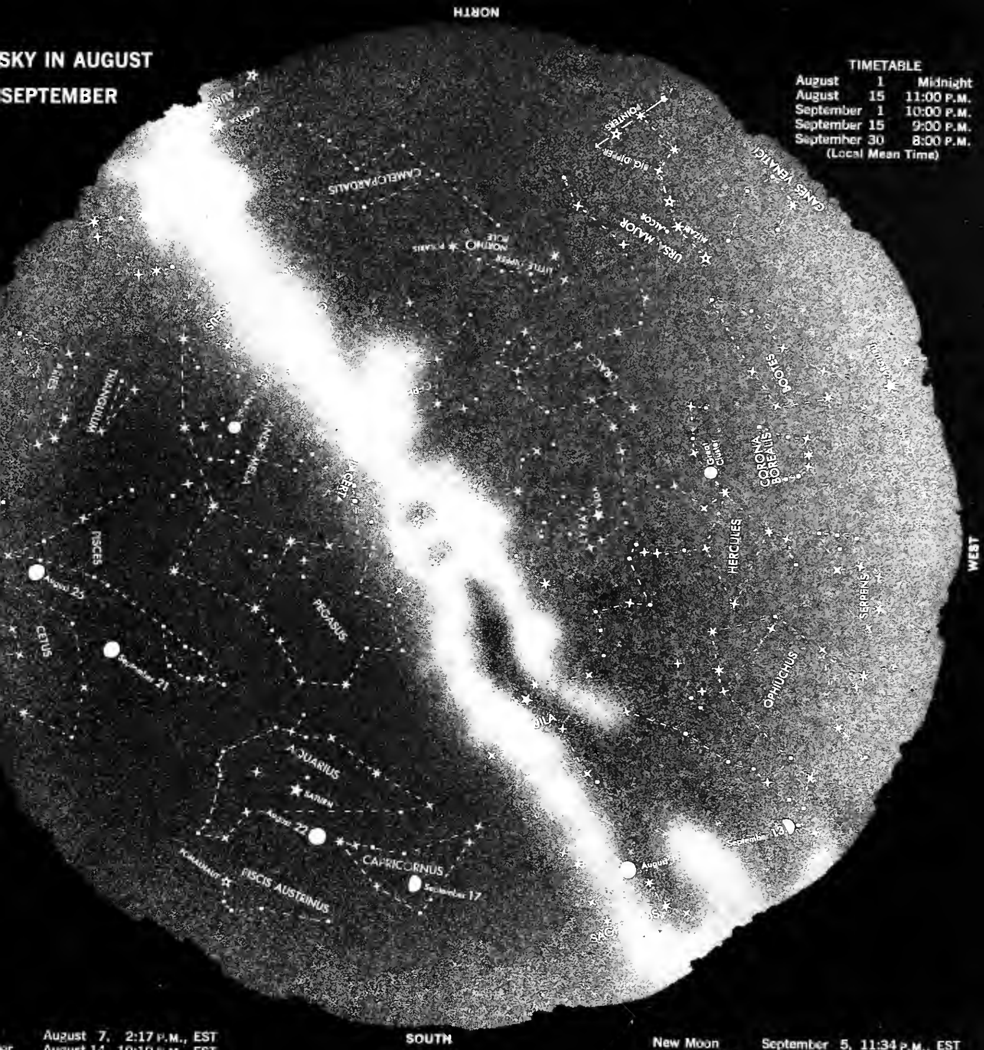
The origin of the countless structures and features
the moon's face has long been one of the most hotly debat
mysteries in astronomy. Are they scars left from the turb
lent surface of the moon when it was created? Are th
products of eruptions—volcanism and gas discharges—fro
a hot, interior lunar core? Did they come from collisio
with swarms of meteoroids early in the moon's histo
when its surface may have been semisolid? Could they
the results of a continual bombardment by meteoroids ov
the billions of years of the moon's existence, some resu
ing in violent explosions upon impact? Almost any theo
can be partly supported by evidence from structures se
somewhere on the moon and by analogy with terrestri
features. Yet the same theories can be flatly contradicted
the appearance of countless other lunar features.

As varied as the face of the moon appears, there are al
signs of remarkable uniformity. The bright rays, se
best at full moon, differ in size with the crater they su
round. The tiny craterlets and crater pits seem too fr
quently arranged in lines and curves to be the result
chance. The rills—long clefts in the surface—are straig
for long distances, crossing mountains, plains, and crate
in their unwavering paths. It is doubtful that they are ac
dental faults in the crust. The fine structure of ridges ar
gullies surrounding high-walled craters resembles t
closely the dried-out watercourses we find on semiar
slopes on earth. Almost everywhere we search in the co
fused detail of the moon's face, we find strange signs
form and pattern and similarity.

There is an urgency about studying the face of the mo
today, with man on the threshold of landing there. Will
future space craft come to rest on a hard, firm surface
rock? Or will it settle into a sea of dust? Some dust shou
be there, from micrometeoroids that have rained down
the moon for ages, from the pounding of the rock surfa
by larger particles from space, from the cooling and hea
ing that occur quickly during the cycle of lunar day a
night. Much of the powdered matter may have settled in
valleys and depressions, however, leaving higher surfac
with only a thin coating. But even this could be a proble
if it billowed up into great obscuring clouds from the e
haust of a retrorocket during descent. There is some e
dence, on the other hand, that dust on the moon's surfa
compacts into a semifirm honeycomb structure. If so, t
space craft may come down on a slightly crushable su
face—rather like a reluctant sponge—which the retrorock
exhaust could break off and throw about in huge chunk

The surface of the moon, then, is the first of our Sev
Wonders of the Universe to be discussed here—the ta
talizing face of a fossil world that will play an increasing
significant role in the future history of our own plan

SKY IN AUGUST
SEPTEMBER



TIMETABLE

August	1	Midnight
August	15	11:00 P.M.
September	1	10:00 P.M.
September	15	9:00 P.M.
September	30	8:00 P.M.

(Local Mean Time)

	August 7, 2:17 P.M., EST
er	August 14, 10:19 P.M., EST
	August 23, 12:25 A.M., EST
er	August 30, 4:15 A.M., EST

New Moon	September 5, 11:34 P.M., EST
First Quarter	September 13, 4:24 P.M., EST
Full Moon	September 21, 12:31 P.M., EST
Last Quarter	September 28, 10:01 A.M., EST

st 4: Mars, Venus, and the moon line up nicely in the sky this morning before sunrise. The late crescent ses first (about 1:30 A.M., local mean time), followed fteen minutes by brilliant Venus and then the reddish y dawn, all three are well up in the east, the moon and toward the right of Venus, Mars lowest and to- left of Venus. During the 4th, the moon passes both nd Mars and rises on the morning of the 5th later er than Mars.

t 5: Mercury is at greatest easterly (evening) elonga- may be seen in the western sky shortly after sunset. wever, is an unfavorable elongation for viewing.

t 11: The Perseid meteors, radiating from near the ar Mirfak, reach maximum tonight. This is one of the wers of the year, with an hourly rate of from twenty or several nights.

t 24: Saturn reaches opposition, remaining in the sky nset to sunrise, and is at its most distant position earth this year—815,000,000 miles.

t 28: Venus is again in conjunction with Mars. The unction, on July 18, occurred when Venus was moving slowly in right ascension as Mars passed Venus in the sky. Now, in August, Venus is moving more rapidly eastward again and has once more overtaken Mars.

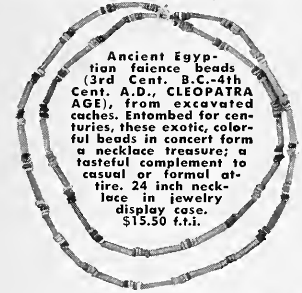
September 2: The crescent moon is again near Venus and Mars in the east this morning. This time, the moon and Mars are both to the right of and higher than Venus. The bright star Pollux also joins the group, above and left of Venus.

September 18: Mercury is at greatest westerly elongation. This is a favorable elongation in the morning sky. For several days before and after, Mercury will be above the eastern horizon for an hour and a half before sunrise.

September 21: The full moon occurring today is the harvest moon. Moonrise occurs at nearly the same hour for three days in a row, the 20th, 21st, and 22nd.

September 22: The sun is at the autumnal equinox at 7:17 P.M., EST. Autumn begins in the Northern Hemisphere.

Throughout August and September, Venus and Mars are close in the morning sky, each rising about three hours before the sun. Saturn, at opposition in late August, is in the sky most of the night through both months. Jupiter is well up in the eastern sky by midnight and remains visible until dawn.



SCIENCE IN ACTION

On ethnological tacti

By Robert L. Carneiro

THE TYPICAL ethnographic monograph is an impersonal document. It presents in a completely detached and objective manner an account of the way of life of a preliterate people. Nowhere does the ethnographer intrude his personality or interject the frustrations and exhilarations that accompanied the collection of his data.

Yet, the story of how an ethnologist makes contact with primitive people, how he gains their confidence, and gradually pieces together a picture of their culture deserves to be told. What follows is an attempt to present, in an admittedly disconnected and anecdotal way, some of my experiences that may impart an idea of what it is like to work and live among primitive peoples.

My field work has been done in the Amazon Basin among the Kuikuru of central Brazil and the Amahuaca of eastern Peru. In both cases it was a joint venture with my wife, Gertrude Dole, who is also an anthropologist.

The first problem in carrying out field work is to establish relations with the tribe you have selected for study. The recommended procedure is to work through an intermediary who has the confidence and good will of the natives. Our initial meeting with the Kuikuru took place at a remote outpost of the Brazilian Indian Service where some thirty Kuikuru had come for a visit. Here we made friends with a number of them and apprised them of our intention to live among them. By the time we arrived at the village, they not only were expecting us but had even begun to build us a house for our stay.

Our introduction to one group of Amahuaca Indians came through a missionary-linguist who had built himself a house deep in the forest and had influenced several Amahuaca families to come to the area. We entered the village of the other Amahuaca group we studied with no advance word at all. Their cordial reception was especially surprising, for these Amahuaca were firm believers in *pishtacos*—white men who appear suddenly among Indians with the intention of killing them and rendering their fat for use as airplane grease.

Following a friendly initial contact, the ethnographer can usually count on a "honeymoon period." But this state of affairs may change abruptly. One morning a Kuikuru, to whose friend I had refused a bar of soap the day before, told us we were stingy and would have to get out of the village. For a couple of hours our field session seemed wrecked. Bu occurred to us to stage an enorm giveaway of our presents, and thus d onstrate our generosity to everybody gambit that proved effective. Our h was more consistently good among Amahuaca. Our relations with them w excellent from the start, and remained the same high level throughout.

The Problem of Gifts

SOUTH AMERICAN Indians are unaba edly materialistic, and one of surest ways of pleasing them is to tribute presents with a free hand. machete, a mirror, a fishhook, or a p of scissors will all find a ready recepti but the gift usually will be accep without the slightest outward sign gratitude. The average Amazonian dian will hide completely whatever s isfaction a present gives him, acting if he were only getting what he deserv Indeed, there is no word for "thank yo in any Indian language I know. The m we ever got from the Kuikuru by way acknowledgement was *enu figei*, "it i present," and that we already knew.

It is always a vexing problem to deci how often to give presents, to whom, a on what basis. It is a good idea to try give material items for services render But this economic principle, so clear the Western mind, often fails to impr Indians. My bitterest experience alo these lines occurred about midw through the field session among the K kuru. Ten men had helped me bri supplies back to the village from t Kuluene River, eight miles away. I ga each of them a bar of soap, several lar fishhooks, and some fishing line, maki it clear that they were being paid f their valued service. They understood all right, but many of the other men wh had not helped also wanted soap, fis hooks, and fishing line—and made thin difficult until they got them.

Conforming to Customs

ONE of the myths about ethnograph field work is that you must alwa eat or drink whatever the natives put front of you. If you fail to do so, t belief runs, the people will be offende and your studies will be jeopardize Being extremely finicky about foo

DR. CARNEIRO, Associate Curator of South American Ethnology at THE AMERICAN MUSEUM, spent nearly one year with the Amahuaca and Kuikuru.

ver, I soon decided to put this shib- i to the test. One day a gourd bowl f manioc gruel was offered to me. turned it down. Nothing happened. Kuikuru did not even seem sur- l. Actually most Tropical Forest is are very permissive, and will not force their customs on others. theless, to take some of the un- usness out of my refusals I soon d the appropriate Kuikuru excuses, is *tugupotsí*—"my stomach is full." ship ties are very important to ive peoples, and one of the ways ome established as a real human is to show that you are also part inship network. This can be done wing photographs of yourself with elatives. It helps, too, if you can y your relatives with the prevail- inship terms. The Kuikuru and iaca never tired of asking to see ctures, and would take great in- in showing them to others, indicat- e relationship each person in the bore to us.

i the Kuikuru and Amahuaca us- addressed us by kinship terms. Kuikuru, even persons we judged f our own age, liked to elevate us eration, calling us father and . The Amahuaca men, however, ach other either *hochí*, "older r," or *chambí*, "younger brother," less of the actual relationship that between them. They fitted me into stem, and I soon learned whom idged older and whom younger The Amahuaca even suggested I wife *chipí*, "younger sister," and e call me *hochí*, which is how hus- nd wife address each other within ship system.

The Language Barrier

HOUT question, the major prob- m facing ethnologists studying ve tribes is the language barrier. lly there is at least one bilingual in the society, and often he be- he principal informant, especially natters where the comprehension le details is important. But bi- persons are often atypical indi- , and it is good practice to use as informants as possible, cross- g the information supplied by iinst that of another. To do this, se, one needs at least a rough g knowledge of the language. If to be in the field a year or less, g the native language fluently is the question. However, I have hat in three months one can ac- enough facility to phrase intel- questions about a variety of s and to understand much of the of the replies.

ugh I am not a specialist in lin- , I find Indian languages fascin- truggling to decipher a language

This is Questar, the first modern 20th century telescope. Mark it well, for it has made history. It weighs but 7 pounds, and each Questar resolves finer detail than either theory or practice predict for its 3.5-inch aperture. Never mind what we say: the photographs Questars take record their powers of resolution for everyone to see.

This cutaway photograph shows some of the innovations that Questar in 1954 brought to the art of telescope design. First, perhaps, is the Questar thin-edge perforate mirror that does away with much useless glass because it is held only by its central hole without metallic contact.

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Let us look at this array of stainless steel tubes. Here is jewelry for fair! The long mirror thimble touches only at small pads on either end, and is precision ground to microns. The little tube up front has a wall no thicker than a stiff piece of paper, and fits so well we need not fasten it.

The photograph shows a few of the 19 internal knife-edged stops which line the tubes to catch internal low-angle reflections that no paint alone can stop.

The light-absorbing paint we do use is very special. This paint is sprayed upon the inside of the aluminum barrel too, where all rays that do not enter nearly parallel to the optical axis come to rest. The making of these aspherically matched Maksutov optics, which Questar first mastered and brought to the world in 1954, is still a problem. Our solution of it is direct and bold. We just reject two perfect systems to obtain one superfine enough to bear our name. The rejects are reworked until they either make the grade or are discarded. That's right, we guarantee each Questar to far exceed its Dawes limit of resolution. Only one of each three sets met this test during 1961, '62 and '63, despite the fact that our skilled opticians have made more Cassegrain compound high-power Maksutov telescopes than all other makers combined. In the beginning we had no idea superfine optics could be made at all. But when they occasionally turned up, we said, "Fine, let's try to make them all that way. Let's make the best small telescopes in the world."

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Our 1963 tour of Pre-Columbian archaeological sites under the expert leade ship of Dr. J. Alden Mason was sold out within a few weeks after it had bee announced.

The 1964 tour is even more exciting. This year Dr. J. Alden Mason, (Curat Emeritus at the University Museum, Philadelphia, Pa. and Editor of publication Brigham Young University, New World Archaeological Foundation), is again o lecturer. Long familiar with the areas Dr. Mason will take you to Peru, where we visit Lima with its many site Cuzco, Machu Picchu, Trujillo with Chan-Chan. Then to Guatemala where we spend two days at Tikal, stop Antigua, Lake Atitlan, Chichicastenango and Santiago. In Honduras we visit the fabulous ruins of Copan a in Mexico we have extended our stay to include not only the sites around Mexico City, but we also visit Oaxa with Mitla and Monte Alban. Finally—Yucatan with Chichen Itza and Uxmal—but this year also Balancanc and the very fascinating excavations at Dzibilchaltun.

The size of the group is of course limited and an early registration is recommended.

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Dr. Gordon is the author of many books and articles on the ancient countries we are visiting. Among the boo are ADVENTURES IN THE NEAREST EAST; THE WORLD OF THE OLD TESTAMENT, AND BEFORE THE BIBL THE COMMON BACKGROUND OF GREEK AND HEBREW CIVILIZATION. For many years he has taught t languages, history, and archaeology of Egypt, Greece, and the Near East.

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Name____________________

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r different from your own—one
is never been written down—is
challenging, often gratifying,
asionally amusing. For instance,
ikuru, who were already familiar
atches, called them *gitifutofo*, a
omposed of the morphemes *giti*,
-*fu*-, "knowledge"; and -*tofo*,
se." Thus, literally, a watch is
ing whose purpose it is to pro-
owledge of the sun." This is a
y reasonable name for it, since
means the Kuikuru have to indi-
elapsed time during the course
is by the changes in the position
un.

r having seen a pair of binoculars,
r, the Kuikuru had no name for it.
t time I showed them mine I de-
give it a Kuikuru name, pat-
on their word for watch. With
rable lexicographic pride I called
péfutofo, "something whose pur-
is to provide knowledge of what
way." The Kuikuru nodded and
when I told them, and I was sure
cored a success. Only later did I
that *kuope* did not mean "far"
ut was a place on a small stream
n which I had happened to train
culars that day.

Allophones and Oinks

language offers its own special
blems; the Amahuaca language,
ple, is extraordinary in the num-
llophones it contains. An allo-
s a unit of sound that is inter-
nerely as a permissible variation
er sound, rather than a separate
f itself. Thus *p* and *b*, *t* and *d*,
, *s* and *th*, *m* and *mb*, *n* and *nd*,
and *o* and *u*—all separate and
sounds in English—are only
allophones in Amahuaca. This
ly lead one astray. For instance,
ere in my notes I had the word
o weed," and elsewhere I found
uruge with the same meaning.
I interpreted them as synonyms,
ter dawned on me that different
seemed to me, they were varying
ciations of the same word.

ru had a fair amount of allo-
ariation, but not to the extent of
ca. It did, however, have a very
sound, the interpretation of
uzzled us for a long time. We
ecided that it was a uvular *g*.
lt is much like that produced by
trying to imitate a frog.

was another method of com-
ion between the Indians and
s, although mainly it promoted
good feelings rather than the
nding of specific points. The
ca are relatively unmusical, and
ked us to sing, but the Kuikuru
pped asking. Their favorite song
lds was "Old MacDonald Had a
We gave so many command performances of it during the time we spent with the Kuikuru that we grew to curse the day it was composed. But it amused us to hear a Kuikuru, at some unexpected moment, muttering under his breath, "Chick, chick . . . quack, quack . . . oink, oink."

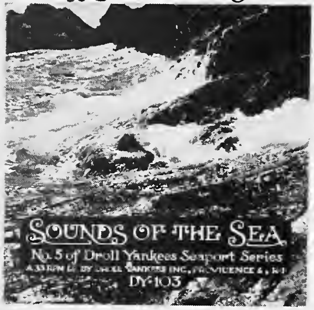
What Julius Beerbohm observed of the Tehuelche of Patagonia many years ago applies to the Kuikuru today: "They are as easy to please as they are difficult to satisfy." We often felt obliged to indulge many of their whims and desires and this usually called for large amounts of patience. Of course, you cannot accede to everything, and when you have to draw the line, the refusal must be made acceptable. For instance, after spending our first ten days in the village in a Kuikuru house, we found living conditions so difficult that we decided to set up our tent. The Kuikuru, who wanted us in their midst all the time, were not pleased at the idea, but did not object outright. However, when we had selected what seemed an ideal site and began to clear it, a very serious-looking delegation of men suddenly confronted us. We had made a bad choice, they said. The area was full of *fitsifitsi* (a certain kind of bush spirit), and if we pitched our tent there, we would have no peace at night.

Knowing that some objection would be raised to any site we picked, we were not disposed to be talked out of our move. At the same time, I did not want to risk antagonizing the Kuikuru. If they said the place teemed with *fitsifitsi*, then it teemed with *fitsifitsi*. It occurred to me that the only way to fight a supernatural argument was with another one. From a suitcase I produced a bottle of vitamin pills and, with gestures combining mystery and flamboyance, took one pill from the container. All we had to do, I said, was to take one of these pills at night, and no *fitsifitsi* in his right mind would dare molest us. The Kuikuru limply gave up the effort to dissuade us and quietly left. (I should add, however, that there were many "I told you so's" when, a few months later, a large tree limb weakened by termites fell on our tent and almost demolished it.)

So far I have dealt mostly with establishing and maintaining good relations with the people one is studying. But an ethnographer is not in the field to win popularity contests. He may never succeed in really ingratiating himself, or in enjoying his tenure in the field, but if he can come back with notebooks bulging, he has done his job.

Approaches May Vary

THE method of gathering ethnographic information varies, of course, with individuals; no two ethnographers work in exactly the same way. On some projects my wife and I used quite dissimilar approaches—not merely in order to com-



plement each other's work but also because our temperaments differ, and because differences in sex affect relations with the informants. In many instances my wife found it most productive to use an unstructured. casual method by which she could pick up and follow the topic of the moment. I often found it most successful to begin with a number of points I wanted to investigate. and to subject informants to a more formal type of interrogation.

Like ethnologists. informants also differ one from another. Some individuals may be eager and colorful informants. but unreliable; others may be reliable. but disinclined to give more than the bare bones of an answer.

Individual spheres of knowledge differ, too. The man with the greatest store of ribald tales may be poor on genealogy, while the kinship specialist may be too reserved to be a good informant about scatology. Sex differences are also important in terms of what a person knows. Indian men, for instance, can readily identify constellations and tell the time of year by them. while the women identify the seasons of the year by the fruiting and flowering of trees and are ignorant of the stars.

Sometimes one's initial assessment of an informant may turn out to be wide of the mark. Pablo, one of the first Amahuaca I met after landing on Chumichinía Island in the Ucayali River, reminded me of a pirate of the South China Sea. He had a scraggly little beard. the rudiments of a droopy mustache, and even the traditional shifty eyes. From the moment I saw him I thought to myself, "This man is going to mean trouble for us." Trouble? A sweeter man never was born. Indeed, Pablo proved to be the most obliging informant I have ever known. As a monument to his accommodating nature I offer the following incident.

I had made arrangements to talk with Pablo. but rain delayed me, and when I arrived I found him sprawled on the porch of one of the houses. He had spent the morning drinking *masato*, "manioc beer," and was virtually stupefied. Under these circumstances anyone, anywhere in the world, has the solemn right to be left severely alone. But with a dulled sense of social proprieties I decided to ask Pablo one question, fully expecting to be told where to get off. To my astonishment, Pablo made a supreme effort to collect his wits and answered. Emboldened. I asked another. Again Pablo replied. In a most extraordinary display of concentration he continued to force himself to answer every question I put to him. But most remarkable of all was that if a question were slow in coming, Pablo would say, "¿Que otra cosita más. Lobelto?" (What other little thing, Robert?)

Pablo surely rates an A + for wil ness, but he scored only about a B- such things as depth of knowledge reliability. The perfect informant does not exist. The person to whom can say. "Tell me everything your ple believe about eclipses." and proceeds to do just that in a clear. nected. and exhaustive manner is n be met with—at least in my experie Moreover, in dealing with a numbe informants there are inevitably crepancies in their information that not be reconciled. There is no si "true" version of a myth, any more there is a true description of a *fits* or of the human soul. Generally one find that there is a core of attrib common to all or most accounts, then a variety of details shared by cessively fewer accounts. This raise problem in recording field data, bu does in writing up an account. M monographs present, one might say, "mean" of a culture without presen its "standard deviation." Some sim fication is inevitable in a monogra but it is misleading not to point out w divergences in belief and practice e for the divergences themselves are ture patterns.

Rewards Offset Hardships

WHILE they lead a simple life, Kuikuru and Amahuaca have keen and sometimes subtle sense humor. and did not place us outside compass. Early in our stay among Kuikuru we began making a house c sus in order to learn the names of eve one who lived in the village. The eas way to do this was to count hammo and inquire who slept in each. In house we saw two hammocks that l been strung up higher than the othe When we asked who slept in them were told, "Oh, they belong to Kapi and his wife Kuagutafa. They've gone the Kuluene to fish, but should be ba in a few days." The days lengther into weeks and inquiries about Kapi and Kuagutafa brought the same rep Finally we tumbled to the fact that such couple existed. and that the K kuru were merely pulling our legs.

I am often asked if I enjoy doing fi work. No simple yes or no answer can given to this question. The insects, t heat. the mildew, the intestinal parasit and all the other hardships of life the rainy tropics make it impossible give an unqualified "yes." Yet life wi the Kuikuru and Amahuaca was oft pleasant. even delightful. and this we far to efface the hardships. But t greatest reward of all for an ethnologi the thing that makes field work wor while regardless of anything else, is t intense satisfaction of discovering a recording ethnographic information th has never previously been made know

About the Authors

Mr. Charles M. Bogert, whose article describes the strange creatures known as amphisbaenids, is Chairman and Curator of The American Museum's Department of Herpetology. Among Mr. Bogert's particular scientific interests are the thermal requirements, ecology, and evolution of reptiles, the zoogeography of Africa and North America, and behavior, taxonomy, distribution, and morphology of reptiles and amphibians.

"Management of Water in Arid Lands" is the work of Mr. George H. Davis, a hydrogeologist with the Water Resources Division of the U.S. Geological Survey. Formerly in charge of ground-water studies by the Geological Survey in the Central Valley of California, Mr. Davis specializes in ground-water geology and studies of land subsidence. He is a member of the Geological Society and of the Association of Petroleum Geologists.

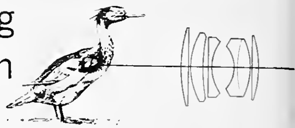
Dr. Janis A. Roze, author of "Pilgrim of the River," is a Research Associate in the Department of Herpetology at The American Museum, where he is preparing a monograph on New World poisonous coral snakes. Dr. Roze is Professor of Zoology and Head of the Department of Zoology at the Universidad Central de Venezuela, in Caracas, which awarded him its Gold Medal of Merit in science. In 1962 he received the Venezuelan National Science Research Award. Dr. Roze is a specialist in herpetology and ecology, and has made extensive investigations of turtle ecology in Venezuela, of reptiles (particularly snakes), and of conservation problems.

In "Arches and Bridges of Stone," Mr. Willard Luce discusses some of the striking rock formations of his native Utah. Mr. Luce, who teaches elementary school, is a graduate of Brigham Young University, in Provo, where he lives. He has written many articles on travel.

Dr. David L. Dineley, whose article about pteraspids appears under the title "Armor-plated and Jawless Devonian Fish," is Professor of Geology at the University of Ottawa. He was born in England, educated at the University of Birmingham, and began his teaching career at the Universities of Exeter and Bristol. His main fields of interest are conodonts ("Problematic Conodonts" appeared in Natural History, January, 1963), ostracoderm fishes, and Devonian rocks. In pursuit of these interests he has visited Scandinavia, Spitsbergen, and Germany. He is currently ending a summer geological expedition to Somerset Island, Arctic Canada, in search of pteraspids and other fossils that he is now studying.

NATURE and the CAMER

Methods for bringing scenery home on film



By David Linton

Fall foliage and landscapes seem to cry out to be photographed—and in color, of course. It often seems that with such breath-taking coloration for a subject, one has only to point the camera in almost any direction and a great picture is sure to result.

All too often a sad awakening comes when the slides are returned by the processing laboratory—the spectacular scenery may look flat and dull. Things that stood out brilliantly in the scene may be lost in the picture. The magic and enchantment have vanished, and what remains is proof of the adage that a picture of a beautiful subject will not necessarily be a beautiful picture.

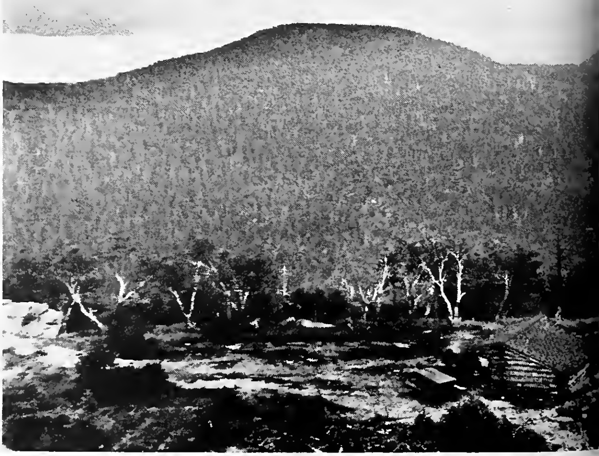
Except in a wide-screen movie theater, a picture cannot fill our whole field of view as scenery does. That a picture is small (at least comparatively) and flat, while a landscape is vast and recedes into the distance, makes the difference between subject and picture more noticeable in landscapes than in photographs of other subjects.

There is also an optical difference between the visually perceived scene and the picture. When we look at a scene we can take in an extremely wide
while simultaneously seeing dista
jects in a fairly large scale. To ap
this effect, a camera would have t
the attributes of both very short
length (wide-angle) and very long
length (telephoto) lenses, an optic
possibility. This is the most fre
cause of disappointment in lan
photographs—everything appears
both tiny and far away.

Selectivity is Crucial

The key to landscape photogra
and to most other kinds of pho
phy—is selection. The impressive
of a wide view cannot be reprodu
a picture that will be held in the
Therefore, the photographer must
the portion of the scene that be
presses the qualities he wants to p
Since distance is an important fac
almost all landscapes, he must sel
area that will allow him to produ
effect of depth in the flat photogra

Visually, distance is revealed
combination of cues. At near dist
(up to about two hundred feet) th
crepancy between the views seen



s gives us a sense of the third
on. Beyond that range we rely
ences in appearance of objects
us distances. The colors of far-
jects are less bright than those of
s. and shadows are not as dark
ights as light. Remote scenery is
with a bluish haze, produced by
tering of light by particles of
and dust in the air. Our impres-
distance is also affected by the
size of objects; if an object looks
though we know it is large, we
at it is far away.

photograph, the means of por-
distance are more limited. Even
otography is not much help in
es, because most such scenes
far away to register differently
o views. The size of objects may
depth effectively in a photo-
ecause the whole picture is so
aller than the original scene.
ative size differences between
t different distances are useful
aying depth in a picture. These
s mean that the hazy appear-
uced contrast, and softer colors
objects are the most impor-
cators of depth in photography.
alities are attributes of what is
"atmospheric perspective."
nds like treason to advocate
the brilliant colors of fall, but
actly how nature shows us that
arts of a scene are distant, and
every device that will help give
re depth.

OBJECTS and haze in the
d depth to this landscape.

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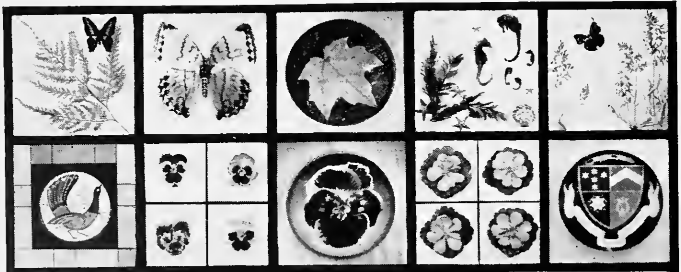

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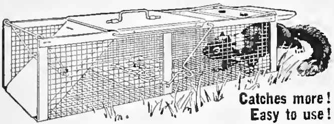

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it may be increased or decreased, wit
certain limits, by the use of appropri
filters on the camera lens. If no fi
is used. the haze will generally app
more pronounced in the photograph t
it did to the photographer's eye.
reasons for this, and a detailed dis
sion of how to control the rendition
atmospheric perspective in photograp
were presented in this column in N
URAL HISTORY, October, 1963.

A simple experiment will show
atmospheric perspective operates in
ture. Look at a distant scene. Then l
at the same scene framed by nearby
jects (two trees, for example). The
ference in color and contrast betw
foreground and distant areas will be
parent. By framing the scene, we
vided points of comparison that allo
atmospheric perspective and the rela
size of objects to suggest distance.

Ideally there should be objects
only in the foreground but also at sev
different distances. When these pl
are separated from one another by
mospheric perspective and variation
lighting, they create an impression
depth and add interest to the pictur

We will not necessarily make the
possible picture when the atmosphe
clearest. In fact, soft, misty days
often more auspicious for landscape
tography. In any season, one of the
times to take pictures of scenery is in
diately after a rain. Another good
is early in the morning, when the su
low and provides more lighting cont

Back-lighted Scenes

THE type of lighting is of the gre
importance in landscape photo
phy. In general, front light, or light
ing from behind the camera, mak
scene appear flat. Side light gives
separation between planes at diffe
distances, and back light (when the
era is pointed toward the light sou
gives the most.

Back lighting requires a few pre
tions, but the improvement in the r
justifies the extra care. The sun sh
usually be hidden—behind a mou
or tree, perhaps, or outside the pi
area. A lens shade should alway
used, but it is doubly important for b
lighted pictures. When the angle o
sun is low, however, a lens shade
not be sufficient to keep direct sun
from falling on the lens. In such
the photographer should try to kee
camera in the shade of some objec
deliberately cast a shadow for the
pose. In this type of work a single
reflex or camera with a ground-
back is desirable because the i
formed by the lens can be examine
fore the picture is taken to make

T AND FRAMING lead viewer's gaze
tograph through series of planes.

no stray light striking the lens.
naking the exposure always look
mage with the lens diaphragm
down to the aperture you will
metimes light striking the lens
ise a bright spot in the picture
he image of the lens diaphragm,
nay not be visible when the dia-
is fully open. In other cases,
iking the lens may cause an over-
shed out" appearance, which can
gnized when one is accustomed to
ving system of a specific camera.

icking a Point of View

the elements of a landscape can-
usually be rearranged, the selec-
a viewpoint for the picture is the
apher's most important decision.
choice depend, to a great extent,
of lighting and the relative posi-
the parts of the scene. Along
ighways, the preselected viewing
at look out over a great valley or
of hills are fine for sight-seeing,
n they are not good viewpoints
ography because the entire scene
lly far away, with little in the
foreground or middle distance. It is far better to scramble up a hillside or stroll down into a forest in search of a more favorable position.

One particular problem with landscapes is that they are likely to stretch out in a long horizontal shape, producing a picture that has all of its subject matter in a thin line at the bottom, while most of the picture space is empty. Shooting from a higher viewpoint and aiming slightly downward will help fill the picture area and it may improve the perspective. Even the slight difference between the waist level viewpoint of some cameras and the eye level viewpoint of others is enough to be noticeable. A long low scene can often be greatly improved by photographing it from the top of a stationary automobile. Many professional photographers carry a stepladder with their field equipment.

Mountains pose a different problem because it is often difficult to find a position from which they really look like mountains. If they are photographed from below it will generally be necessary to tilt the camera upward to get the top of the mountain in the picture. This makes it seem to lean backward. Even when using a view camera, with which this optical effect can be corrected, the view from below will not give a satisfactory rendering. Neither will a view from above, which tends to dwarf the subject. The one really satisfactory viewpoint would be from halfway up a facing mountain. Obviously there are many mountains that have no neighbors of the right height and at a suitable distance. In such cases, a helicopter would be a fine camera platform except for the excessive vibration.

Color and Composition

Autumn foliage runs a color scale from yellow through red. Think for a moment how a painting would look if limited to the same bit of the spectrum. In nature the effect may be breath-taking, but a color picture containing only reds, oranges, and yellows is more likely to be stifling. Some contrast—in color as well as intensity—is essential to the visual organization of a picture.

The contrasting areas need not be large and they should never be equal. A picture that is half blue sky and half orange leaves would look static and unsatisfying. But a small area of contrasting color, properly placed, can balance a great mass of foliage. A small lake, reflecting the blue of the sky, or an outcropping of rock will serve nicely. Even the dark gray line of a highway may help the picture, although most of us would prefer not to bring man-made objects into a natural scene. A smaller area of foliage—perhaps even a single tree—can be balanced against a larger area of sky, but this generally provides contrast only in color and not in intensity. Therefore it may be desirable to include a very bright or very dark patch—a bird, a snow-capped mountain, or a foreground object in silhouette.

David Linton's by-line has appeared under photographs in all the nation's leading magazines. His camera column is a regular feature on these pages.

Photographing Flowers

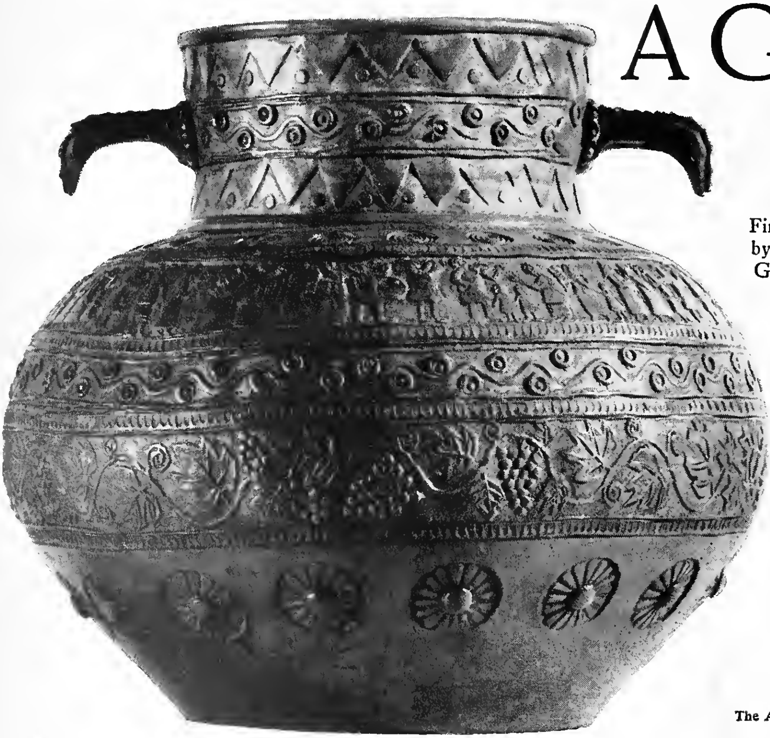
The same principle applies to photographs of flowers. Pictures of masses of blossoms are rarely satisfactory. It is better to select one outstanding specimen and devote extra care to photographing it in a closeup or semicloseup view. One of the few ways a whole field of flowers can be used effectively in a photograph is as a background. While landscape photographs need extra attention to the foreground, in photographs of flowers it is usually the background that is difficult to cope with. When we look at a flower we are able to conc trate our attention on it, and we rar notice the background. How differen is when we see it in a photograph! O recorded on film, a distracting ba ground cannot be ignored.

Since most flowers are comparativ small, they are usually photographed close range, and the background is of out of focus. The contrast between sharp principal image and the unsh background helps create a feeling depth, but the background must also fer from the subject in color and brig ness to make the subject stand out.

Here again, back lighting is extrem useful. In fact, one may almost reve the old box camera rule and say, "Ne shoot with the sun at your back."

This list details the photographer, art or other source of illustrations, by pa

COVER—Willard Luce
16—San Diego Zoo-R. Van Nostrand
18—Charles M. Bogert except top, AMNH
19—AMNH
20—AMNH after M. A. Smith and S. B. McDowell
21-23—AMNH
24-25—Charles M. Bogert
26-29—U.S. Bureau of Reclamation except 29-bottom, AMNH after U.S. Geological Survey
30—State of California, Dept. of Water Resourc
31—AMNH after U.S. Geological Survey
32—AMNH after State California, Dept. of Wa Resources
33—AMNH after U.S. Geological Survey
34-41—Janis A. Roze
42-47—Willard Luce
48-53—AMNH after Dav Dineley
54-56—Lick Observator
57—AMNH
64-67—David Linton



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Additional Reading

"LITTLE SNAKE WITH HANDS"

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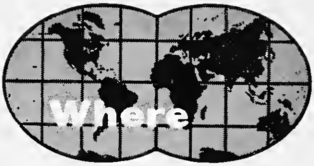

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Cape Hatteras must not be the last of America's scenic glories to be so preserved. We need more natural areas set aside, so that all Americans, for all time, can keep the look of far horizons in their eyes.

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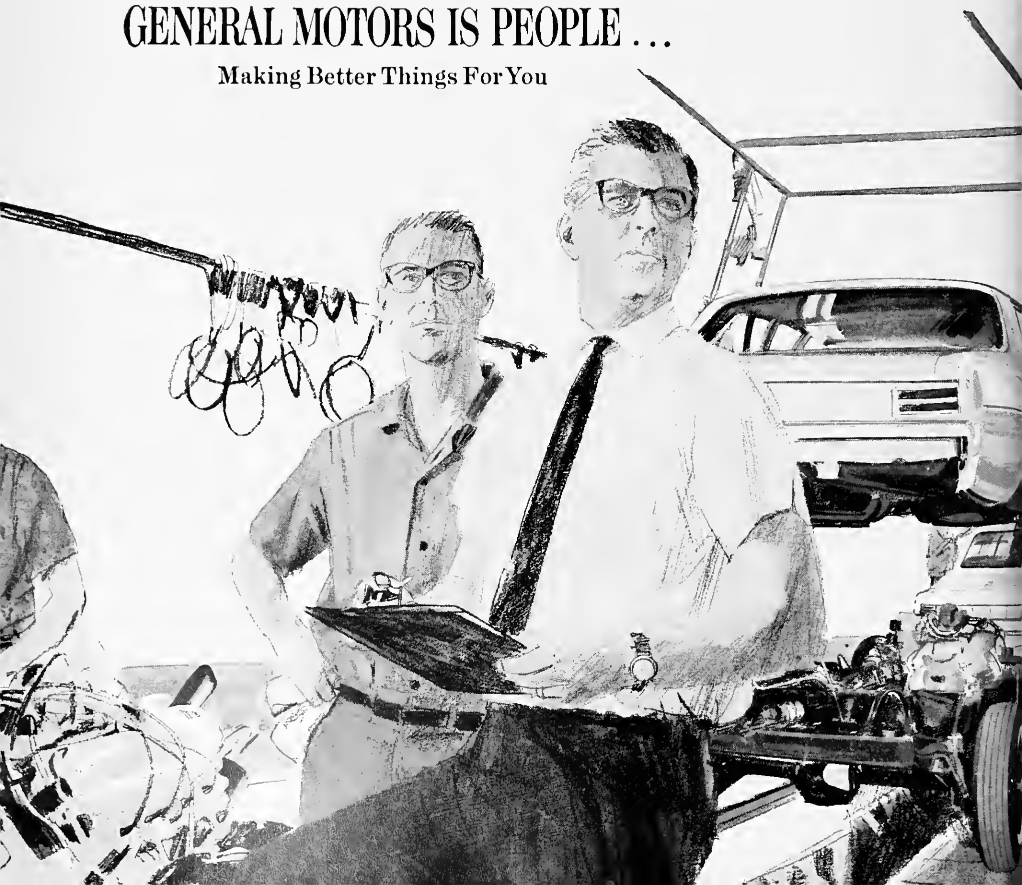

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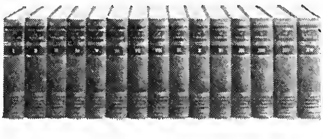

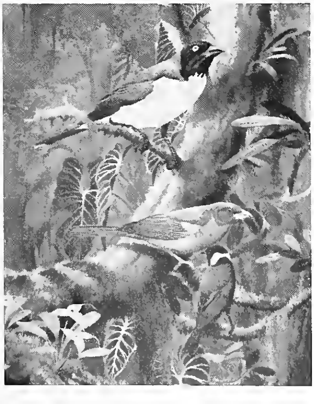

Natural Histor

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THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HIS

Vol. LXXIII OCTOBER 1964

ARTICLES

DEPARTMENTS

COVER: Many songbirds in the Peruvian Andes are among the least fami
South American birds. The three species on the cover are: *Buthraupis mo*
top, Hooded Mountain Tanager; *Chlorornis reifferii*, Grass Green Tanage
Iridosornis reinhardti, Yellow-naped Tanager. Starting on page 26, Dr. W
G. George discusses these and other birds found in Peru. The plates wer
specially for this article by the outstanding bird artist Mr. Arthur
Vegetation is rendered as accurately as available information permits.
on cover are *Philodendron verrucosum;* the orchid is *Masdevallia pandur*

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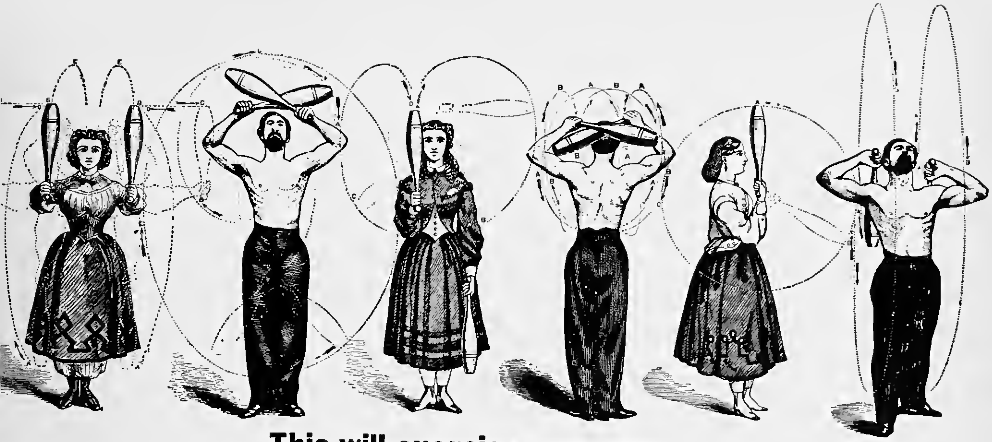

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BOOKS / IN REVIEW

Three histories of man

By Harry L. Shapiro

A MILLION YEARS OF MAN, by Richard Carrington. *The World Publishing Co., $7.50; 335 pp., illus.* AND THEN CAME MAN, by Hartmut Bastian. *The Viking Press. $6.95; 354 pp., illus.* FROM APE MAN TO HOMER, by H. E. L. Mellersh. *Taplinger, $5.00; 222 pp., illus.*

THE discoveries of science are generally first announced, as is proper, in technical journals or in books written for highly specialized readers. Most scientists, having done this, feel they have discharged their responsibility to society. But there is another public with an appetite for knowledge that never or rarely encounters these publications. It is composed of general readers who are curious and interested in the general progress of scientific investigation—and this includes scientists reading in areas outside their own specialties. Lacking the highly technical knowledge and vocabulary to pursue scientific reports filled with allusive and cryptic statements, or the stomach for the minutiae of technical papers, these readers have created a market and a demand for books on science written in terms that are accessible to them. The gift for this kind of so-called popular writing is unfortunately not widely dispersed among scientists, who in any case are usually reluctant to undertake it at the expense of their research. As a result, a growing class of professional writers has taken on the job of translating the technical works of science into the vernacular and making them palatable to as wide a readership as possible. It must be admitted that if something of precision and accuracy is often lost in this process, the gain in communication and education may be a compensation.

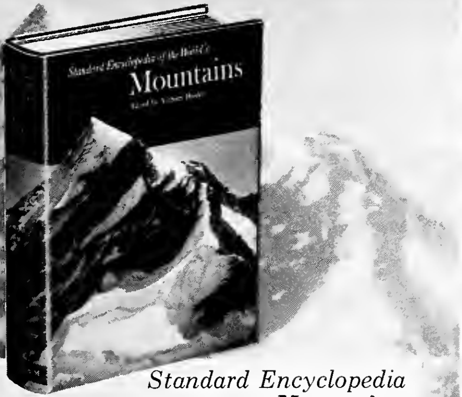
All three books under review here belong in this category of popular science writing. A scientist in the fields the books represent is inevitably faced with certain problems when he comes to them as a critic. Obviously, if he is reasonable, he cannot expect the extreme caution and qualification characteristic of technical writing. That would be inappropriate, not to say self-defeating. But on the other hand, how much latitude is reasonable in order to make a book interesting? I suppose in the end the standards demanded by such hypothetical reviewers would vary.

Richard Carrington's *A Million Years of Man* is a solid piece of work. It covers, as the title suggests, pretty much the whole story from the emergence of manlike creatures up to modern times.
introductory chapters are devote
fairly standardized information on n
primate ancestry, with emphasis o
evolution of those characters tha
sumed particular importance as a
heritage of early man. After recou
man's biological evolution, the a
continues with his cultural developn
On the whole it is a well-informed
that is marred by errors in detail
are often typical of professional wr
who are not trained in the field the
cultivating. For example, the bony
ridges are identified as areas of at
ment for the jaw muscles. They are
The australopithecines are classed
family. They are a subfamily. In
gence is said to "depend" on the b
body size ratio. This presents a fals
pression of a relationship that is s
somewhat sticky problem.

More troublesome, however, is the
dency to read a social philosophy
the history of cultural developn
Aside from any dissent I might reg
I question whether this book is a
propriate place for it.

Bastian's *And Then Came Man* t
the origin of man and his cultur
one of the end products of organic e
tion. Most of the book is devoted t
origin of the earth and the histor
the life that invested it. Considering
little space is left in the text for ma
his works, the coverage is fairly
quate, if not distinguished. For rea
interested in the whole panorama of
And Then Came Man offers a rea
ably good but elementary coverage.
not know whether the publisher o
author or some other culprit is res
sible for the illustrations. Some of t
are not only poor, but are even gr
inaccurate. For example, a "family"
meant to illuminate the text does
agree with it: it places *Australopith*
earlier in time than *Zinjanthropus*,
signing a wrong date to him, and
Pithecanthropus appearing twice at
ferent time levels, neither of whic
correct, and without making it
whether these two are meant to be
same type or not.

From Ape Man to Homer is by H.
Mellersh, an amateur biologist, acc
ing to the publisher's information o
dust jacket. Mr. Mellersh is conce
here mainly with the cultural e
leading up to the establishment of c
zation and terminating with the Heb
and the Greeks. In a little over two



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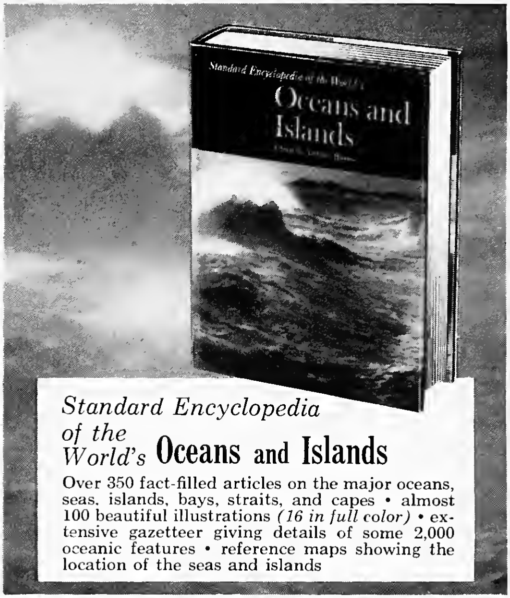

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dred pages Mr. Mellersh can obviously do no more for this tremendous story than provide thumbnail sketches of the various periods and peoples he includes. But what he does provide is done with considerable proficiency. Since the documents that illuminate this stretch of time are refractory and often open to a variety of interpretations, there is some freedom allowable to an author. In general, Mr. Mellersh exhibits respect for the data.

Dr. Shapiro, Chairman of the Department of Anthropology and Curator of Physical Anthropology at The American Museum, is a frequent contributor to this section.

ON SAFARI, by Armand Denis. *E. P. Dutton & Co., $5.95; 320 pp., illus.*

It would be normal to expect that the autobiography of a man who has spent his lifetime photographing wild animals and primitive peoples would be packed with information, excitement, and impressions. Armand Denis' autobiography is but little more informative than a biography in "Who's Who," and it certainly tells little of the man behind the camera. In fact, the book is so devoid of personality or character that it is a huge disappointment.

From his boyhood animal collecting to his current weekly television photography, Denis simply tells the reader what happened. Nowhere does one really find out how the author is affected. Nowhere does one get the feeling of a tropical camp, a real impression of a co-worker or a native king, or the thrill of adventure. Considering that Mr. Denis worked for so many years with animals, there is surprisingly little in the way of original observations about wildlife.

This is not a bad book. It is readable but unimaginative. It is illustrated with photographs that range from good to surprisingly poor for a professional photographer. The captions, as well as the pictures, show a lack of imagination.

RICHARD G. VAN GELDER
The American Museum

THE ALPS, by Wilfrid Noyce and Karl Lukan. *G. P. Putnam's Sons, $15.00; 312 pp., illus.*

I am told by those familiar with the subject that this attractive book on the Alps is comprehensive in coverage and accurate in fact. I shall, therefore, limit my comment to the photographs, layout, and reproduction in terms of the interest and excitement they may or may not create.

This is the age of the picture book. Some are good: many are sterile, in that they treat only of the surface aspects of nature, objects, and people. They may be informative, but it is increasingly apparent that aesthetic and emotional fac-

tors should be added to create impact and transmit conviction. The efficiency of the medium and the standardization of procedures weaken much of the perception and interpretation that are the prime qualities of communicative art

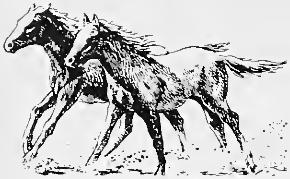
The opportunities latent in the concept of the picture book are seldom revealed. To one who has never directly experienced the *subject*, the successful picture or picture series should convey authenticity and also give impressions of the intrinsic beauty of the subject and comprehension and spirit of the artist.

Some of the photographs in the book succeed in this goal, but certain factors in layout and reproduction seriously interrupt the logical and appropriate flow of the images. The choice of an apricot-tan paper for the text sections seems unfortunate in relation to the clear palette and mood of the mountain scene. It is especially disturbing in conflict with the rather bleak, cold black values of the plates. When seen opposite each other the illustrations have a rather consistent quality of vigor and tonal value.

What is called "change-of-pace" is very important in any picture sequence. There should be variation not only of subject but also of tonal weight and of picture size and shape to hold one's interest. Occasionally a full double-page spread is rewarding, and an occasional blank page will give a certain relief in any extended sequence. "Bleeds," or pictures running to the edge of the page, are risky when the edges of the pictures are important. I have a sense of crowding in this book; a small picture with a generous amount of white margin around it sometimes can be more impressive than the same picture as a full page, especially if there is a monotony of crowded pages in the book.

At the turn of the nineteenth century Coleridge wrote that all art was the balance of the external and the internal. Art should not deny the external world, and should do much more than merely translate it at the informative level. Every serious picture book should be considered an opportunity for something more than mere representation. The reader and viewer should be drawn into some emotional and aesthetic experience, not necessarily at the level of the creative artist, but certainly at a level beyond his ordinary experience. Mountains, because of their sheer grandeur and scale, dominance of form, and adventurous connotations, hold their own in spite of the frequent absence of the elements of art in their interpretation.

Most of the scenes in this book are very good record pictures—clean, honest, sharp, and uninspired. Opinion will differ because of personally nurtured ideas of the mountain scene. Most of the photographs appear to have been printed by



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the same photofinisher, and whatever leveling-off of quality and impact he did not accomplish the engraver and pressman completed. Among my selections of the most expressive shots, only one photographer (Erick Weber) is represented by as many as three pictures; another (Albert Steiner) by two pictures. Hence, it cannot be said that there is a concentration of the style of a small number of mountain photographers. The other photographs remain rather sterile and conventional; some are of *salon* character, others are weak and indecisive. Many are sentimental arrangements or include far too much in the field of view. The merits of simplifying, cutting to the essence of things, and printing with conviction of tone and texture often are overlooked by both photographer and editor. A good editor can suggest appropriate cropping, but should *not* crop without the photographer's permission!

After many perusals of the photographs in this book, I feel I have gained a good look at many aspects of a remarkable part of the earth's surface. However, as I read the text I feel a sharp perception of the basic qualities of the mountain scene and a rewarding sense of adventure. These do much to fill in the gaps of mountain experience that are only sometimes evident in the photographs themselves.

Ansel Adams
Photographer and Conservationist

The Art of Warfare in Biblical Lands in the Light of Archaeological Study, by Yigael Yadin. *McGraw-Hill Book Co., Inc., $25.00; 2 volumes, 484 pp., illus.*

Scientific and popular studies of the social, historical, and economic phenomenon of warfare generally pay little attention to the ancient Mediterranean world before the Greeks. Yet the lands that formed this world—Egypt, Palestine-Syria, Mesopotamia, Asia Minor, and Iran—constantly rang to the clash of arms. Their histories, which existed for a good two millenniums before the fall of Troy and which to a large extent are the chronicles and annals of their kings and armies, continued even into Roman times. For the modern scholar and interested layman alike, however, there has existed no comprehensive work that dealt with the totality of warfare as practiced in the ancient Near East, together with descriptions of the development of weapons and of armor, of land and sea tactics, of grand strategy, of doctrines of attack and defense, and of logistics and training. Such a work now exists in the book of Professor Yadin, who is doubly qualified to write it, first as a biblical archeologist and second as a major-general in the Israeli Army.

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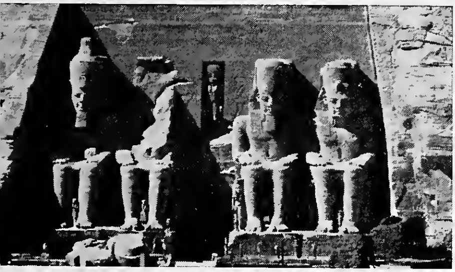

.t parts: the text, which chronolly describes and discusses the s aspects and techniques of war- ı the lands of the Bible, and the , which thoroughly illustrate and ement the preceding discussions. :hronological framework around the text is based is that of the Old ıent. Volume I covers the period the most ancient beginnings in ..C. (the fortifications of Neolithic o) until the conquest of Canaan hua. Volume II continues from the f the Judges until the kingdoms of and Israel, and concludes with a ehensive bibliography, a subject- for the plates, and the illustration s for both volumes.

text is supplemented by numerous rawings in black and white. The ty of plates are in color and are ' of special note. On the one hand, re well chosen and vividly portray litary tools and techniques of the t Orient. On the other hand, the s not always accurate, but this is r flaw in an otherwise ambitiously ved and brilliantly executed work. .ough Yadin claims that this is pioneer attempt to investigate the s aspects of ancient preclassic war- ıctually it is much more. In my ı, it is the most significant book written to date on biblical military arts. It will long remain a classic for the biblical scholar, the orientalist, the military historian, and all who are interested in the ancient military past of man.

Alan R. Schulman
Columbia University

Green Medicine, by Margaret B. Krieg. *Rand McNally, $5.95; 462 pp., illus.*

There is scarcely a person in the world who has not used plants, plant products, or their synthetic equivalents for therapeutic purposes. The Americans seem to consume tranquilizers (originally derived from plants) like popcorn; Europeans are antibiotic-happy, and the Chinese process roots and herbs. All this is in addition to various plant derivatives such as curare, quinine, digitalis, dicumarol, and many other products that are used in the treatment of specific diseases.

The story of the history, the ideas, and—above all—the men and women who are engaged in the search for plants of medicinal value should have been told many times, for it is exciting, important, and of vital interest to all of us. Yet Margaret Krieg, a professional writer, seems to have been the first to recognize that there was something worth telling. In her preface, she details the increasing interest in the field and discusses the reasons why she wrote this book.

It is inevitable that *Green Medicine* will be compared to the standard pattern for such reporting—the classic *Microbe Hunters*, by Paul de Kruif. I regret that *Green Medicine* suffers badly by comparison. The book is too breathy, too cute, and too wide-eyed. Although familiar with most of the subject matter, I became somewhat lost in trying to follow the thread of her tale. It is a pity that the book is not all the good things it might have been, for as De Kruif made America aware of bacteriology and stimulated many young people to enter careers in this science, so Mrs. Krieg might have called attention to pharmacognosy and plant sciences. She almost makes it, but not quite.

Nevertheless, *Green Medicine* has many good things to recommend it, and the book is cheerfully endorsed for those who want an over-all view of an important area of economic botany. It is unusually accurate—no small praise. The author has taken the trouble to visit most of the people about whom she has written. Her examination of the voluminous literature, her historical notes, and her reportage of current research is almost faultless, if uncritical. She has attempted, with considerable success, to

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Dr. Gordon is the author of many books and articles on the ancient countries we are visiting. Among the books are ADVENTURES IN THE NEAREST EAST; THE WORLD OF THE OLD TESTAMENT, AND BEFORE THE BIBLE; THE COMMON BACKGROUND OF GREEK AND HEBREW CIVILIZATION. For many years he has taught the languages, history, and archaeology of Egypt, Greece, and the Near East.

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The internationally renowned ornithologist, John G. Williams of the Coryndon Museum in Nairobi, will act as advisor to the expedition. Mr. Williams led the Queeny Expedition of the American Museum of Natural History in 1950, the Chicago Natural History Expedition in 1954, the British-American Expedition to Angola in 1957, the Carnegie Expedition in 1958, and the Los Angeles Museum Expedition in 1963.

The tour will include visits to Lake Magadi, Amboseli Game Reserve, the Treetops, Lakes Naivasha, Nakuru, Baringo and Hannington, Kakamega Forest, and Sirimon Track on Mount Kenya—among other places.

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erect a solid foundation for an intelligent reading of the chemotherapeutic news that is published almost daily in newspapers and popular magazines. Glimpses of the international politics, industrial co-operations and lacks thereof, and of the labor that forms the basis for discovery are all most fascinating.

Richard M. Klein
N. Y. Botanical Garden

Photographing Nature, by David Linton. *The Natural History Press, $1.95; 262 pp., illus.*

Mr. Linton is a well-known magazine and scientific photographer, and has a great deal of experience in the field he is writing about. Unfortunately, the subtitle of this paperback—*A handbook for the beginner and the expert*—is a misnomer, as the book is too complex for the beginner and too elementary for the expert. In the first half of the book the beginner will be faced with complicated concepts and an excess of verbiage that will only further confuse him; the expert will learn nothing that is not already a part of his craft.

In the second half of his book, Mr. Linton has done a better writing job, but he skips and skims over vast scientific areas in a very unscientific way, leaving the beginner hopelessly confused, and the expert a little frustrated with bits and pieces of hints that are not sufficiently explained.

This reviewer feels that better editing on the part of the publisher would have made better use of the valuable material that Mr. Linton has to offer.

Jack Manning
The New York Times

Byzantine Aesthetics, by Gervase Mathew. *The Viking Press, $6.50; 189 pp.*

Russian ballet, suggests the author, is one of the best introductions to Byzantine art, but, in fact, one of the best introductions is the book under review. No one interested in Byzantine civilization can afford to neglect this learned, sensitive, and illuminating commentary. Father Mathew reviews works of art in the light of Byzantine texts, expounds the aesthetic theories disclosed by the literature, and provides insight into numerous aspects of the Byzantine world: personalities, situations, and places. Due emphasis is given to the part played by the Byzantine emperors, to the importance of liturgy—religious and lay—and to the contribution of the extraordinary civil service of the times. "It seems," states the author, "to have possessed some of the close-knit texture of a good Late Victorian club." By the sixth century, however, John Lydus, a Byzantine civil servant of the period, wrote that formerly it was the custom "to employ

only the finest paper in official business while the clerks were as resplendent as the paper they wrote on. But now both are gone and they exact a most mean and miserable fee and issue leaves of grass instead of leaves of paper, with cheap writing that smells of poverty."

The main factors in Byzantine aesthetics were a recurrent taste for classical reminiscence, an essentially mathematical approach to beauty, an absorbed interest in optics—experiments in light, color, and space—and, finally, a belief in the existence of an invisible world of which the material is the shadow. "This then," wrote Plotinus in the third century A.D., "is how the material becomes beautiful—by communicating in the thought that flows from the Divine." Father Mathew points out that there is little literary evidence that Plotinus' writings, titled *Enneads*, were known to the medieval Greeks, but the altering art forms of the late third century coincided with a new Greek theory of aesthetics that provides an explanation for much of Byzantine art. The medieval Greeks—they called themselves Romans—had a zest for multiple and hidden meanings, for harmony of color and proportion, and for tactile sensations caused by rich materials—gold, silver, enamel, marble, semiprecious stones, ivory, and silk. Indeed, the patterns on some of the fi Byzantine silks could only be seen w the wearer moved. They liked stra machines: fountains that sang as played, birds of gold screeching beating their wings, automatic toys o kinds, and the secret of Greek fire well kept. All this is a far cry from strictures of the nineteenth cent which knew Byzantine art only in te of late Greek and Russian icons frescoes; little more than fifty years one of the most complex, subtle, l and beautiful of all artistic styles partially dismissed as "the narrow ficiency of perpetual iteration." A reading Father Mathew's enchan book such strictures become obsole

JOHN BECKW
Fogg Art Museum, Har

PEOPLE OF EIGHT SEASONS, by E Manker. *The Viking Press, $20.00;* *pp., illus.*

INTEREST in the life and habits of Lapps began as far back as Roman historian Tacitus and contir today. More than thirty thousand these self-sufficient people, Europe's nomads, still follow their reindeer h north of the Arctic Circle and still skis, as they have for thousands of ye

The text of this beautifully designed book by Ernst Manker, Senior Curator of the Nordiska Museet, Stockholm, details the Lapps' adaptation of their lives to migration patterns of reindeer, on which they depend. The author outlines the mystery of their origin and describes their land and its natural resources. Then, using one present-day family as an example, he follows the complex series of marches and countermarches that make up the yearly cycle—a year of eight seasons. Within the framework of this simple life, the author finds there is room for adventure, beauty, and philosophy.

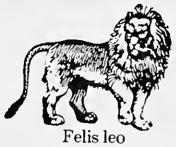
Nature drawings and illustrations by Ake Gustavsson enhance the clarity and charm of the text. Large color photographs show details of the costumes, and there are excellent sketches of camp life and the industries of the people. It is rare to find a book as authoritative and at the same time as beautiful as *People of Eight Seasons.*

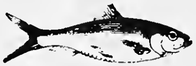
PHILIP C. GIFFORD
The American Museum

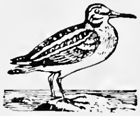
PUEBLO GODS AND MYTHS, by Hamilton A. Tyler. *University of Oklahoma Press, $5.95; 313 pp.* BOOK OF THE HOPI, by Frank Waters. *The Viking Press, $10.00; 347 pp., illus.* THE SIOUX, by Royal B. Hassrick. *University of Oklahoma Press, $5.95; 337 pp., illus.*

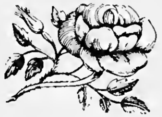
ONLY the most determined readers, or those with considerable prior knowledge, will be able to learn much about Pueblo religion from Hamilton A. Tyler's *Pueblo Gods and Myths.* This is not because of a lack of information, for the author has obviously done considerable library research and presents a great deal of data. The trouble is that in writing about all the Pueblo tribes, Tyler must face the problem of differences among the Pueblos. When he ignores these differences, the reader does not know for which Pueblo the information is valid, and when he deals with them, the discussion of the different names and attributes of the deities in the various Pueblos is overwhelming. This confusion is compounded by frequent allusions to other religions (principally ancient Greek), which do not help the reader understand Pueblo Indian religion. Consequently, Tyler fails to present a coherent picture of the religion either of a single Pueblo tribe or of all the Pueblos.

Book of the Hopi, by Frank Waters, deals with the religion and history of this tribe (one of the Pueblos) since the initial Spanish contact in 1540. The bulk of the book discusses religion and is based upon interviews with Hopi informants tape recorded by the author over a period of three years, translated by a Hopi, and edited and rearranged into a format resembling the Bible. Waters









tends to take Hopi myths and the testimony of his informants at their face value when applying them to such problems as the origin of the Hopi. Thus, he has them coming from Asia to North America by way of the Pacific—hopping from island to island and occasionally making use of drifting continents. Once here, they wander all over the continent, helping to build the civilizations of Mesoamerica and the great Serpent Mound in Ohio before finally settling in their present location. This is nonsense, but not much worse than some of Waters' interpretations of later historical events. His description and interpretation of the conquest of the West is a mixture of righteousness and chauvinism. The book is beautifully illustrated and contains some excellent photographs, but in view of the text, one can only regret the time and money the publishers have devoted to this volume.

Hassrick's *The Sioux* is a straightforward ethnography of the Teton Dakota. The Dakota, commonly called the Sioux, are typical warriors and buffalo hunters of the Great Plains. Of all the American Indians, the Indians of the Plains are best known to Americans because of their frequent appearances in motion pictures, and of the Plains Indians, the Sioux are probably most renowned in story and drama. Yet, until now, there has not been a good popular ethnography of any of the Dakota groups. Hassrick has admirably filled this need for the Teton Dakota. He knows his people well and has written a book that is a must for anyone interested in the Sioux or in the Plains Indians in general.

STANLEY A. FREED
The American Museum

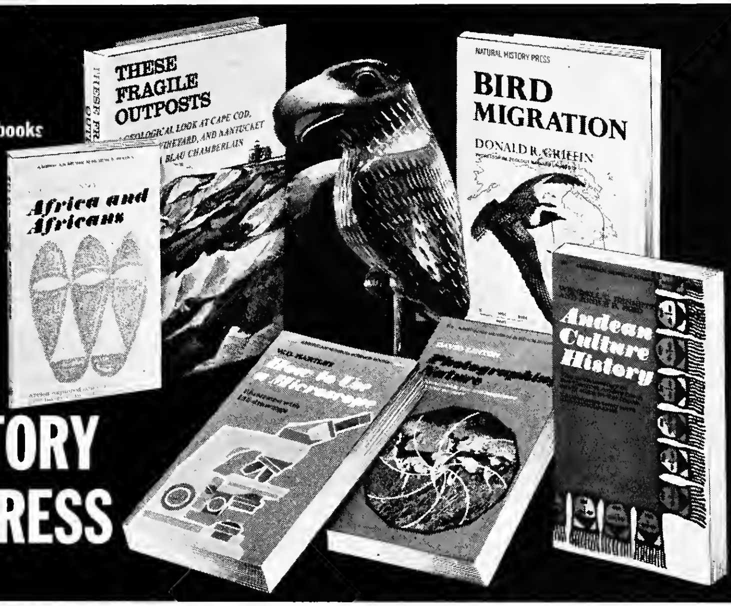
THE AMAZING WORLD OF INSECTS, by Arend T. Bandsma and Robin T. Brandt. *The Macmillan Co., $9.95; 46 pp., illus.*

THIS is another insect picture book, but one with a major advantage. The photographs are outstanding—in fact, I have never seen better ones and do not expect to for a long while. Many of them, although greatly magnified, show almost incredible sharpness and depth. While some are posed (with pretty flowers) there is no evidence of the use of dead or anesthetized specimens, a technique that, to me at least, verges on faking.

The text falls far short of the illustrations, being badly lacking in organization. Some sound generalizations about insects are given, and many interesting facts are related about the species and groups pictured. However, the insects —all from Europe, Australia, or New Zealand—are indiscriminately mixed gether, often with no clue as to wh they came from. Not all are identi as to family, which would have hel readers in other lands. Some highly p togenic groups receive disproportion representation, while others, promin and worldwide, are omitted. Althou many of the specimens were identified museum entomologists, there are err such as identifying a common Europ bee *(Anthidium)* as a wasp, and in g eral confusing ichneumon and paras wasps, flies and social wasps. Des such weaknesses in the text, howe the magnificently reproduced ph graphs are a joy.

ALEXANDER B. Kl
The American Muse

NOTE: In past years, the December sue of this magazine has carried a spe review section surveying science bo for young people. This year, however, survey will appear in November. The cision to change the date was based the large number of requests we have ceived from teachers and librarians, w point out that their purchasing perio earlier in the fall. We hope this cha may also help Christmas shoppers.


THESE FRAGILE OUTPOSTS
A GEOLOGICAL LOOK AT CAPE COD, MARTHAS VINEYARD, AND NANTUCKET
BARBARA BLAU CHAMBERLAIN
Africa and Africans
NATURAL HISTORY PRESS
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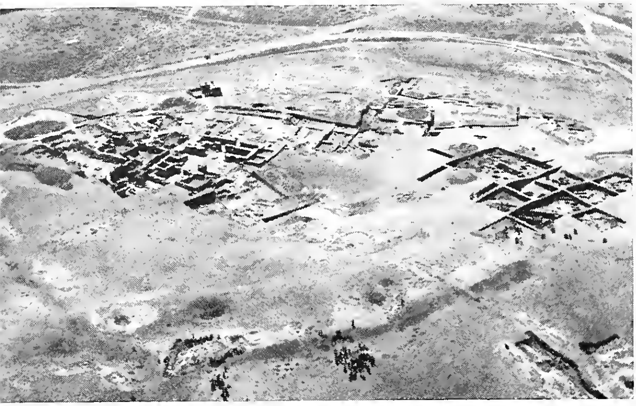
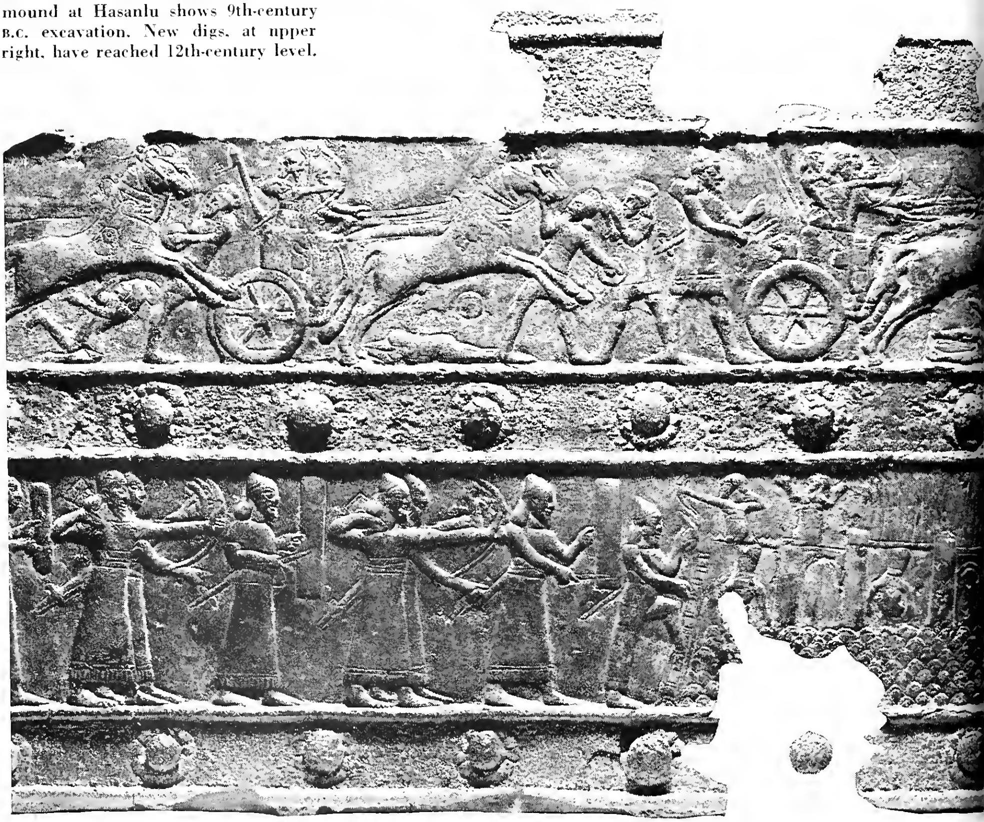
DONALD R. GRIFFIN
W. G. HARTLEY
How to Use a Microscope
Andean Culture History

Sciences Meet i Ancien Hasanl



AERIAL VIEW of 75-foot-high Citadel mound at Hasanlu shows 9th-century B.C. excavation. New digs, at upper right, have reached 12th-century level.

By R. H. DYSON, JR.



ıt fire to their houses which
ilt with art; I made the smoke
m them, like a hurricane, I
cover the face of the sky. . . .

Iusasir the home of Haldia, I
master in the palace, residence
ıa, I lived as ruler.

rooms] filled full, which over-
with heaped up treasures, I
e seals of its reserves:

alents 18 minas of gold, 167
2½ minas of silver, pure
'ead, carnelian, lapis lazuli . . .
ntities of precious stones,

y staffs of ivory, of ebony, of
ɔd] with [their] pommels set
d and silver,

ısins of bronze, [large vessels]
ze, vessels for washing of
. . bronze cauldrons, pots of

nulticolored robes and tunics
of blue wool and wool to be
' the scarlet color of the coun-
Jrartu and Kilhu. . . ."

Copper relief on Balawat gates from Iraq-Iran border shows Assyrians in a battle with Urartians. Battle gear is like that found on Hasanlu artifacts.

Thus did Sargon II, the great military leader of the Assyrians in the eighth century B.C., boast of his success in a campaign in northwestern Iran in which he blunted the power of Urartu by capturing the famous temple of Musasir with all of its treasure. The list of booty shows us the richness of the material culture of the times and indicates a prime incentive for such a campaign. The ninth century had also been a time of much military activity. In the reign of Shalmaneser III (858-824 B.C.) the Assyrians first ventured east into the Zagros Mountains and the high plateau of Iran. A visual record of some of these campaigns is still preserved on the bronze gates from Balawat, now in the British Museum.

In view of the many towns and villages reported as having been left in smoking ruins by the Assyrians, it is not surprising that many abandoned city mounds dot the landscape in this part of Iran. One of these, Hasanlu, lies a few miles south of Urmia, a salt lake in a rich valley-plain known today as Solduz. In ancient times Solduz lay on the border of the country of Mannai, which occupied the area to the south and east. Control of Mannai was sought by both Assyrians and Urartians. Excavations at Hasanlu during the past seven years have uncovered the charred remains of a great citadel filled with weapons, jewelry, pottery, and the burned remains of inhabitants trapped under wooden columns and brick walls—victims of some sudden attack in the late ninth century B.C.

Thus today, 2,700 years later, preserved through the twin accidents of charring and unexpected burial beneath collapsed buildings, a mass of exciting evidence on the world of the ninth century is coming to light. Under the combined scrutiny of archeology and several of the disciplines in the biological and physical sciences, our knowledge of this world is gradually expanding.

Consider, for example, bits of wood found in the form of charcoal or preserved by contact with oxidized objects of bronze or iron. Microscopic examination of the cell structure in these small fragments often makes it possible to identify the species of tree from which they came. Such identifications are of interest, because the present landscape in Solduz is treeless except for poplars and willows planted along irrigation canals or growing along the Qadar River, and small orchards of fruit trees planted near houses. The only trees that now grow here naturally are high up on the slopes of the Zagros Mountains and represent a remnant mixed-oak forest. In the ninth century B.C., a greater variety of woods appears to have been available locally and trees were often mature when cut. Poplar, as at the present time in Solduz, was the favorite wood for building, and was used for rafters, door frames, and columns in the large buildings that we have excavated. In some instances the columns stood at least twenty feet high, made from tree trunks trimmed down to a diameter of about two feet.

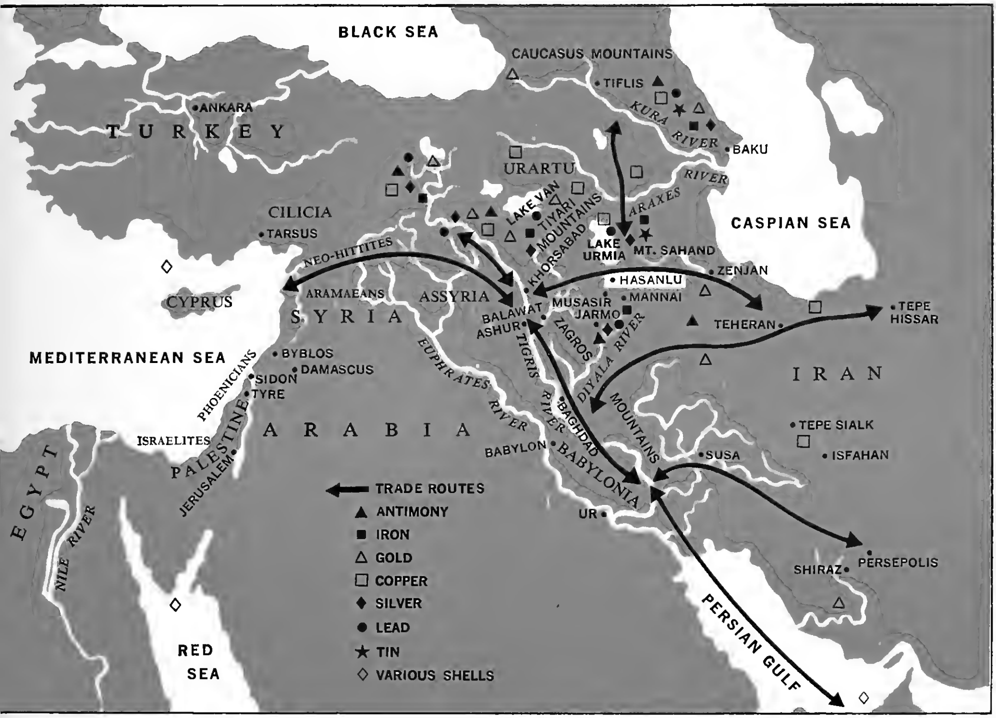
Dr. Henry Michael of the Center for Applied Science in Archaeology at the University Museum in Philadelphia cut and polished a fragment of this wood and found an average yearly growth of about 4.4 mm. The regularity of the growth pattern indicates that the tree received an adequate and steady supply of water. On the basis of observable ring patterns from modern poplars we may estimate that the columns would have been made from mature trees at least fifty years old. Probably they grew by the river or a canal in the manner of modern poplars. Poplar, a soft wood used in the United States today primarily for paper pulp, was also used at Hasanlu in the manufacture of small objects such as buttons, bosses, and cores for objects of hammered copper. Another important wood was elm, a hardwood used for beams in one of the main buildings and for the shafts of iron-tipped spears and arrows. Still another piece of hardwood, identified as the handle of a bronze mace, was boxwood (*Buxus sempervirens*), which was once common in Asia Minor, but is now scarce. Objects of boxwood are mentioned frequently in lists of the plunder carried off from Musasir by Sargon. The rest of the wood identifications, all of which were provided through B. Francis Kukachka of the United States Department of Agriculture Forest Service Laboratory in Madison, Wisconsin, include cypress, hawthorn, and apple or pear. Fragments of these woods were all from small objects. The hawthorn was from a small bowl, and

PART of a drinking horn of hammered copper, this horse head was found in the ruins of a great pillared hall that collapsed during sacking of Hasanlu.

FRAGMENTS from ivory plaque, at top, show diamond-eyed visages of Hasanlu citizens of 9th century B.C. At center are pieces of woven fabric, and at the bottom are buttons cast from antimony, probably Transcaucasian importations.

the apple or pear wood forme
handle of a bronze mace. Indir
of course, we thus learn that appl
pears were available food.

BESIDES fragments of wood, nu
ous plant remains have
found among the charred ruins.
agricultural economy they refle
very similar to that already know
the Assyrians. The major crops
six-rowed hulled barley (*Hord*
polystichum), a glume wheat (*T*
cum dicoccum, or emmer), an
naked wheat (*T. vulgare*, or b
wheat). The six-rowed barley h
long archeological history in the
East, beginning about 4000 B.
probably originated from the
rowed barley grown at Jarmo in n
ern Iraq about 6500 B.C. Wheat
also one of the original domestic
plants, and emmer has been comm
associated with early village far
from western Asia to Scandin
These cereal crops were grown in f
prepared with iron hoes or wo
plows and were harvested with
sickles. Tools of these types have
found at Hasanlu. Once the grain
harvested, the usual procedure wa
thresh it by spreading it on cle
land and trampling it by driving c
or donkeys around on it in cir
Then it was winnowed by tossin
into the air (probably with woo
forks, although three-pronged
pitchforks were also known). G
flour for bread was ground on la
stone querns, and the bread was ba
in domed clay ovens. Beer may h
been brewed, as it was by the Ass
ans, for large vats more than hal
tall as a man have been found ass
ated with large pottery funnels. I
possible, however, that these vats h
wine, as remains of crushed gra
(*Vitis vinifera*) also have been fou
Certainly, sun-dried raisins wo
have supplemented the diet. Even
day grapes form a large crop in
valley in late summer. Among
other plants identified by the fam
Danish paleobotanist Hans Helb
were millet (*Panicum miliaceum*
chickpea (*Cicer arietinum*), figs (
cus carica). and quince (*Cydonia*
longa). Millet was grown through
the Near East, having been used
predynastic Egypt, and in Iraq a
Bronze Age Iran: chickpeas, one of
most nutritious legumes grown
human consumption, were cultiva
as early as 2500 B.C. in Palestine a



ia. The figs, which were found ng on a string or a straw, probably imported from Assyria, where were grown in the gardens of rsabad and elsewhere. The custom ringing figs is very old; they have found in that condition at Tarsus the Middle Bronze Age (1900- B.C.). The prehistoric occurrence uince at Hasanlu seems to be the reported. In view of the close tical and cultural connections be- n Hasanlu and Assyria, as shown eologically and indicated histor- y (although we do not know anlu's ancient name), we may also ulate that in addition to these ts, the gardens of Hasanlu—like e of ninth-century Assyria—may have contained such herbs as , basil, thyme, and fennel, as well arlic, onions, leeks, lentils, beets, lettuce. All of these plants grow ne area today, although none of has been preserved from the h century. A fruit pit and wood ments show that two or more trees the apple, pear, apricot, plum, each group were being grown, al- gh we cannot at the moment ify which. They are all cultivated throughout the general region today.

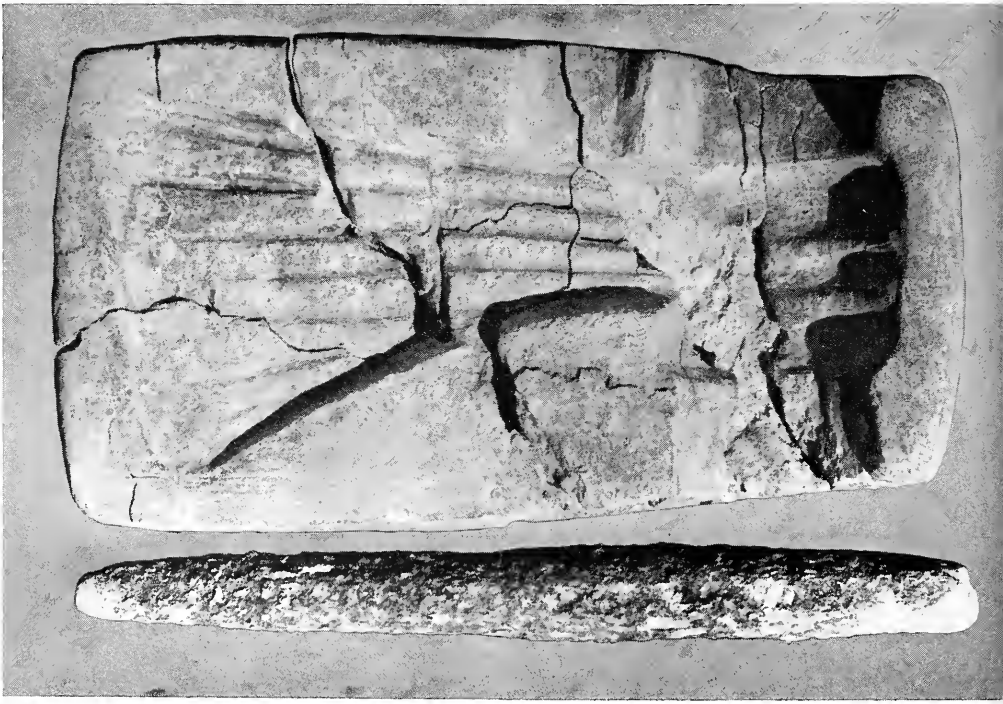
Like the plants, the animal bones recovered from some of the excavations show that the local domestic animals were similar to those of the nearby Assyrians. The identifications of domestic and wild animals must be made by comparing each bone with those of known animals until they can be matched. This is the work of zoologists who specialize in the study of the early stages of still-living species. Dr. Charles A. Reed of Yale University, one of the investigators of the subject in the Near East, has undertaken the task of making the final identifications of some of the Hasanlu bones. As might be expected, the major domestic animals are present—cattle, sheep. goat, and horse. Among the local fauna was boar, as indicated by the tusks that have been found. These animals are still hunted in the area, and in winter come down from the hills to forage in the fields.

ANIMAL bone was used in the manufacture of small artifacts such as buttons or tiny arrowheads for hunting birds or small game. Among other bone objects, the most common are tall, rectangular containers made from long bones and decorated with incised concentric circles. Sometimes they are equipped with four tiny feet on which they stand upright. Unique among the containers is one carved on four sides in low relief with representations of animals and men. The latter are shown drinking—an activity that the local inhabitants obviously enjoyed, to judge by the numerous drinking vessels found. One of these was in the form of a sensitively fashioned horse head of hammered copper. Among the small containers of bone and bronze, some held a powdery gray substance that was analyzed spectroscopically by the University Museum chemist. Eric Parkinson. In each case the major element was lead. In early historic times in the Near East, galena, a form of lead, was used as an eye paint, to ward off disease, and for religious reasons. Powdered antimony was used in the same way. The material was ground up on a small palette and mixed with water or a solution of some water-soluble gum into a paste known as kohl, which was then spread on the eyelid with the finger or a small stick of bone. wood. or ivory. Such a "kohl stick" was found with the carved bone container, showing that the latter was in fact an ancient cosmetic jar.

In addition to using eye paint to enhance their appearance, the Hasanlu people also wore necklaces of metal, stones, and sea shells. The shells, like the plants and animal bones, lead us to our colleagues in natural history, since their identification provides us with a knowledge of habitat. This, in turn, indicates the direction from which the shells have been traded. Dr. R. Tucker Abbott of Philadelphia's Academy of Natural Sciences has made the needed technical identifications. Surprisingly, none of the shells comes from the Caspian Sea, which is less than two hundred miles away. Instead they are from the Red Sea, the Mediterranean Sea (over five hundred miles due west), or from the Persian Gulf (a similar distance south). Among the Mediterranean shells is a "triton" shell, *Charonia variegata* (Lamarck); a "cone" shell, *Conus mediterraneus* Bruguière; and a small spiral shell, *Nassarius gibbosulus* (Linné). Shells of the latter species are fairly common at Ashur, Hasanlu, Tepe Sialk (near Kashan in central Iran), and Tepe Hissar (near Damghan in northeastern Iran). A fourth shell, *Murex brandaris* Linné, is from the rock whelk, which was used by the Phoenicians in the preparation of the famous Tyrian purple dye (NATURAL HISTORY, January, 1964). While great piles of the discarded whelk shells have been found at Sidon near Tyre on the Mediterranean coast, the occurrence of the shell in a necklace at Hasanlu suggests that they were used secondarily for trade. Significantly, perhaps, one necklace at Hasanlu contained only shells from the Red Sea and the Mediterranean, suggesting that the necklace itself, rather than the loose shells, may have been a trade item. The two shells native to the Red Sea—*Engina mendicaria* Linné and *Columbella fulgurans* Lamarck—most probably followed the established overland trade route through Palestine and Syria to Assyria and Iran along with the Mediterranean shells.

By far the most common shells were those found in the Red Sea and Persian Gulf, and in the Indian Ocean. No doubt they were traded along the main routes up the Tigris and Euphrates rivers to Assyria and thence overla
to Hasanlu and points east. A toc
shell; a conch shell (*Strombus decor*
subsp. *persicus* Swainson); an *Oli*
shell; and several others (*Nerita pol*
Linné, *Conus ebraeus* Linné, *Charor*
tritonis Linné, and *Murex virgine*
Röding) complete the list. Two mari
bivalves (*Crassitella* sp. and *Gly*
meris sp.) were also found, alo
with a snail (*Clanculus pharaon*
Linné) native to the coast of Arab
These shells are combined on some
the necklaces with shells from t
Mediterranean, indicating that th
were either traded separately at tin
or else were restrung either in Assy
or at Hasanlu.

THE contribution of malacology
archeology does not end w
the identification of sea shells, f
among the excavated remains the
were also shells of fresh-water muss
and land snails. These belong to t
species, both of which are found fr
the northwestern corner of Ir
through Turkey. The snail is *He*



**MOLDS for bronze casting were eitl
open faced or double. Half of a doul
mold for ax and bronze ingot are show**

CAST COPPER basin handle in the shape of a bird was cleaned electrolytically.

ANALYSIS of iron dagger blade, *right*, showed that technically it is steel.

MACEHEAD, broken open, shows mold on inner surface. Shaft fitted in hole.

ılina Rossmässler, and the fresh-
er mussel is *Unio durieui* De-
yes. The clam shells occur rather
ely, but the snail, which is edible,
urs in large quantities, showing
it formed a part of the local diet.
hells were not the only imports
n far away. Ivory was used in small
ntities for plaques carved in low
ef or for parts of figures carved in
round. While there is the possibil-
that the raw ivory may have been
orted from Pakistan across Iran—
more likely, via the Persian Gulf—
e is an equal possibility that it
e from Syria, where elephants in-
ited the upper Euphrates Valley
l they disappeared about the sev-
century B.C.
he ivory plaques probably formed
sides of small boxes, which were
rated with scenes representing the
l inhabitants. The figures shown
he plaques and on other objects
Hasanlu wear knee-length tunics
ned at the waist with a belt. Some
ese costumes were of leather (two
ments have been identified chemi-
) and others were of woven tex-
. Charred patches of textile have
recovered and examined by
old Burnam of the Textile Depart-
t of the Royal Ontario Museum.
combed yarn was made from wool
ohair and used in the making of
th of tabby construction—a weav-
method in which the warp and
threads pass over each other al-
ately. Most of the pieces exhibit
ft-faced tabby weave in which the
ds of the weft are tightly packed
obscure those of the warp. In
instances, the surface of the cloth
vered with a pile or fringe. On
specimen, the pile was in the form
oops made in a technique pre-
sly known only later in Coptic
t. Sometimes the pile is as much
ree centimeters long.

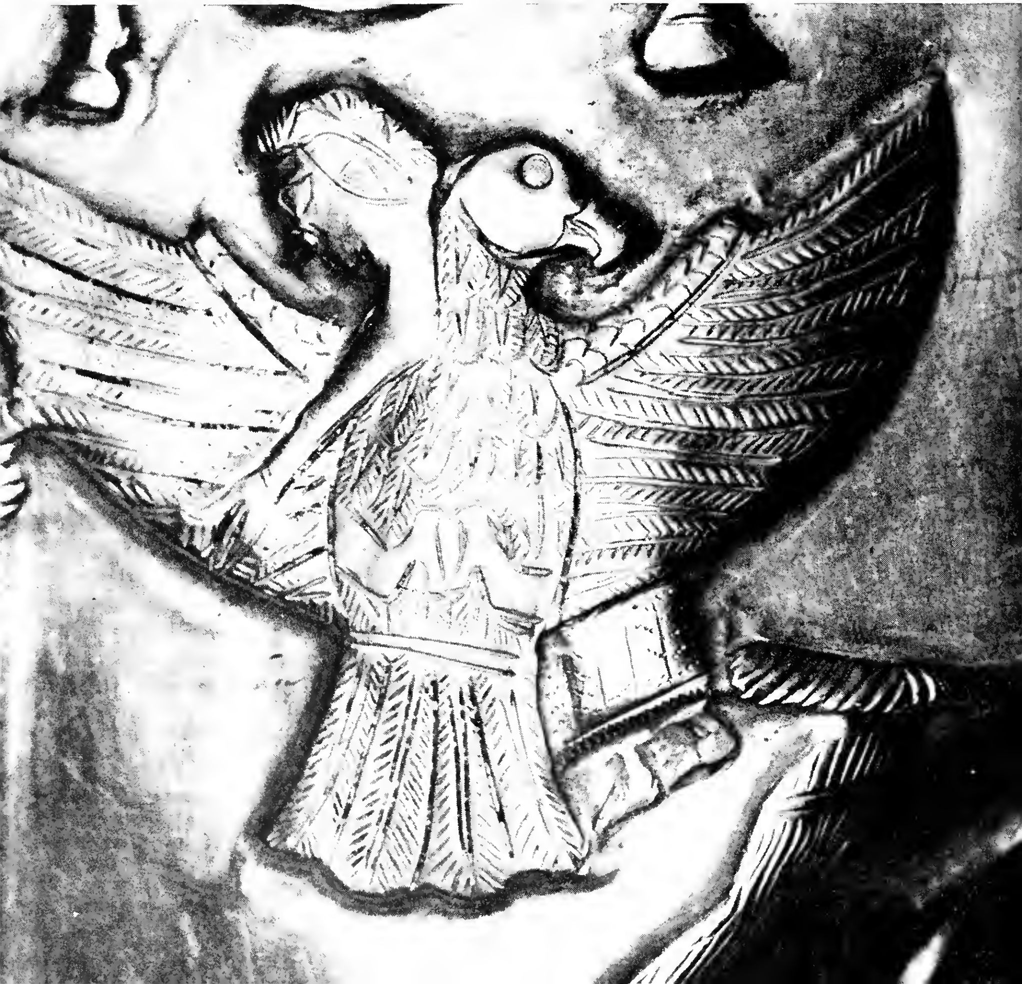
OTHER fragment preserves the
sewed joining of two selvages.
another, embedded in clay, shows
ants of some red coloring. (Red,
y be noted, was a prominent color
e cloth looted from Musasir by
on.) Even three balls of yarn
d up. The discovery of these tex-
fragments is a unique event in
ian prehistory, as no other sites
produced actual fabrics beyond
mpressions in verdigris found on
pieces of prehistoric copper at
and Tepe Sialk. The earliest historic textile found at Susa dates to the sixth century B.C. Unfortunately, no information as to the type of loom is indicated by the cloth, but the discovery of over a dozen doughnut-shaped clay weights and other weights of stone suggests the use of a vertical loom in which the bottom of the warp was held down by weights. Should this prove to be the case, it may be a point of considerable interest, because such looms were used in this period by Halstatt Iron Age people in central Europe and by the Greeks. Since related tribes speaking Indo-European languages were entering Iran at this time, there is the possibility that they may have introduced this type of loom.

Besides the wool and mohair materials, several woven bits were made

from a bast fiber of some kind—pro
ably hemp, clearly not flax. This ba
fiber was also used to make weft-fac
tabby cloth, but in at least two i
stances it is found as the thread
which beads were strung. It also w
used for woven belts, as shown by i
pressions preserved on the corrod
surface of a copper belt plaque. Sor
species of grass was also employed
make the rope that was used to li
the inside and the outer edge of
copper helmet.

The copper used in the helmet w
one of a variety of metals recover
at Hasanlu. Others were antimor
lead, silver, bronze, iron, and gold. T
variety is not surprising, in view of t
fact that lead, silver, copper, and ir
occur together at Mount Sahand
the east shore of Lake Urmia abo

OXIDES now replace the once-solid iron in plaque decorated with winged horse.



CHASING and *repoussé*, as in Hasanlu bowl detail, were common in goldwork.

miles northeast of Hasanlu, in the
ri Mountains about a hundred
northwest between Lake Urmia
Lake Van, and around the head-
rs of the Diyala River, about a
red miles south. Additional metal
es lay around the upper reaches
e Tigris River in Turkey and the
River in Transcaucasia. Thus,
y lines existed both locally and
gh the great countries of Assyria
Urartu. An additional source of
iony lay southeast at Takht-i-
man in what is now Afshar Prov-
of Iran. Little field work has yet
done in search of mines and struc-
associated with these early ore
es, and almost no scientific
ses have been made of the local
amples for comparison with ex-
ed metal objects. When this work
een done, it may be possible to
int the sources of these metals
precisely.

E presence of pure antimony at
asanlu in the form of cast but-
surprised us. At first sight, they
r to be hammered native silver,
was only by means of the spec-
pe that their true nature was
ered. Probably they represent
ts from Transcaucasia, for ob-
nade of antimony were common
t area in the ninth century, but
oddities elsewhere in almost all
ls. Certain of the bronze weapons
es and daggers—also suggest
t with this area. Like antimony,
vas imported. Part of it, at least,
iave come from Zenjan, east of
lu, for many gold objects have
excavated in the mountains be-
that city and the Caspian Sea,
ome are closely related stylisti-
o objects at Hasanlu. The docu-
tion of gold at Hasanlu is a great
tage to us, because it provides
es of known age and archeologi-
ntext in Iran. Modern forgeries
nian gold antiquities have been
blem for museums for many
but there has been no known
d of checking the authenticity of
eces objectively. It has been gen-
accepted that gold, essentially an
metal, does not change signifi-
over the years. This conclusion
t altogether certain, however,
it remains to be tested in the
of the new methods of investiga-
eveloped by modern chemistry
hysics. Several pieces of gold of
ent known ages, including some
from Hasanlu, were photographed under the electron microscope by Mrs. Althea Revere of Vineyard Haven, Martha's Vineyard, Massachusetts. In the photographs, the outlines of various shapes, the bodies of which have the same light color as the background, may be seen. Mrs. Revere believes that these predominantly octahedral forms may be an indication of the antiquity of the object, as they were not seen in the one modern object studied. Whether these shapes are to be explained in this way is not yet clear; at present they simply represent an unexplained phenomenon.

Additional gold objects documented to different periods, and some of those photographed by Mrs. Revere, are now being studied by Dr. P. Hornblower at the Research Laboratory for Archaeology and the History of Art at Oxford University, with an electron probe analyzer. This is a specialized instrument that scans cross-sections of the gold objects. It is hoped that it may be possible to detect some evidence of change in the region of impurities in the gold's outer surfaces. This might appear as a purer gold content near the surface because of the disappearance of less stable impurities. The question is unanswered, but holds some promise for the future.

Among the problems presented by the Hasanlu metal objects is that of discovering the use to which some of them were put. Take, for example, a group of bronze objects that are commonly called maceheads, but which are sometimes also referred to as end pieces for furniture legs. These occur in several forms. Often they look like a ball set on a short tube. Sometimes the ball is replaced by the many projecting points of a star. The latter form is certainly a true macehead, for one example has been found with the impression of its wooden handle still intact. The ball-shaped forms are, however, more problematical. Tubes of several of these were filled with a powdery gray substance, which, upon analysis, proved to be powdered lead—just as in the case of the bone containers. The powder filled the hollow central tube, which, in the case of the star-shaped mace, was the socket for the wooden handle.

These ball-shaped forms were further shown to be containers rather than maceheads when one of them was found with a small wooden plug still in position at one end of the tube. Lying between the central opening into which the lead powder was packed and the bronze outer surface of the ball was a gray-buff clay core left inside from the casting, and consisting of aluminum, silica, and other elements. Clearly these were used as kohl jars and not as maceheads or furniture attachments.

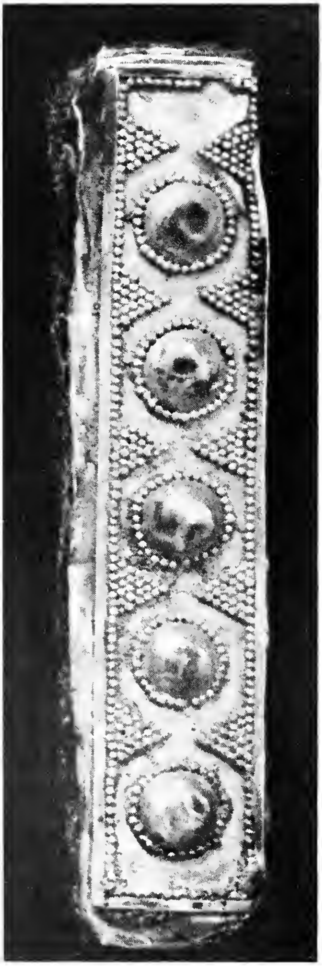
Knife haft is adorned in cloisonné, using gold strips and inlays of stone.

Another problem involves the difficulty of uncovering sufficient surface of badly corroded objects to reconstruct their original appearance. It is possible to pick up some of the lines or raised surfaces by brushing the corrosion lightly to remove the dust and loose particles, and by then observing them in light directed at different angles. This examination may be aided on occasion by the use of an X-ray, a technique used on several Hasanlu pieces by Drs. Madden and Parthe of the School of Metallurgical Engineering at the University of Pennsylvania. By combining visual and X-ray information, partial reconstructions have been possible, as in the case of a hammered copper plaque from a box found crushed on the floor of the pillared hall in Burned Building III at Hasanlu. The plaque represents archers defending a fortified wall from its towers. The fortification bears a striking resemblance to the wall surrounding the Citadel at Hasanlu and recalls Urartian towers seen on the Balawat gates. Where the corrosion is not too advanced the metal can be cleaned successfully by soaking it in constantly changing distilled water over long periods. Unfortunately, such treatment is not always possible. Cast bronze fares better in this respect than thin, hammered. copper sheet metal, which is highly vulnerable to corrosion and is often not solid when found.

OBJECTS of iron are even more vulnerable to destructive forces of weathering. The ninth century B.C. marks the high point of the early Iron Age in this part of Iran, and many tools and weapons were made of the material. When excavated, they are all too often simply a pile of rust maintaining a semblance of the original shape (what metallurgists call a "pseudomorph") but little else. Some pieces can be prevented from falling apart if they are first impregnated with polyvinyl and then removed from the ground, but none of these any longer contains a core of solid iron. Consequently, no amount of cleaning aw
of the corrosive products will rev
any original metal forms within
mass of iron oxide; so we must
satisfied to observe what we can vi
ally, as in the case of the winged ho
plaque shown here. An X-ray reve
only that there are a number of ho
around the outer rim, probably us
to attach the object to some backi
material. In spite of the disappearan
of the core metal, some technical d
can be obtained, as the work carr
out on an iron dagger blade by
Reed Knox, Jr., of the University
Pennsylvania School of Engineerin
has recently proved. A cross-secti
was cut from the end of the brok
blade, was mounted on Lucite, groun
and polished. It was then possible
study the structure, which include
few tiny particles of metal in ox
matrix. The particles proved to be
typical high-carbon steel with a f
lamellar structure called pearlite. T
ghost of some of the structure
mained in the oxide after the ir
itself had disappeared. The stu
showed that the blade had been fa
ricated by hammering, and that it h
been cooled at a slow rate from a hi
temperature. According to Dr. Cy
Smith of M.I.T., the bronze hilt h
been cast onto the tang of the ir
blade, for some of the bronze had r
into a seam in the iron. This casting-
technique was also used in the man
facture of some Luristan bronze a
iron daggers. Whether the producti
of a high-carbon steel was intentio
will be better known when other spe
mens are studied. What is shown
the first time by this particular analy
is, as Knox points out, that "it is p
sible to distinguish ancient wrou
iron from steel by metallurgi
means, although all metal has be
converted to oxide."

Thus, modern techniques of analy
and modern knowledge of natural h
tory are able, by working in tand
with the archeological spade, to bri
new perspective to natural histo
and to the history of technolo
Together they begin to reveal son
thing of the "heaped up treasures"
which Sargon spoke; treasures of
field of knowledge infinitely rich
than even he could ever have imagin

CARVED BONE cosmetic box has a small hole at base for one of two pegs that held bottom of the container in place.



GOLD GRANULATION decorated edge of $1\frac{1}{2}$-inch limestone square with an agate set in its surface. Its use is unknown.

HAMMERED SILVER beaker has rais
electrum-overlaid figures. Impressi
of textile shows on corroded surfa

Rarely Seen Songbirds of Peru's High Andes

By WILLIAM G. GEORGE

THE Peruvian Andes look as forbidding as they ever have, I suppose, but this is offset today by roads that cross the river canyons, scale the cliffs, and traverse the ridges. Not long ago I traveled upward by car into the highest habitats of the Andean avifauna, and for nine months easily scouted through regions that the early naturalists had to labor hard even to reach.

Some of the tanagers, honeycreepers, and finches that occupy the brush and woodlands of the Peruvian cordilleras rank among the least known of South American birds. Their nests, eggs, and life histories still remain unreported, and their distribution and seasonal movements have yet to be fully worked out. Furthermore, many unanswered questions exist concerning the degree of relationship that the various species have to each other within the songbird assemblage to which they belong, the American Nine-primaried Oscines (NATURAL HISTORY, February, 1963).

The South American members of this group, numbering about 500 living species, include principally the vireos, wood warblers, blackbirds, orioles, and the already mentioned honeycreepers, tanagers, and finches. One of the least typical is the Giant Conebill, *Oreomanes fraseri.* I found it a common bird at about 13,000 feet in the Department of Puno, along the road from Nuñoa to Macusani. There the road climbs a grassy ridge and enters a rich, parklike woodland that seems misplaced at that altitude and in that region. The trees in this area are *Polylepis.* They are 40 feet or less in height and have a peculiar bark, rather like that of shagbark hickory, consisting of paper-thin layers that tend to separate, peel, curl, and flap noisily in the continuous wind.

IN appearance, size, and habits, the Giant Conebill generally parallels the Sittidae, or nuthatches—a family of holarctic songbirds that does not reach South America. It feeds in the bark and less often works among the leaves. It crawls over the trunks and larger branches, but never descends face downward or delivers group contact and foraging calls, as do nuthatches. It searches for insects by using its long bill both as a probe and as pliers to grip the sheets of bark and wrench them away. This operation produces splintering sounds and tugging movements that merge with the rustling of the wind-blown bark. Because the outer bark surfaces are cinnamon-colored like the conebill's underside, and the inner bark surfaces are bluish gray like the conebill's back, the bird is so well camouflaged that it ranks high among species that provide support for the theory of protective coloration in animals.

The bird seems to be confined to *Polylepis* and to prefer the most luxuriant growths. On the other hand, the bird also occurs in the impoverished *Polylepis* that grow as mere bushes on many of the dry western slopes of the Andes. This is a recent discovery, and one that indicates the species may well be found in places beyond its present recorded range. The bird heretofore has been known onl from the eastern Andean slope from Bolivia to Colombi I suspect it will soon be found in northwestern Chile, for encountered a specimen in stunted *Polylepis* of the weste sierra above Tacna, not far from the Peruvian-Chilean bo der, across which *Polylepis* woodlands presumably exten

The mating of the Nuñoa population was in progress c October 19, 1962. The males were chasing and were singir from their treetop perches a high-pitched, plaintive, ar monotonous "ssit, ssit, ssit," or "sseet, sseet, sseet." Whe I returned to the site on November 30, small mixed flocl of adults, immatures, and a few juveniles were preser As the conebill painting shows, the juveniles have odd streaked and spotted breasts, a characteristic of some juv niles of another and better-known bird of the tempera zone of Peru, the Coal-black Flower-piercer, *Diglossa ca bonaria.* This may indicate, in combination with certa technical data, a near relationship of the two species.

In the Department of Cuzco, northeast of Nuñoa, tl Chestnut-belted Finch, *Poospizopsis caesar*, inhabits wide spaced brush thickets in steep ravines among the stark hil above Paucartambo. It is a Peruvian endemic of narro distribution and of wild habit. They fly from their thicke instantly on sighting a human being; after spanning se eral hundred yards they plunge into another thicket ar vanish. The juveniles, which I saw being fed by adults c December 9, flew off as quickly as the adults.

The Tit-like Dacnis, *Xenodacnis parina,* is another P ruvian endemic, and clearly an aberrant form. Its princ pal habitat may be *Gynoxis*, a soft-leaved shrub. On tl western slope of the great mountain Picchupicchu, *Gynox* grows immediately below the lowest limits of *Polylep* brush. Almost silvery in appearance because of its pall gray leaves, and standing about eight feet in height, forms a conspicuous zone that can be easily spotted agair its background of dark soil and brown rocks.

Numerous Tit-like Dacnis' were present in the *Gyno* on Picchupicchu from December 21 to January 24. The breeding season had ended prior to the December date, a the entire population, adults and immatures alike (I s no juveniles), were still undergoing the post-breeding mc They moved in small groups among the bushes in t

Illustrations by Arthur Singer


Dubusia taeniata
Delothraupis
Poospizopsis
Arthur Singer

ines, feeding on insects down in the maze of bare, col- ral stems that together emerge from the earth in the e of a main stem. When disturbed, the birds seemed ctant to abandon one ravine in favor of another; they ld simply slip out of view or fly within the ravine for a rt distance. They have a low, deft, and effortless style of it, and even as they launch themselves suddenly out of ish they are strikingly graceful. None of them emitted notes at any time when I was in the area.

enodacnis is one of those "problem" genera that per- the taxonomist. Alone of the American Nine-primaried ines it has the bill of a titmouse. Its tongue refinements, to some extent its feeding behavior, also parallel those ie titmice, or Paridae, a northern family that does not ge into South America and with which *Xenodacnis* es relatively few significant traits. For example, titmice ten primaries in the wing while *Xenodacnis* has nine, there are other important anatomical disjunctions be- n them. Nevertheless, *Xenodacnis* merits the name nouse-like." Accordingly, it provides, as does the Giant ebill, an example of a neotropical songbird that has iired several characteristics of holarctic songbirds from h it is genetically distinct. The problem is, which genus ie assemblage of nine-primaried songbirds may be its est kin? There are four possibilities. The first is *Dacnis*, nus of honeycreepers, the males of which exhibit blue ieir plumage. But the bills of all *Dacnis* are sharp and rved, and their tongues are highly modified for suck- nectar; furthermore, the female plumage of none of i is like that of *Xenodacnis*. Traditionally, it is true, nomists have aligned *Xenodacnis* with *Dacnis*, having guided less by any biological similarity of the species, spect, than by the occurrence of the term dacnis in generic names. This nomenclatorial convergence tends nply close relationships of the species; but the names coined in 1817 and 1873, during the period of explora- when Andean birds were relatively unknown.

HE second and third possibilities lie within the blue buntings of the genera *Passerina* and *Cyanocompsa*, within the finches of the genus *Catamenia*. The males ese species are totally or partly deep blue or slaty-blue, some of the females have tawny-brownish underparts the female of *Xenodacnis*. However, the buntings and ies are seed-feeders and have tough, thick-walled stom- adapted for grinding harsh foods; so, to a large ex- do insectivorous species, for the chitinous parts of prey must be mashed during digestion. *Xenodacnis* isectivorous, yet it has a relatively tiny, thin-walled ach, scarcely better developed than the stomachs of ir-feeders. The hint in this seems unmistakable: *Xeno- is* probably stemmed from a honeycreeper line, and ibly from the same one as *Dacnis* after all.

ie fourth near relative is another honeycreeper genus, *rostrum*. These are small, warbler-like species that be considered because they possess among them a spectrum of plumage features that more or less agree some of those of *Xenodacnis*. To be honest about it, , one has to admit that the Tit-like Dacnis is a species may agitate taxonomists for many years to come.

found the rest of the birds portrayed in the paintings ie of the richest birding areas in Peru—the Hacienda aynioc, within the Department of Junin. To reach it, must travel from Palca on a road that is a mere twenty (mainly vertical) kilometers in length. After leaving the eastern outskirts of Palca, the road more or less soars over a series of grassy slopes of the temperate zone. Ultimately it crests among clumps of large, lichen-clad bushes, descends into and out of the hacienda village, and enters a valley. It ends at 11,000 feet on a ridge overlooking a river canyon choked with a lush forest of temperate and humid-temperate trees that eventually mix far below with the upper level of the subtropical vegetation.

The abundance of birds during late May, both within the forest and on its brushy outskirts, was unlike anything I had seen before. In a tropical habitat it is the insects that quicken the awareness of teeming life. At Maraynioc that awareness comes from the birds, and especially from hummingbirds like the Sparkling Violet-ear *(Colibri coruscans)* and the giant Sapphire-wing *(Pterophanes cyanoptera)*. The conspicuous Trochilidae tend to eclipse the activities of the many shyer species. The Chestnut-bellied Tanager, *Delothraupis castaneoventris*, and the Buff-breasted Mountain Tanager, *Dubusia taeniata*, were both quiet and timid. They fed on insects and buds on the brushy hillsides, frequenting a small tree named *Hesperomeles*.

The morning sky was usually clear and blue at Maraynioc, but as each day wore on mist would begin to gather far down in the subtropical valley of Chanchamayo. By early afternoon it rose through the river canyon, drenching the forest and turning out hordes of gnats. Thrushes, honeycreepers, wrens, hummingbirds, finches, flycatchers, and some tanagers—among them the Chestnut-bellied—then leaped out of the *Hesperomeles* to fly, bills snapping, through the gnat swarms. This, as much as the mist itself, signaled the approach of dusk and a night of dankness.

The Grass Green Tanager, *Chlorornis reifferii;* the Yellow-naped Tanager, *Iridosornis reinhardti;* and the Hooded Mountain Tanager, *Buthraupis montana*—the largest of all the tanagers—stayed within the high foliage of the humid temperate forest, foraging together in wandering bands. The sound of bustling and twig snapping sounded from wherever they fed, and entire sprays of leaves tumbled down at the same time, yet the birds were difficult to see.

The forest at Maraynioc remains unspoiled. The owner of the hacienda discourages visitors, and the forest itself has discouraged the zeal of the lumbering interests in Peru. As a result, this gloomy and moist birding heaven, which clings to extraordinarily steep rock walls, seems today to be little threatened by the encroachments of civilization.

Topographic maps portray works of man and natur

Mapping the Surface of the Earth

By Morris M. Thompson
and Julius L. Speert

Everyone is familiar with maps of one sort or another, most of which depict the activities, works, or history of man but tell little, if anything, about the natural world he lives in. An important exception is the topographic map.

A topographic map is a graphic representation of the physical features of a portion of the earth's surface, plotted to scale on a flat sheet. It depicts relief, water features, vegetation, and the works of man, thereby portraying the cumulative effects of the forces of nature and man.

Because they literally picture the face of the earth, topographic maps are used mainly in applications related to surface features. Perhaps the most important and best-known uses are in the fields of engineering and economic development. In hydraulic engineering, including flood control, water-power development, irrigation, water supply, and the design of dams and reservoirs, topographic maps are a prime necessity, for they show in detail the characteristics of the drainage basins involved. Highways, railroads, power lines, sewers, and other arteries cannot be planned economically and safely without precise knowledge of the terrain, most readily obtained from topographic maps.

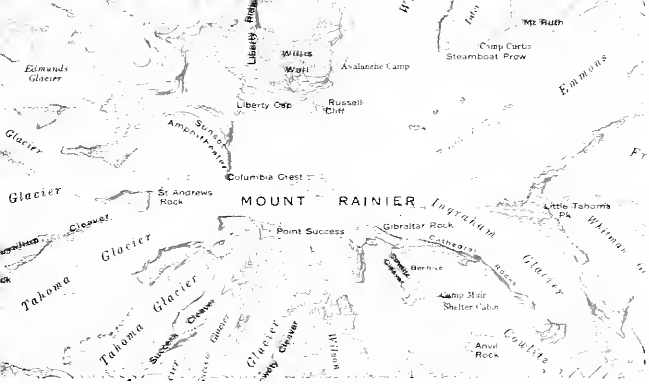
In many instances, a real-estate subdivision, including its lots, streets, sewers, and other utilities, is first laid out on a topographic map. A manufacturing concern seeking a site for a new factory is apt to study numerous topographic quadrangle maps to find a location near water, transportation routes, power supplies, raw materials, labor supply, and its potential markets. The list of uses in civic, economic, and in industrial development could be extended indefinitely, but we mean to focus our attention on the use of topographic maps in studying natural features.

Perhaps the most popular use of such maps among nature enthusiasts is in the planning of outdoor recreation. Because the topographic map shows woodland, trails, streams, and hills, it is ideal for planning hikes: hunting, fishing, and camping trips; and similar excursions. From the community point of view, the topographic map is a prerequisite to the planning and construction of parks, playgrounds, natural-state reservations, and wildlife refuges.

The information shown on topographic maps generally falls into the following four distinct categories: hypsographic, hydrographic, woodland, and culture.

Hypsographic, or relief, features of a map are normally printed in brown, and the usual method of showing relief is by means of contours. A contour is an imaginary line on the ground, all points of which are at the same elevation, or height, above a horizontal reference datum, usually mean sea level. Thus, the shoreline of a quiescent pond or lake is, in effect, a contour. Lines drawn on the map to represent the contours are contour lines, but are frequently called contours, for short. If you envision a hilltop sliced off by a horizontal plane, the perimeter of the slice is a contour. Picture, now, another horizontal slice twenty feet below the first, then another, and another, and so on. The perimeter of each slice would determine a contour line on the map. With the slices twenty feet apart vertically, we have set a contour interval of twenty feet.

If the ground is steeply sloping, the contour lines will be close to-



Topographic map shows crater of an inactive volcano as well as numerous glaciers emanating from Mount Rainier.

Landscape of Mount Rainier was made from northeast at sunrise. At left of Columbia Crest is the Gibraltar Rock.

gether; if it is gently sloping or almost flat ground, the contours will be widely spaced. Thus we can determine the slope of the ground by the spacing of the contour lines. If the ground is so steep that the contours would be crowded on the map, we must use a larger contour interval to allow more room between them. Similarly, if we double the scale of the map we automatically spread the contour spacing and can use a smaller contour interval without crowding. In practice, the interval selected is that which can best portray the character of the terrain at map scale without undue crowding.

CONTOURS on a map would have little meaning unless they could be identified. Therefore it is customary to emphasize every fifth contour and to label these "index" contours with their elevation. Then, to read the height of any point on the map, the heights of the adjoining contours are determined by counting the number of contour intervals from the nearest labeled contours, and the height of the point is interpolated by estimating its relative distance from the two adjoining contours. With a little practice this can be done accurately.

Much can be learned about an area from a study of its contour map. If the ground has a uniform, steady slope, the contours will be equally spaced. If the country is rough, this will be reflected in the irregularity of the contours. Some common topographic features are shown in the illustration comparing a perspective drawing with a topographic map *(bottom, right)*. Note how easily each feature can be recognized from the shapes of the contours.

In multicolored renderings of the maps, hydrographic, or water, features are usually printed in blue. These include oceans, lakes, rivers, streams, glaciers, canals, and swamps. As the level of the ocean is usually the reference datum for elevation, its shoreline is, except for minor technical refinements, the zero contour. Since rivers and streams run downhill from their source, they must cross all contours between source and mouth. Note
on the illustrations *(right)* how t
shape of the contours clearly indicat
the location of a watercourse or na
ural drain. Canals are characteriz
by their straight lines, a condition n
usual in natural watercourses, and
the fact that they usually run near
parallel to the contours instead
crossing them, as streams do. Swam
occur in flatland that is poor
drained, and are shown by speci
symbols. Glaciers appear on mou
tain slopes, with their surface defin
by blue contours.

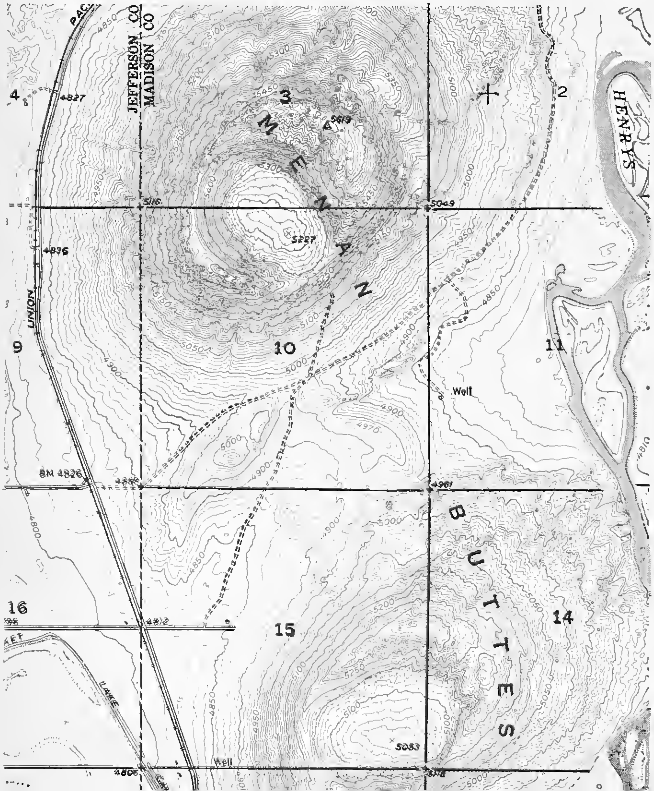
Woodland is shown on maps by
green overprint. Special symbols a
used to portray orchards, vineyard
and other distinct types of vegetatio

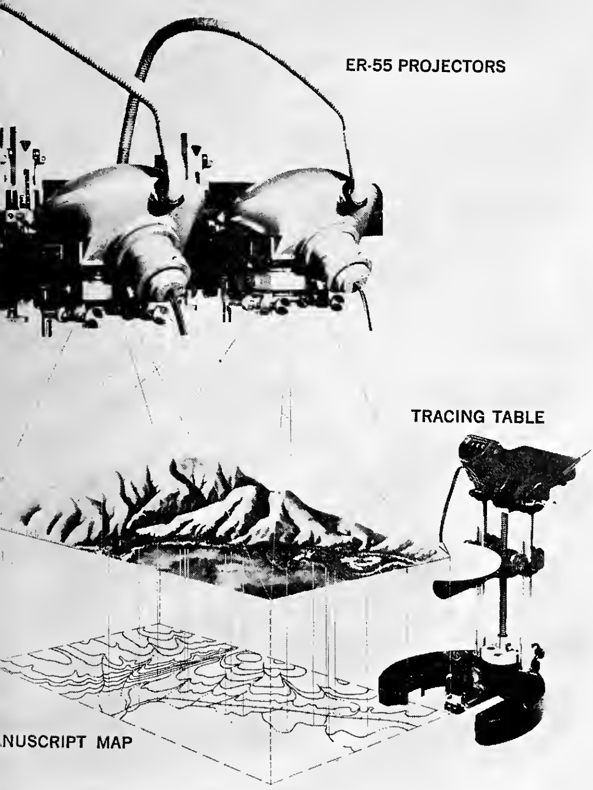
Culture is the name given to t
works of man that are shown on top
graphic maps. This category includ
all types of construction, roads, ra
roads, political boundaries, and pla
names. They are usually printed
black, but red is also used to he
classify certain types of highways ar
boundary lines. If all the building
in heavily built-up areas were show
such areas would appear almost so
idly black. To avoid this, built-u
urban areas are shown by a screene
red overprint, with the street patte
fully developed, and all houses
the area are omitted except landma
buildings, such as public building
schools, and churches.

Most people tend to take the su
face of the earth for granted. It wa
here when we arrived, we expect
leave it here when we depart, and w
are unable to notice any significa
changes in it during our stay. Th
study of geology teaches us, howeve
that the earth's surface is not stabl
It is undergoing constant chang
under the influence of all of the force
of nature, both from within the eart
and from without. Some of the inte
nal forces act so slowly as to be u
noticeable except to the expert. The
account for the gradual rising or se
tling of continents and of the ocea
floor. Other internal forces, such a
earthquakes and volcanic eruption
produce such sudden and catastrophi
changes that they are abundantly ap
parent. Many of our great valleys an
mountain ranges have been forme
during a shrinking of the earth's crus
in much the same way that the surfac
of a prune becomes wrinkled as th
plump, fresh fruit is dried.

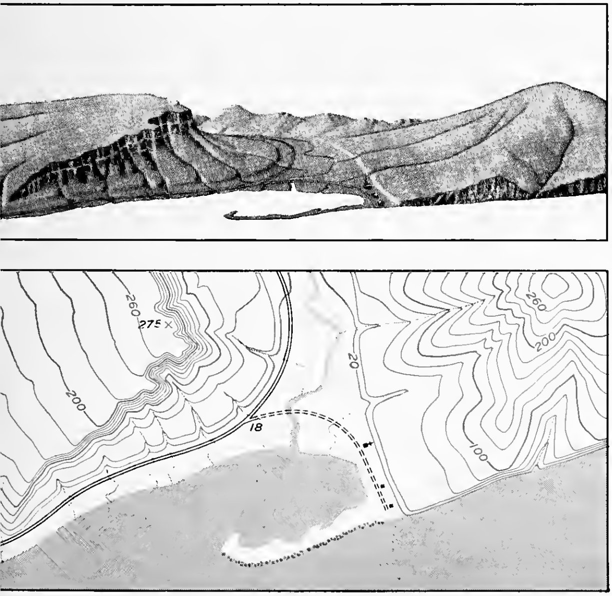
But while powerful forces are work
ing from within to change the face o

MENAN BUTTES, in Idaho, are really volcanic cinder cones. Large craters are indicated by depression contours.





ED AERIAL PHOTOS are projected rm optical model of terrain on ng table, permitting operator to convert 3-D image to topographic map. *Below*, sketch of river valley, bay, and hooked sand bar is compared to a map.



the earth, equally powerful but more subtle forces are working from without to sculpt the surface into the various features that are so familiar to us. These external forces include wind, sun, rain, frost, rivers, ocean waves, glaciers, and vegetation. Each operates in its own way, alone or in conjunction with others, and forms features characteristic of its powers. Some of these forces and surface features they create, which show on topographic maps, are discussed below.

Action of rivers: Rivers work in two principal ways to change the face of the earth. Together with freshly fallen rain, the rivers and streams scour the surface of the earth and the river beds; they undercut riverbanks and carry away soil. Later, when the water is no longer able to carry the load, it deposits the sediment on flood plains, deltas, or alluvial fans.

Glacial erosion: The work of glaciers in some respects resembles that of rivers; glaciers erode the earth along their path, carry the load a distance, and drop it as the leading face melts and recedes. The typical products of glacial erosion, such as cirques, drumlins, and eskers, are readily identified on topographic maps.

Work of the wind: Wind sculpture is most evident in areas of sparse vegetation. Its handiwork is easily recognized in such features as barkhans and dune ridges.

Coastal formations: Tides, waves, and ocean currents produce characteristic patterns along the coastlines in the form of barrier beaches, hooks, spits, and other features.

Volcanic physiography: The characteristic shape of a volcanic cone and its crater are easily recognized on a topographic map *(opposite page)*.

Influence of vegetation: The effect of vegetation on physiography is less obvious than that of the principal erosive forces—wind and water. It is mostly protective; it tends to retard the erosive action of the others. But since vegetation requires a favorable combination of moisture and temperature, there are regions where trees do not grow, either because of lack of water or because of low average temperatures at high altitudes and at high latitudes. The timber line, beyond which trees are scarce, is often well defined on topographic maps. By the same token, tree growth is likely to be more lavish where there is ample water and where temperatures are favorable. Thus we often find that growth is denser and the trees are larger along watercourses than in the surrounding countryside.

Considering the vast amount of information involved, the reader may well wonder how topographic maps are made. Prior to the modern age of mechanization and automation, say thirty or forty years ago, practically the entire process was done in the field. The principal tools, still used extensively today, were the plane table (a drawing board supported on a tripod) and an alidade (a sighting telescope fastened to a flat base with a straightedge for drawing lines on the map manuscript). In addition, theodolites and transits (for measuring angles), steel tapes and stadia rods (for measuring distances), and levels and level rods (for measuring elevations) were used for control surveys.

The topographer reached the area to be mapped by the best transportation available to him. From then on it was his responsibility to cover the ground—on horseback, by canoe, on foot, or by whatever combination of facilities he could manage—as best he could, carrying his equipment. Even when the automobile arrived on the scene, many of the areas to be mapped were far removed from passable highways, and much of the country still had to be covered by the more primitive means of transportation.

The season's work would be started with a clean sheet of map manuscript paper on the plane table. On this would be plotted a projection graticule (network) of parallels and meridians (latitude and longitude) to contain the area. Then any control stations previously established by control surveys would be plotted in correct position with respect to the projection lines. At this point, the topographer was ready for the field. All too often he was also the control surveyor, and the two operations overlapped.

With the plane table set up on a high vantage point, a large expanse of ground could be surveyed. Distant points were located and plotted on the manuscript by triangulation, intersection, and resection techniques. Elevations of points were computed from vertical-angle measurements with the alidade. Contours were sketched to fit the measured elevations while the topographer studied the actual shape of the ground. Drainage was located and plotted, and cultural features were added to the map. By diligent search for ground evidence and legal records, and extensive inquiry of local residents, information was obtained on political boundaries, names, and other essential map data.

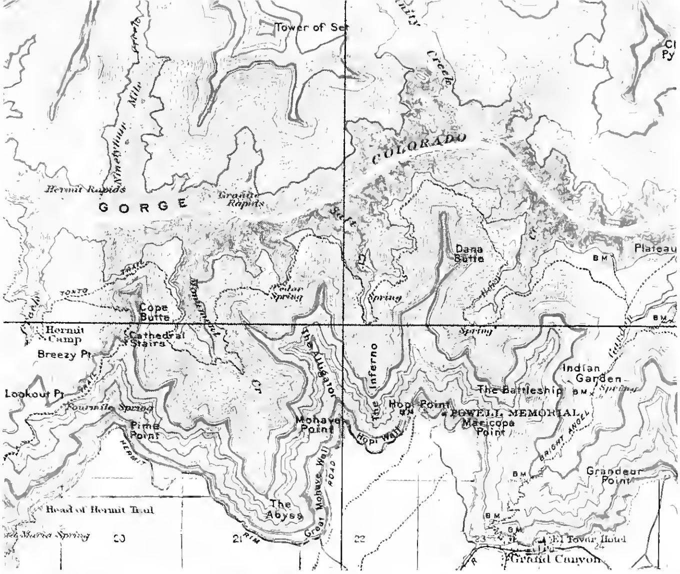
With all available field information assembled, the map manuscript was brought into the headquarters office for fine drafting and reproduction. Thus another topographic quadrangle map was born.

With the advent of modern aircraft, precision aerial cameras, and related plotting equipment, a new era developed in map making. No longer does the topographer cover the ground on foot or on horseback, sketching as he goes. No longer is he severely restricted by short working seasons or adverse weather. Through the eye of the aerial camera, his vantage point has been moved from the hilltop to a point thousands of feet above the ground. He can now see both sides of the distant mountain range instead of only the near side. He can study the photographs in comfort in an air-conditioned laboratory and measure the ground surface with greater speed
and economy than was possible befo
By studying the pictures in ov
lapping pairs through an optical s
tem in which the left eye sees one p
ture and the right eye sees the oth
he can get a three-dimensional opti
model and see and measure the rel
in fine detail. In fact, the view av
able in the stereoscopic model (*p*
31, top) is superior in almost all
spects to that observed from
ground stations.

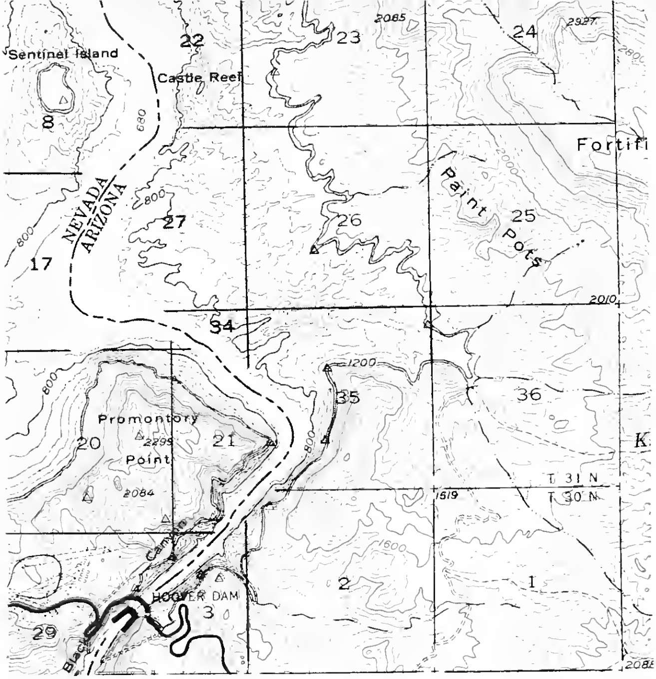
The viewing system contains
"floating dot" or similar dev
that can be raised or lowered by
operator to keep it "on the grour
as it is moved over the model. A per
moves over the map manuscript
trace the path of the dot over
model. Thus the photogrammet
traces roads and streams, buildin
forests, and other details. By movi
the floating dot along the ground
a constant height above sea level,
traces a contour on the model and
the map. For the next contour he me
ly raises or lowers the dot by one c
tour interval and repeats the proce
Nevertheless, field work has
been completely eliminated. To ma
tain correct scale, position, a

TIME TOPOGRAPHER worked with an
ide and a plane table, *left,* which
acked with supplies to survey site.

NITE GORGE, Grand Canyon, *right,*
mapped at turn of century. Tinted
l corresponds to air view, *below.*



AL PHOTO shows fidelity of map.
rado River scoured the mile-deep
e. Dense map contours are cliffs.



HOOVER DAM, lower left, *above*, is shown in enlargement of small part of topographic map. Surveys before flooding yielded submerged contours.

orientation of the map and of ea
stereo model used to prepare it, ar
to insure accurate positions and el
vations of the features shown, son
field measurements are still neede
For this purpose, points that are di
tinctly recognizable on the picture a
identified on the ground, and contr
surveys are run to determine the
latitude, longitude, and elevation,
needed. Some of these control poir
are marked on the ground with of
cial bronze or aluminum tablets set
masonry or rock, and are shown
the maps by appropriate symbo
They are useful as a reference datu
for many other kinds of surveys. Oth
points, intended only for the speci
mapping project, are not so marke

After the photographic models ha
been assembled and adjusted to fit t
ground control, and after all t
visible topographic detail has be
transferred to the map manuscri
there is still need for further field i
vestigation. A competent "field co
pletion" surveyor takes the mar

OVERHEAD aerial view of Lake Mead and Hoover Dam, bottom center, *above*, is step in preparation of such a map.

PROMONTORY POINT and Hoover Dam are seen in an oblique photo. Compare this view with the illustrations at left.

ipt into the field with his plane le and alidade. By a few judicious asurements he tests the accuracy of office compilation. He verifies the otogrammetrist's interpretation of p detail. Was that break in the ods a trail or a mountain stream? hat building a barn or a factory? adds detail that was obscured by se foliage or by heavy shadow. obtains information on political undaries, place names, and similar a not obtainable from the photo- phs. After field completion, the nuscript is returned to the office for ting, cartographic processing, and, mately, publication.

HE basic responsibility for preparing and publishing general pose topographic maps of the ited States and its outlying areas been assigned to the United States ological Survey. The topographic ps prepared by other government ncies in connection with their regu- activities are edited and published by the Geological Survey and are included in the National Topographic Map Series. The standard map unit is a quadrangle, a four-sided figure bounded by parallels of latitude and meridians of longitude. The area covered by a quadrangle map depends on the size of the quadrangle and its location with respect to latitude. For example, a 7½-minute quadrangle, covering 7½ minutes of latitude by 7½ minutes of longitude, usually at a scale of 1:24,000 (or one inch to 2,000 feet), may have an area between 49 and 70 square miles; a 15-minute quadrangle, usually at a scale of 1:62,500 (approximately one inch to the mile), may have an area between 197 and 280 square miles. Another important series, at the scale of 1:250,000, covers one degree of latitude by two degrees of longitude, with areas varying between 6,346 and 8,669 square miles.

Approximately 70 per cent of the United States is covered by accurate modern maps in the 7½-minute and 15-minute series, and an active program is under way to complete this coverage as soon as possible. Coverage in the 1:250,000-scale series is virtually complete today. A descriptive folder on topographic maps, index circulars for each state showing the availability of specific maps, and other map information may be obtained from the Map Information Office, U.S. Geological Survey, Washington 25, D.C.

In this article we have touched only briefly on topographic maps—what they are, how they are made, what they show, how they can be obtained, and a few of their uses. Many excellent books have been written on this subject and on specific aspects of it. To a student of nature and natural history, the topographic map presents an invaluable record of the evolution of the earth's surface: what happened to it in the past, and what is happening today. The topographic map is a powerful tool in nature study that is all too frequently overlooked.

Return of the Beaver

Economic factors have had a large bearing on population flu

By Sydney Anderson

The history of the North American beaver presents a conservation problem that has affected many of our continent's natural resources—that of maintaining a proper balance between overexploitation and overprotection. The beaver first became a significant economic entity during the sixteenth century as fur trade originating in North America attained large-scale international proportions. At first, trade was carried on only to a limited degree by French fishermen who got furs from Indians in exchange for trinkets. The prices these pelts brought in Europe provided an incentive for many of the fishermen to become full-time trappers, but most of their activities were carried out along the coast. As the demand for hats, trimmings, fur for linings, and leather shoes began to increase toward the end of the sixteenth century. Henry IV of France saw fur trade a way of building an economic empire. With th vision, he sent many explorers to the coasts of Nova Scot and Newfoundland.

But although it was the French who led the way, it w ultimately the powerful Hudson's Bay Company—create in 1670—that came to dominate the fur trade in Nor America. While Europe provided Hudson's Bay and less companies with a market for marten, otter, wolverin mink, and other pelts, the largest demand by far was f beaver. It has been estimated that between the years 18 and 1877, Hudson's Bay sold nearly three million beav pelts. As the continent was being settled, the range of t beaver was extensive—from coast to coast and from Alasl

WHEN a beaver dives, nose and ear valves shut and remain closed until the animal surfaces. The beaver is able to remain underwater 15 minutes.

HEAVY outer coat, soft, dense underfur, and body oils all combine to keep animal warm and insulate it against icy streams and cold air.

to the Gulf of Mexico, with the exception of the frozen tundra and some drier areas of the interior. Subjected to continuous exploitation over many decades, however, they began to disappear—first from local streams, then from river systems, and finally from entire states. About 1900, when the beaver population in the United States fell to its lowest level, many state legislatures passed laws prohibiting beaver trapping. In some areas, a few of the animals survived and multiplied, and some game departments obtained beavers from other states and released them in the wild. Gradually, the beavers spread as the young sought new homesites, moving upstream, downstream, and overland—becoming abundant again in habitats where their numbers had been virtually exterminated. In Illinois, for exampl the beaver population had nearly disappeared by 1912. I 1924, beavers were reintroduced, and by 1950 they we found in 45 of the 102 counties in the state and number over 3,500. By 1954, beaver were in 55 counties.

As beavers became more numerous, so did complain that they were cutting crops, flooding cultivated lands wi their dams, and damming up irrigation ditches. At fir game managers tried trapping them alive and moving the to other areas. This method of control was expensive, ar it eventually became ineffective as the beavers sprea Other methods were tried; sometimes, state employe trapped and pelted the beavers, special hunting permi were granted to landowners troubled by the animals, ar occasionally open seasons were declared. In many state economic factors have had a decided effect on the ups ar downs of beaver management. In Illinois, the annual ha vest declined from 659 in 1951 to 250 in 1955, althoug the beaver population was increasing. The state huntin and trapping regulations and the low price for pelts di couraged many trappers.

CURRENTLY, we are beginning to realize that neith uncontrolled exploitation nor absolute protection satisfactory in regulating the beaver population. The be management must be based on such factors as reprodu tive and mortality rates, food supplies, and degree ar rate of dispersal.

Having traced the pendulum-like fortunes of the beav in North America, it is appropriate to examine, at lea briefly, the object of so much intellectual, economic, ar legislative attention. Many books and articles have,

BEAVERS have a varied diet, such as duckweed and many other aquatic plants, grass, shrubs, the roots of soil plants, bark and outer layers of trees.

DAMS are usually built only in smaller streams. By raising water levels, they provide pools in which beavers store food and hide from predators.

SPLIT claws on webbed hind feet groom fur, spreading proofing oil. The forefeet, *center,* manipulate foods.

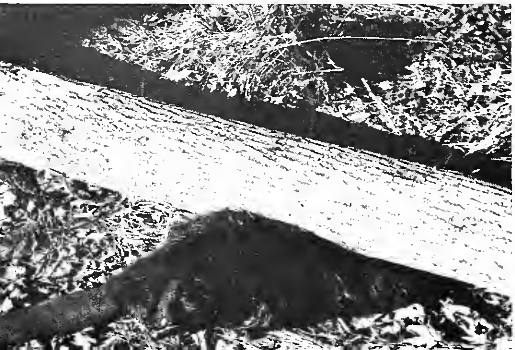
Upper incisors hold the wood, while the lower pair cut. Lips draw tight behind teeth and permit underwater cutting.

e, been written about the beaver—perhaps because with his capacity to build things, is especially inter- in animals that also have the ability to construct. d in Eurasia as well as North America, beavers are orld's second largest rodents; only the South Ameri- capybara is bigger. American beavers are usually ded as a species, *Castor canadensis*, separate from ld World *Castor fiber*. At one time, however, Ameri- eavers were introduced into Finland, where they inter- with native beavers and produced fertile offspring, which indicates that probably all the living beavers are members of the same species.

In the Pleistocene, another North American beaver was the giant *Castoroides*, whose remains have been found in several widely separated northern states, indicating its extensive range. From nose to tail, they measured over seven feet—longer than a black bear. The average modern beaver measures between three and four feet and weighs from thirty to seventy-five pounds. Like all rodents, beavers have two pair of gnawing teeth—one pair in the upper and

CUT TREES are peeled for food; the remainder may be used in dams. In winter, sticks are cached in mud beneath ice.

SOME TREES cut by beavers measure more than one foot in diameter. They can fell smaller ones within a few minutes.



another in the lower jaw. A space separates them fr chewing teeth that are located farther back in the mou These large front teeth are one of the beaver's most d tinguishing features and enable it to perform such fe as felling a tree more than a foot and a half in diamet

Other remarkable anatomical features allow beavers thrive in water, while equally remarkable habits help th create and maintain conditions necessary for their surviv Underfur of an unusually soft, smooth, and dense qual traps air, insulating the beaver's skin from contact w water or cold air. The animal's legs are short and stro The large hind feet have five webbed toes, forming powerful paddle. The two inside toes have split claws w which the beaver grooms itself. The front feet are smal and not webbed. The "trade-mark" of the beaver, of cour is its broad, flattened, scaly tail. Ten to twelve inches lo and six inches wide, it is used for steering and to a les extent for propulsion when the animal swims. The tail a serves as a prop when a beaver stands while gnawing, when it carries mud, stones, grass, or other materials w the forefeet to plaster a lodge or a dam.

IN addition to these two structures, beavers also bu burrows and canals. Dams are usually built in smal streams to raise the water level, while canals are used transport food, and lodges and burrows provide shel from adverse weather or predators such as bobcats, mo tain lions, or man. Lodges, like dams, are usually built o in smaller streams and are perhaps the most interesti beaver structures. Roughly conical in shape, a lodge m measure thirty feet across the base. Sometimes it beg as a pile of tree limbs left around a burrow or feeding pl after the bark has been eaten. Converting such a pile i a lodge involves the expenditure of much beaver ener Limbs, grass, mud, and rocks are piled higher and high Usually, more than one underwater passage is built i the lodge, whose interior may be enlarged to six or ei feet across. The top of the lodge is the thinnest part a often allows some ventilation. Although most lodges surrounded by water, some are built against a bank over the entrance to a burrow in the bank.

While, as indicated earlier, beaver habits have made animals unpopular with some farmers and other la owners, it should be added that beaver structures often ha positive effects. In parts of the western United States, instance, beaver dams conserve water by slowing do runoff, and prove beneficial to agricultural and ot interests by stabilizing the flow of streams. Ponds crea by the dams may also aid in flood control by acting catch basins, as well as providing water for irrigation

The activities of the beaver, then, are both benefic and detrimental to the interests of man—depending on circumstances in each local area. The eventual status the animal in terms of protecting and limiting its popu tion will, in turn, be dependent upon continuous resear carried on in every environment where the beaver is fou

BEAVERS cannot determine the direction in which a t will topple, and consequently animals are sometimes kill

LODGEHOUSE contains one large room, and must be n deep water where the entrance tunnels can open under i

Copepods,
foraminifera,
diatoms.

Tiny Drifters of the Sea

By John J. Lee and Hugo Freudentha

ALTHOUGH FISH are probably the most obvious members of the marine biota, it is becoming increasingly apparent that their importance, as well as their numbers, is dwarfed by multitudes of smaller, less-known organisms. A man casually watching the waves from ship or shore, or even from the vantage point of a diver, can only imagine this world that is made up of microorganisms—diatoms, radiolaria, acantharia, foraminifera, dinoflagellates, yeasts, molds, and bacteria.

For obvious reasons, more is known about the creatures that live on the edges of the ocean than about those inhabiting the depths. Also, it is easier, and certainly more economical, for a biologist to put on hip boots and wade out a few feet to collect organisms than it is to find a ship that is equipped to handle collecting in the open ocean. Fortunately, as increasing emphasis is put on studies of the sea, more oceanographic research vessels are becoming available. For instance, we have been especially fortunate in having the cooperation and assistance of the United States Coast Guard in our studies, and have traveled on a number of their patrols to make deep-sea collections.

Although plankton is found in all the oceans and at all depths, water rapidly absorbs sunlight, so that photosynthetic organisms are rarely found deeper than 250 feet. It is in this photic zone that the many small animal species are found feeding on the marine photosynthetic algae. Collecting them is simply a matter of straining out the plankton from the water with a special plankton net—a large cone of very fine nylon mesh attached to a metal frame.

Our primary interest has been the collection of planktonic foraminifera, a large group of marine amoebae that have tests, or shells, of calcite. Usually they are relatively minor constituents in a mixed population of organisms dominated by pelagic crustacea. However, we have sometimes been fortunate enough to find them in large numbers, or "blooms," where ideal conditions have permitted the foraminifera to multiply rapidly, overgrowing other organisms.

Recently we have learned more about the seasonal and spatial distribution of foraminifera, and have been able, by culturing them in the laboratory, to begin to understand their physiology. The foraminifera contain a number of unusual cytological organelles of as yet unknown function. Perhaps some of them serve as flotation devices, since a freshly collected foraminifer will sink like a stone. The noted biomathematician Sir D'Arcy Thompson remarked on this apparent paradox nearly fifty years ago. Indeed, it is difficult to understand how an armor-encased amoeba can be found floating within a few meters of the surface in water more than five miles deep. Many foraminifera, as well as the radiolaria, acantharia, and some pelagic diatoms, bear spines. These structures increase the surface area of the organism, allowing it to plane near the surface on the turbulence of the waves.

THE *left center* photograph shows a mixed group of foraminifera. *Globigerina bulloides* is the yellower, more rotund species, while *Globorotalia truncatulinoides* is the flatter and the more closely coiled one. Next to these *(right center)* is an individual *Orbulina* sp., one of the most beautiful of the spined foraminifera. It is a creamy-white, glossy sphere, some 750 microns in diameter (1,000 microns equal one millimeter). In addition to the long spines, pseudopodial appendages extend through the delicate round holes in the test.

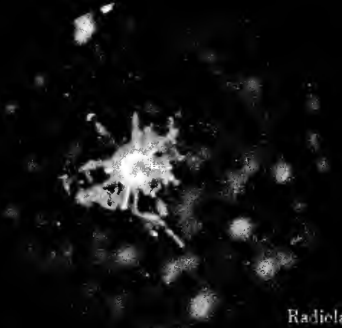
We have often found radiolaria and their close relatives, the acantharia, in dense blooms accompanying the foraminifera during the winter and spring months in the North Atlanti
These radially symmetrical, spined an
mals are among the most beautiful an
delicate creatures to be found in th
sea. Their shells, while intricate
pierced like those of the foraminifer
are not of calcite but of biological
secreted silica glass. Beneath the sh
lies a central capsular body of cyt
plasm often colored yellow, red, brow
violet, blue, or green by the presen
of oil droplets. Most radiolaria ran
in size from 100 to 500 microns ar
are well represented in the oceans.

THE acantharia are close rel
tives, both phylogenetically an
morphologically, of the radiolaria, b
differ in that they have a thin mer
brane around the central capsule, ar
their skeletal material is constructed
strontium and calcium sulfates in add
tion to silicates. Because the acanthar
are able to absorb, concentrate, ar
incorporate strontium as a part of the
normal metabolic processes they a
uniquely useful in various studies
radioactive fallout over the great e
panses of the oceans of the world.

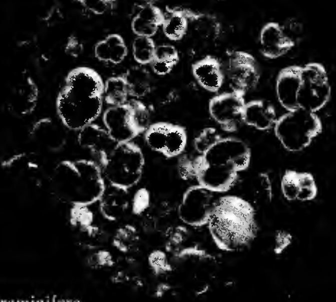
The largest and most elegant of a
the animals that we have collecte
are the medusae. These are mult
cellular, radially symmetrical coele
terates ranging in size from one to fi
millimeters in diameter. They may
variously colored or nearly transpa
ent. They prey on clam larvae, cop
pods, and ostracods by using rows
"stinging cells" borne on arms th
surround a central digestive cavity.

From the standpoint of classic
ecology, the sea has been considere
a relatively infertile environment. T
increasing world population, with i
demands for a higher standard of e
istence, is now forcing all nations
reappraise their views about the sea
productivity and, in many cases,
embark on basic research progran
concerned with marine microbial li

an

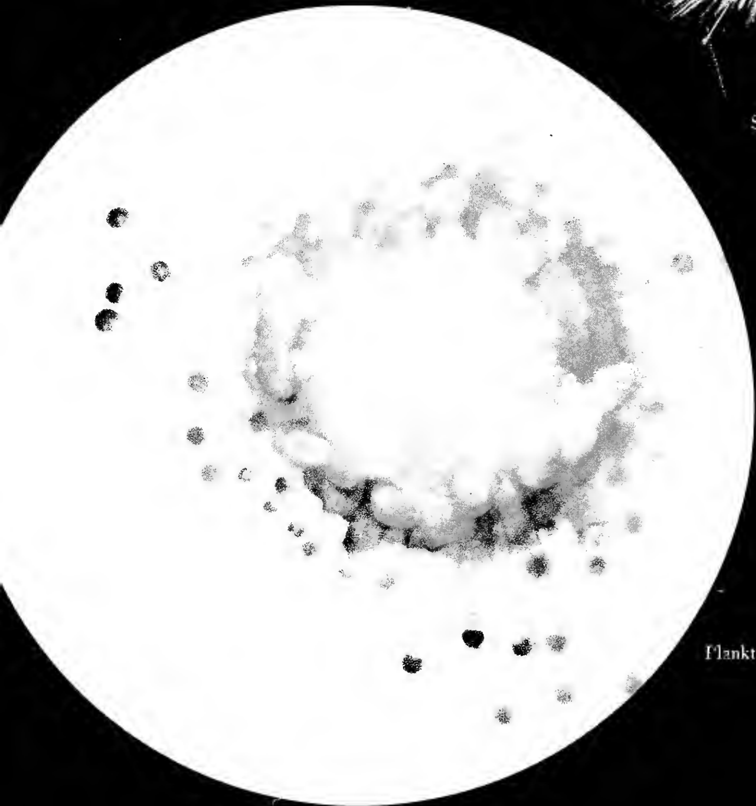


Radiolarian



Mixed planktonic foraminifera

Spherical foraminifer



Planktonic medusa

Migration in Maine

Eastern brook trout are threatened by man-made obstacles

ɔUT leaps falls to reach remote
grounds in Misery Stream.

LOW-WATER PERIOD, before late autumn rains, precedes the October trout run.

ᴀUL J. FOURNIER

ʀY AUTUMN, far up on the lonely
:adwaters of Misery Stream in
estern Maine, an event takes
ıat is seldom witnessed save by
asional woodsman or a disin-
l moose or deer—the spawning
on and courtship of *Salvelinus*
lis, the brook trout.

fish, also known affectionately
glers as brookie, redspot, or
ail, is a member of that large
of so-called cold-water fishes
to ichthyologists as salmonoids,
nclude most of the fishes known
nly as trout and salmon. As do
f its cold-water cousins, the
rout spawns in the fall.

big trout of northern Maine,
for a relatively few "resident"
refer the region's deep, cold
ıd ponds to the streams, which
:d primarily as breeding and
areas. The approach of the
g season manifests itself in
s northern areas as early as mid-
when miles of the traditional
ınd summer fishing spots in the
ecome virtually bare of sizable
ıost overnight. That is the time
ıe trout emerge from their mid-
r lethargy and embark upon the
ıges of the dangerous journey
ll reach its climax a couple of
later on spawning beds far up
ler streams and rivers.

ng late August and early Sep-
the trout cease feeding and
congregate at the mouths of
tributaries. Throughout this
with fish packed into relatively
reas, knowledgeable fishermen
ap a bounteous harvest. The
tirred to a high pitch of excite-
rike pugnaciously at practically
e presented to them.

Another manifestation of the approaching spawning season is the unusual appearance of the trout brought in by the fall fishermen. The roe-heavy females have a distended, rounded conformation. The bellies and fins of the male are alive with color that ranges from glowing orange to nearly blood-red. The red and black spots on the body deepen and show very prominently. In addition, some of the larger males grow a hook, known as a "kype," at the tip of the lower jaw. The purpose of the kype is a mystery to ichthyologists. It is common to most salmonoids, especially the salmon group.

The trout usually remain schooled at mouths of the tributaries until mid-October, waiting for conditions—especially the water temperature—to be right before starting the upstream push. Usually the most-favored spawning beds are miles upstream, and the intervening mileage is composed chiefly of boulder-studded rapids and riffles. The trout must fight up every inch of the way, often being forced to leap over small waterfalls and the remnants of old logging dams. Lumbermen's log-driving dams have often formed insurmountable barriers to the migrating fish, and even the dam-building efforts of beavers frequently bar the way to the coveted spawning grounds. Maine biologists and game wardens often tear down or dynamite portions of these old dams to make passageways for the fish.

Adding to the journey's hazards are a host of predators. Chief among these in the Maine area are mink and otter. I received firsthand proof of this one day last fall. I approached a small waterfall to watch the fish leaping and arrived just in time to see a large mink emerge from the deep pool below the falls, staggering under the weight of a trout nearly as long as itself, and drag its prize under a nearby brush pile. On another occasion, while checking the spawning beds farther upstream, my attention was attracted to a tall clump of grass on the stream bank when a Canada jay dropped into it. A moment later it popped up again with something hanging from its bill. I parted the grass and found a mound of eggs, a few entrails, and a couple of large fins—all that remained of what had obviously been a good-sized female trout.

One Maine fishery biologist told me he has often caught blue herons in the act of killing trout (they kill large fish by stabbing them in the spine with their sharp bills), and he believes they may take a heavy toll of the spawners when they are jammed into the narrow confines of the spawning beds. And, of course, there are the human poachers.

Most Maine game men and woodsmen are of the opinion that the area's healthy population of black bears prey little, if at all, on the spawning trout, as do their famous salmon-fishing cousins of the Pacific Northwest. This they attribute to the fact that the Maine trout are not driven by the frenzied, do-or-die determination of the northern Pacific salmon and, therefore, are more likely to shy away from anything as large and menacing as a black bear.

On the other hand, I once saw trout acting in a most irrational manner. Several days of torrential rains had brought the stream up over its banks, and the water pouring over the falls was too much for the trout to scale. They were trapped in the pool for several days, and in desperate attempts to clear the obstacle many leaped along the edges of the rushing water and slammed head-on into the stone ledges, where a number of them lay on the bare rocks for several seconds, stunned by the impact. Indeed, when I stepped close to the water's edge to see them better, several crashed against my feet and legs with such force that I had to step back to avoid actual injury. Had I been so inclined, I could easily have picked up all the trout I wanted with my bare hands. Presumably, a bear would have made the most of the situation, and certainly the bulk of my body and my movements must have appeared as menacing as a bear's to a fish's eye. Yet, driven by the urge to propagate, they were heedless of my presence.

FISHERY BIOLOGIST digs a passageway for the trout through old beaver dam.

CANADA JAY eats dead fish. Note eggs on the bird's beak and near its feet.

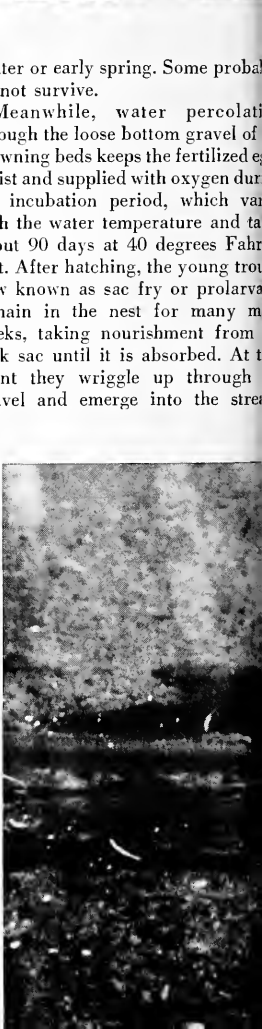
Salvelinus has always been particular in selecting a habitat and especially the spawning grounds. For one thing, it is probably one of the least tolerant of all fishes to polluted or silted waters. For another, the brook trout is truly a cold-water fish. It is seldom found in waters warmer than 60 to 65 degrees and generally prefers it colder. Ideally, the bottom of a spawning stream is composed of coarse gravel, loose rubble, or fine, clean sand. Whenever possible, the trout also chooses a stretch of stream bed that is fed by underground springs that insure a constant supply of cold, clean water—especially in spots where the temperature is near the ideal egg-incubation point of 40 degrees.

THE trout generally stay on the beds for several days to a week or more, and their presence is marked by considerable thrashing and splashing. The males, now aggressively vying for the females' attentions, engage in many battles, marked by nipping, shoving, and lightning-fast chases upstream and downstream. A fishery biologist reported he had once watched a pair of lusty males lock jaws and roll over and over a long stretch of rapids.

Apparently oblivious to this violence staged for her benefit, the female critically selects a suitable site and busies herself in preparing the "redd," or nest. Lying on her side near the bottom, she violently flaps her blunt, powerful caudal fin and caudal peduncle (tail fin and muscular tail root) up and down. Currents generated by the action loosen bottom material and wash it downstream. Alternately flapping and resting, she remains at the task until the nest's dimensions suit her. Generally it is from four to twelve inches deep, and one to two feet in diameter, depending to some extent on her size. Then the female slowly swims in over the nest and remains nearly motionless, while one or sometimes two males move next to her, pressing against her sides. Eggs and milt are released simultaneously. Fertilization (in the form of the male spermatozoa entering the ovum through a tiny aperture called the micropyle, which is open for scarcely two minutes after the egg is released), takes place as they drop into the nest and are mixed by currents. The female then immediately moves upstream and loosens some bottom material, which is carried downstream and covers the fertilized eggs.

The process of spawning is a tremendous, body-sapping ordeal to the trout. For weeks they have been battling the obstacles of frothing-white rapids, leaping over near-vertical waterfalls, and evading a host of predators. Yet, overnight the stream is left nearly empty of fish, as the trout race downstream to the lake or pond from whence they came. There, under the protective mantle of winter ice that sheaths the waters, they spend a relatively quiet winter, feeding and slowly regaining the strength that was lost during the non-feeding period before spawning. It takes them many weeks to recuperate, and many do not show their characteristic vitality until late winter or early spring. Some probal
do not survive.

Meanwhile, water percolati
through the loose bottom gravel of
spawning beds keeps the fertilized e
moist and supplied with oxygen dur
the incubation period, which va
with the water temperature and ta
about 90 days at 40 degrees Fahr
heit. After hatching, the young trou
now known as sac fry or prolarva
remain in the nest for many m
weeks, taking nourishment from
yolk sac until it is absorbed. At t
point they wriggle up through
gravel and emerge into the stre



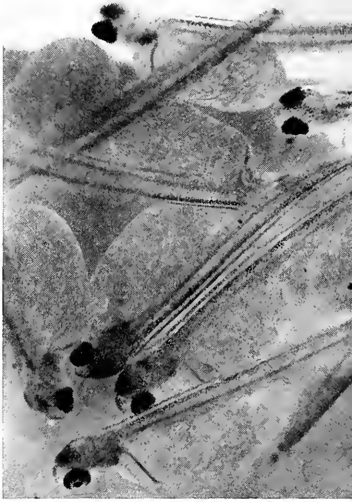
ust contain ample nursery r the advanced fry remain in ım from one to three years. heir early life, the young feed y on immature aquatic insects er minute animal life, later ng to larger insects and finally fish. Growth rate varies con- , depending on the individual productivity, but generally ıch the legal length of six to hes in their second year.

inus fontinalis has long been aristocrat of the game fish sport fishermen. Originally to waters from Labrador d along the Appalachians to and westward to the upper pi River waters, its popu- s caused the species to be in- to many parts of the world. its range has thus been vastly d artificially, its natural as been drastically reduced in nes.

f the waters in which it has oduced come anywhere near the exacting requirements of n water and extensive spawn- nursery areas. In addition, the waters already contain ulations of other fish species, such fiercely competitive brown trout and the undesir- ıgh," or "trash" fish, such as rch, with which the trout is ed to compete. The brook ves best when it alone, except for small forage fish, occupies a fishery. In many of the stocked waters, few breeding fish—probably less than 10 per cent—survive from one year to another, and much of the trout population exists on a put-and-take proposition, governed by the output of the hatcheries and the regularity of the stock truck's visits. In the wild, perhaps 50 per cent survive.

Even on their traditional home grounds of the northeast, the brook trout are now inexorably losing ground before the advance of civilization. More and more waters are becoming polluted. Forests are being stripped off, with subsequent warming and drying and increased silting-in of waterways. Undesirable fish species are infesting once-exclusive trout waters. Many experienced woodsmen are of the opinion that a prime trout-producing stream, such as Misery, is "worth every fish hatchery in the state!" Fishery biologists won't go that far, but they readily admit that natural reproduction of trout is more efficient than artificial production. They have also become convinced that spawn from wild stock is far superior to that produced artificially and purchased from out of state, and as a result the Maine Fish and Game Department's Hatchery Division recently began trapping wild spawning trout and stripping them of their eggs. From these they hope to develop a strain of fish that will become brood fish as adults and will supply embryos for future stocking of streams.

The eastern brook trout still manage to make their annual pilgrimage to their ancient spawning grounds as they have done for millenniums, despite the ever increasing obstacles thrown in their paths by man and his "improvements," which unfortunately include pollution, dams, bulldozers, and the thoughtless sowing of exotic fish species. If such programs continue or expand, the existence of wild trout will become increasingly precarious.



Fingerlings are in "nursery" stream, where they stay for one to three years.

g beds reached, the trout will make nests to receive the eggs.

SKY REPORTER

The wondrous rings of Saturn

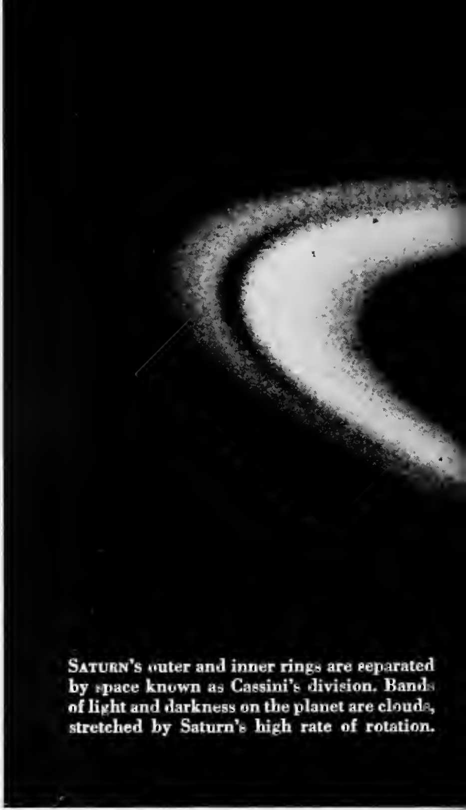
By Thomas D. Nicholson

One of the most widely used astronomical symbols is that of a ringed planet. The use of this symbol is a little strange in one way, for ringed worlds are not at all common. So far as we know, there is only one—the planet Saturn—in all of the universe. It is unique and beautiful to behold, in telescope or in photograph, and somehow stimulates interest and challenges the imagination. These are probably the reasons why Saturn and its rings are so popular as a symbol of astronomy. These are also some of the reasons why the rings were the second of the Seven Wonders of the Universe chosen by astronomers at The American Museum-Hayden Planetarium.

Saturn should be easy to find in the evening sky during October. It is in the constellation Aquarius *(see map, page 53)*, high in the southeast during early evening hours. Meridian passage (when Saturn is in the south) occurs at about 9:30 P.M., local mean time, at the beginning of the month, about an hour earlier in the middle, and two hours earlier at the end of the month.

Once found, Saturn offers anyone with a small telescope, or even a pair of good, steadily mounted binoculars, an interesting opportunity to relive some of the great mysteries and discoveries in astronomy. This October the rings of Saturn are inclined to our line of sight from earth by about 10 degrees. We are looking down at the north face of the rings and can see Saturn's north pole on the visible hemisphere. At this inclination it would be difficult to identify rings around the planet with a small optical device, but patient watching with a well-steadied instrument should easily show that there is something peculiar about Saturn —that it is not simply a spherical object but has an appendage of some kind on either side of it. This is precisely what Galileo saw in July, 1610, when he looked at Saturn for the first time with a telescope, for Saturn and its rings were oriented for him just about the way they are for us this year.

"I have observed Saturn to be triple . . ." Galileo wrote to his colleagues, as his explanation for the strange appearance of the planet. But it was to become stranger still for the astronomer. By 1612, Galileo, although he did not realize it, was looking directly along the plane of Saturn's rings, because the earth was then located very nearly in the ring plane. The appendages he had seen in 1610 had disappeared completely, and Saturn simply looked like a single disk, just as it will appear to us in 1966 when the earth again passes through the plane of the rings. Not knowing what he was looking at, Galileo asked in a letter, "Has Saturn, perhaps, eaten his own children? Or were the appearances [of 1610] indeed illusion or fraud?"

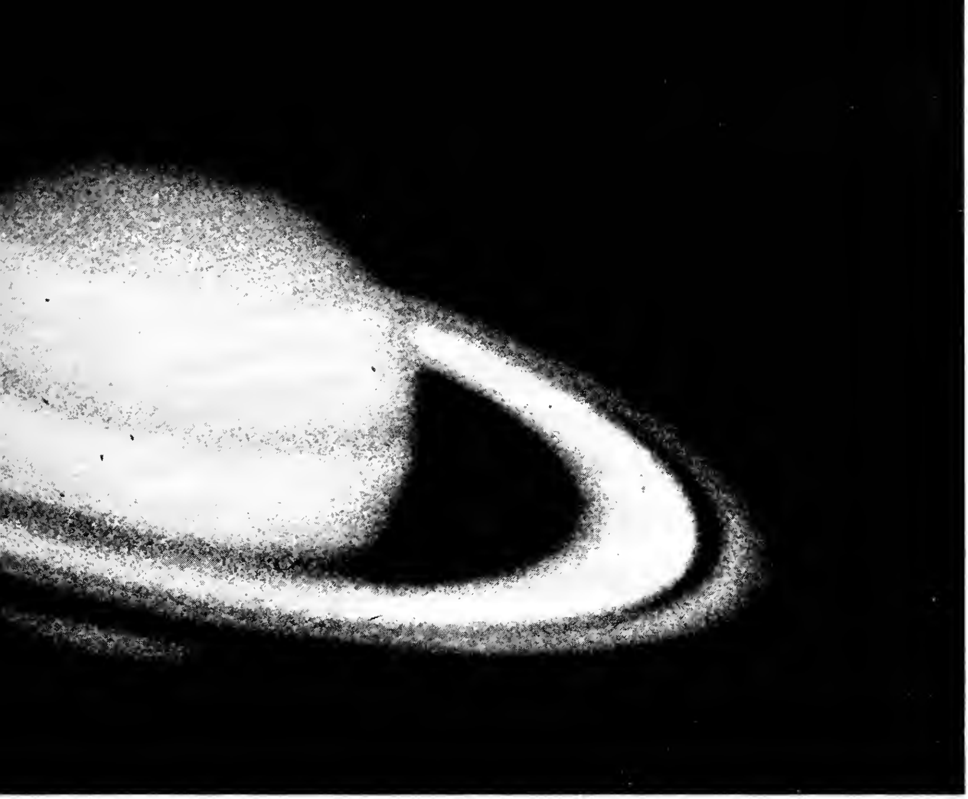


Saturn's outer and inner rings are separated by space known as Cassini's division. Bands of light and darkness on the planet are clouds, stretched by Saturn's high rate of rotation.

The mystery of the changing appearance of Saturn v
explained by the Dutch astronomer Christian Huygens.
first put forward his ideas in 1656 in the form of an a
gram, which reads literally, "It [Saturn] is encircled
a ring, thin, plane, nowhere attached, inclined to
ecliptic." Later, in 1659, he wrote the *Systema Saturniu*
in which he described and explained his hypothesis to
count for the changes in Saturn's appearance.

According to Huygens, Saturn was encircled around
equator by a broad, but thin ring that was visil
because of reflected sunlight, when it was tilted with resp
to the earth. The plane of this ring, because of the incli
tion of Saturn's equator, is inclined to the ecliptic by ab
27 degrees. Most times, the earth is located above or bel
the plane of the rings, so that we can see one face or anot
of the ring tilted to our line of sight. But on two occasio
during each revolution of Saturn around the sun (29
years), the earth is in the plane of the ring so that it
invisible to us. This explanation of Huygens' accounted
the great variations in the appearance of Saturn report
by Galileo and others. It happened that Galileo discove
the abnormal appearance of Saturn at a time when the
of the ring was slight and decreasing swiftly. Had he
served it at another time, he might himself have guess
at its true nature.

Up to this point, we have spoken of a "ring," for it v
not until 1675 that anyone suspected that it was not mer
a single disk that surrounded the planet. Giovanni Cassi



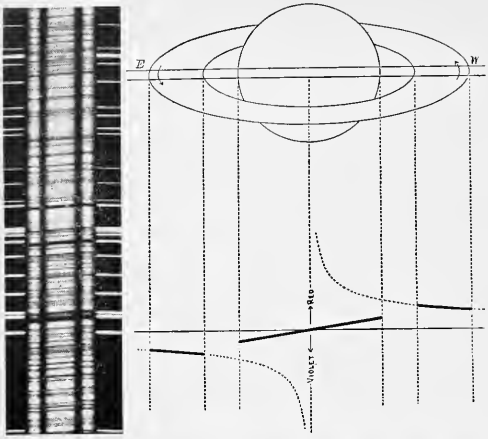
an director of the Paris Observatory, reported that
seen a dark band extending through the ring. He
observed that "the breadth of the ring was divided
rk line into two equal parts, of which the interior
rer one to the globe was very bright, and the ex-
art slightly dark." A third ring was observed by
erican astronomer G. P. Bond of Harvard College
tory in 1850. Bond saw a faint, dusky light filling
on inside of Saturn's bright ring, clearly casting
w on Saturn. The new ring was separated from the
es by a faintly seen dark band, and its inner edge
erved to be short of the visible surface of Saturn
he semitransparent, veil-like appearance of this
st ring prompted the English astronomer W. Las-
ame it the crepe ring.

we now know that the rings of Saturn are three:
, the outer ring; Ring B, the central and brightest
d Ring C, faintest of all, the crepe ring. The linear
r across the entire ring system is about 169,300
ing A is about 10,150 miles wide. The gap between
r and inner rings, known as Cassini's division, is
,750 miles across. Then comes Ring B, widest of
e 16,450 miles across. Inside this, with no appre-
ivision, is Ring C, the crepe ring, about 9,850 miles
The inner edge of the crepe ring is some 6,000
bove the visible surface of Saturn. All in all, the
dth of the ring system is about 38,200 miles.

hickness of the ring system remains a puzzle even
The earliest observers noted that the rings were invisible for only a short period of time as the earth passed through their plane—a matter of hours, certainly less than half a day. This fact of observation supported the belief that the rings were quite thin. Successive observers who have sought to estimate the rings' thickness have produced smaller and smaller values as better instruments became available. In 1789, W. Herschel, in England, estimated the thickness to be "less than 280 miles." Later observers lowered this figure, and in 1919, the value put forth by L. Bell, in the United States, was "less than ten miles."

As to the structure of the rings, Cassini suggested, in 1705, that Saturn's rings might be made of countless small particles in orbit around the planet. The French mathematician and astronomer P. S. Laplace proved in 1785 that a solid ring, unless rotating, would collapse under Saturn's gravitational attraction. He went on to describe a system of many infinitely thin rings, each rotating around Saturn eccentrically, and each unevenly distributed around their circumference, which could account for the appearance of a solid ring. Aside from these suggestions, however, it was generally believed, until the middle of the nineteenth century, that the rings were solid.

THE theory of solid rings was finally abandoned when James Clark Maxwell, an English mathematician, published his paper *On the Stability and Motion of Saturn's Rings*, in 1859. Maxwell showed that a solid ring or system of rings, no matter how the mass might be distributed around the planet, could not remain stable for long, but



White bands, spectrum of Saturn and rings, are crossed by lines showing motion. Variance in tilt of lines, as seen in diagram, indicates that rings could not be solid mass.

would inevitably disintegrate. He concluded that "the only system of rings which can exist is one composed of an indefinite number of unconnected particles, revolving round the planet with different velocities according to their respective distances." Thus, he theorized Saturn's rings were an enormous number of satellites revolving around the planet in a common plane. Each object, of course, revolved in accordance with Kepler's laws of planetary motion, so that the more distant particles moved in orbit at a considerably slower speed and for a longer period than the ones located closer to the planet.

The observational proof of Maxwell's theory of the ring structure was provided in 1895 by James E. Keeler of the Lick Observatory, California. Keeler obtained photographic spectra across the long axis of the ring system. These spectrograms showed the typical dark line spectrum of sunlight reflected from the planet and from the bright portions of the rings on either side of the planet *(illustration, above)*. The dark lines in the spectrograms were produced, however, by a rotating source. The parts of Saturn that were rotating toward the earth caused the dark lines to shift toward the violet end of the spectrum. Where the reflecting surface was rotating *away* from the earth, the lines were shifted toward the red end of the spectrum. The cause of the shifts was the well-understood Doppler effect, whereby, with respect to an observer, the wavelength of light from a source in motion is increased or decreased as the source is in motion away from or toward the observer.

In Keeler's spectrograms of Saturn, the rotation of the planet was clearly seen in the inclination of the dark lines of the planet's spectrum. The approaching edge of Saturn caused the lines to shift toward the violet, and the receding edge to shift toward the red end of the spectrum, thus causing the inclination of the lines observed. On either side of the spectrum of the planet's disk were the narrow spectra of the two ends of the rings. If the rings rotated as a solid disk, then the lines in the spectra of the rings would in each case be inclined in the same direction as the lines in the spectra of Saturn. The inclination would occur because the outer edge of the rings would be rotating fastest and would cause the greatest displacement of the lines. B
such was not the case.

Dr. Nicholson, the regular author of this column, is also Chairman of **The American Museum-Hayden Planetarium**,

The thin spectra of the two ends of the rings appeared
be untilted, but careful inspection of the plates reveal
that each showed a very slight displacement in the oppos
direction of the tilt of the lines in the disk spectrum. Th
the outer edges of the rings caused a lesser displacement
the lines than did the inner edges of the rings. This indicat
that the velocity in the rings is least at the outer edge,
it must be if the ring motion obeyed the laws of planeta
motion. The spectrograms gave direct proof, therefo
that the rings were composed of individual particles,
Maxwell had proposed.

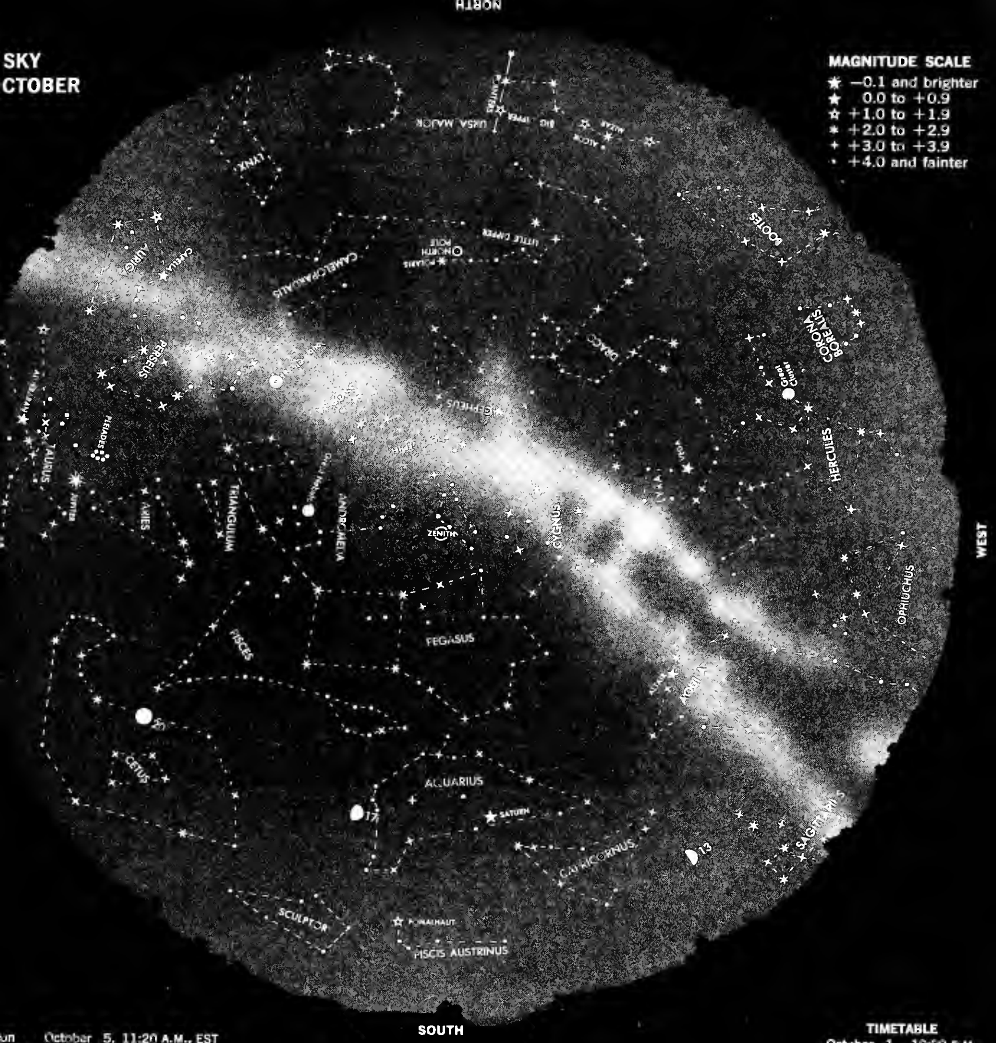
But what were the particles? Were they particles crea
or left over from the original cloud that condensed i
Saturn itself, particles that had failed to produce one la
satellite, as other parts of the original cloud had produce
Or were they the shattered remains of a satellite that h
disintegrated under enormous tidal forces imposed
Saturn, and which had since ground themselves into d
by internal encounters among them? Both these theo
have been considered seriously by astronomers.

Studies by the Russian astronomer M. S. Bobrov fr
1951-56 led him to conclude that the particles compos
the rings are "fairly large" and probably have rou
angular, and pitted surfaces. In 1958 A. F. Cook and F.
Franklin of Harvard College Observatory studied the o
cal properties of the rings and decided that the aver
particle size is still open to question. They discussed t
hypotheses as equally satisfactory to their observatio
one in which the average particle size in the rings is ab
a yard in diameter; the other in which the particles
microscopic in size. Dr. A. Dollfus, at the Pic-du-M
Observatory in Paris, suggested in 1958 that the parti
are long and thin, with their long axes aligned in th
orbits. G. F. Kuiper, of the Yerkes Observatory in W
consin, who in 1943 discovered the atmosphere of Tit
Saturn's fifth satellite, has found evidence that ice crys
may be present in the rings. Much, of course, still is
be learned about the particles.

WITHOUT its rings, we would hardly hear of Sat
itself, for it would be paled by the greater size
brightness of its neighbor, Jupiter. With the rings, Sat
stands alone of all the celestial bodies we know—a ring
world, which brightens or dims as its rings expose or h
their faces. When the rings are open wide to our view
they were in 1958, and will be again in 1973, Saturn ri
the most brilliant of stars, except for Canopus and Sir
But when the rings are closed to our view, as in 1965
1966, the planet fades with them, until it is no more not
able than an ordinary bright star.

The gradual accumulation of knowledge about the ri
of Saturn has not in any way tarnished the beauty
grandeur of their appearance. Although few persons
ever get to see the rings as they appear in a telescope, ne
everyone has shared something of their majestic appeara
in the excellent photographs produced by modern obse
tories. In the entire universe around us, nothing else
motely resembling Saturn's rings has ever been fou

SKY
CTOBER



un	October 5, 11:20 A.M., EST
arter	October 13, 11:56 A.M., EST
on	October 20, 11:45 P.M., EST
arter	October 27, 4:59 P.M., EST

TIMETABLE

October 1	10:00 P.M.
October 15	9:00 P.M.
October 31	8:00 P.M.

(Local Mean Time)

ober 1: The late crescent moon joins Mars and Venus morning sky today. About two hours before sunrise, s well up in the southeast, Venus is low in the east, and oon is between the two, somewhat closer to Mars. On orning of the 2nd, the moon rises just below and to the Venus.

ober 4-5: The bright star near Venus in the morning sky se two days is Regulus, in the constellation Leo. On the egulus is to the left of Venus, and to the right on the 5th. is in conjunction with the star at 1:00 A.M., EST, on the ut they are below the horizon in the United States.

ober 16: Saturn is close to the waxing gibbous moon in ening sky tonight. At 1:00 P.M., EST, the moon passes degrees south of Saturn. By dark this evening, the moon to the east and below Saturn in the southeastern sky.

ober 20: The Orionid meteor shower reaches maximum but the brightness of full moon, in the sky all night, ake observation of meteors rather difficult.

ober 22: Jupiter and the moon are in conjunction at 6:00 P.M., EST, just before moonrise. They rise in tonight's sky, in the early evening, quite close together.

October 29: The conjunction of Mars and the moon, at 4:00 A.M., EST, is visible in the morning sky over most of the United States. Mars, at that time, is three degrees south of the waning crescent moon in the southeastern sky.

Morning stars for October are Venus and Mars. Venus (magnitude —3.6) is very brilliant over the eastern horizon at dawn, rising about three hours before sunrise. It rises later and appears lower as the month progresses. Mars is higher and well to the right (south) of Venus in the dawn sky, but not nearly so bright (magnitude 1.5) as Venus. In the constellation Cancer, it rises shortly after midnight.

Jupiter appears above the eastern horizon shortly after nightfall, and is conspicuously bright (magnitude —2.4) until dawn. Late in the month, it moves from Taurus into Aries, still going in a retrograde (westward) direction. Saturn (magnitude 0.8) is in Aquarius, well up in the southeast at sunset. The planet remains in the sky until it sets after midnight.

Place for All Things

LESE WOMAN balances her goods
d, *left*, as she walks to market.

Vendors and buyers, *above*, congregate in the market place at Gulu in Uganda.

ican markets fulfill many functions

AUL BOHANNAN

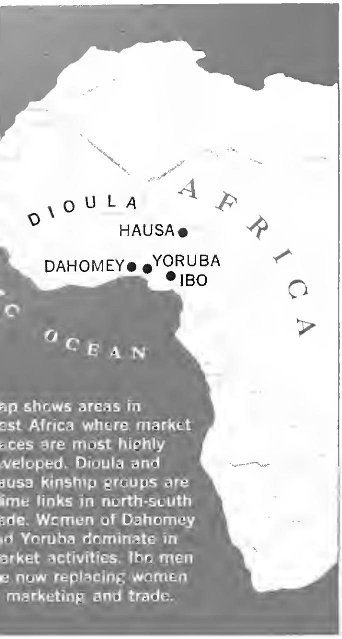
RKET PLACES are found indige-
nously throughout North Africa
he Congo, and are especially
developed in almost all parts
t Africa. They are much less im-
t in East Africa south of Ethi-
nd, until they were introduced
ropeans, seem to have been all
known in the Rhodesias, Mo-
que, and South Africa.
market places were absent in
arts of Africa until the colonial
of the late nineteenth century
ot mean that goods were not
and sold on the market prin-
f price, regulated by supply and
d. Nor does the fact that market
are almost overpoweringly pres-
other parts of Africa mean that
ocieties are dominated by the
principle and its accompany-
al principle of contract, as is the
the modern West. The market
in Africa are almost as im-
t politically and socially as they
nomically.
ket places can be, and some-
are, highly developed institu-
even in areas in which trade is
ndary importance. The differ-
one that was drawn at least as
is Marx, and that must be re-
specifically in the case of

Africa. Marketing is an activity in which the producer takes some of his produce to market and exchanges it for other produce. This is a difference in degree and social emphasis from producing *for* the market, where the producer takes his produce to market and exchanges it for money with which he buys the major portion of his subsistence from the same market. While many agrarian economies are marked by highly developed produce markets, the societies would not perish if those markets were to disappear. People would be made uncomfortable and they would have to change their style of living, but the society would not fall apart or even alter its structure.

Trade, on the other hand, is an activity in which entrepreneurs buy in cheap markets and sell in dear markets. That marketing and trading often go hand in hand does not mean that they are inseparable. Market places appear in many parts of Africa in which trade was only minimally developed; trade, across the Sahara and along the east coast, often took place in the absence of market places.

Much marketing in the West African and Congolese areas was done traditionally by women. In many, but not all, of these areas where the women were the chief marketers, the men were the chief producers. There have been

TRIBAL YOUTH in market at Langshi, northern Nigeria, holds live chicken.



ap shows areas in
est Africa where market
aces are most highly
veloped. Dioula and
ausa kinship groups are
ime links in north-south
ade. Women of Dahomey
d Yoruba dominate in
arket activities. Ibo men
e now replacing women
marketing and trade.

for decades now—the history of the matter is not at all clear—many women who have slipped over from marketing into trade, particularly if (as with the Yoruba, for example) men did the major tasks in food producing. By the second and third decades of the twentieth century (and perhaps long before that) the major internal trade in produce throughout the West African area was in the hands of women. Although their wealth and their activities have sometimes been grossly overestimated by travelers, it is nevertheless true that some women, particularly from the Yoruba and Dahomey areas, built up large empires in trade, and in some cases became the chief sources of merchandise for European import and export houses.

Today that situation is changing. Competition to market women is coming from men who are grasping more and more of the trading opportunities as the market expands and becomes central, rather than peripheral, to the economy. The clans and extended families, or kinship groups, of Ibo in Nigeria, for example, as well as new "firms" of Ibo founded on contractual relationships, are taking over much of the long-distance trade. Ibo women resent the fact that their trade

Dancers and musicians perform in a market in Ghana, *above*. The guns are fired during dance. Medieval marke of Europe also offered entertainme

Tribeswoman examines the wares of a salt seller at Langshi, *above*. Girl at a refreshment stand in a Ghani market, *below*, prepares fruit snac

en their marketing is now being ·ut by men.

sa and Dioula kinship groups, have always provided the most ant link in the north-south trade n forest and savanna, are ex- g their activities. The telegraph the posts and telegraph depart- of the government makes it easy ɔ in touch. These groups own f trucks. The result is that Ibo Iausa trading "empires" are through Nigeria and across its ıries into neighboring coun- Vith the development of trade the communications and trans- on network, the market prin- as entered more fully into the all Africans, and market places ıken on new emphases.

individual transaction in most ı markets involves a good deal gling. Traditionally—and to a xtent today—prices varied with ıus of the individuals involved: her the customer, the more he pected to pay—and he would be ·d to pay less. On the other ·rices in some areas—traditional ean market places, for example rigidly controlled by the king's cracy and by producers' guilds.

rica, labor and time are seldom luated in terms of money be- hese factors of production are ·ributed by the market mechan- once knew a Nigerian who car- xteen gallons of palm oil on d almost fifty miles to market. I asked why he did not take a e said he did not want to "spoil ıey." I suggested that he would his body if he did not: his ·as that he would recover. This so much an economic choice— h, from the economist's point , it can be so considered—as dis- that his labor might be sold. marketing is not distinguished ving. The economy cannot be ıished, in such cases, from the c economy. Everybody "lives e store."

amount of internal trade that ·ough the market places in vari- ·ican countries is tremendous, ɔody has any idea how much or what value of goods may be distributed in this way. s and measures are more or ent, although in many parts of ıtinent standard weights and es have appeared in the last few

PYGMIES IN CONGO inspect fish for which they will swap meat. Coming to market from outlying areas, Africans exchange news in addition to staples.

Mats for sale in Sura, Nigeria, made from split stalks of Guinea co

Containers of varied shape and size measure oil of palm in Doka, Nigeria.

Roots and bundles are lashed to top of Nigerian shopper's hat in Ka

Hat salesman in Nigeria sits beside fezlike headgear in market at Panyam.

s. The quart beer bottle. the rd-size cigarette tin and four- kerosene tin, and an empty shell casing, for instance, are all s measures. There are also many ndardized units of measure- Moreover, no formal records are y individual marketers.

n those marketers who do a little trading along with their market- ver separate their marketing or rading from their domestic ac- . Obviously, acquiring any kind ntitative ideas about the amount value of such goods becomes a n data acquisition that has ly been tackled, let alone solved.

true that vast quantities of local oduce such as food, craft prod- ivestock, cloth—everything that taff of life and the basis for pro- ng society — may go through narkets in parts of West Africa e Congo. Yet in relatively few are people significantly depend- the markets for the basis of their day subsistence.

kets, however, are vital links— re the very nodes—in the trans- on network. The famous "bush ph"—the rapid spread of news ans unknown to Europeans— in part through the market Africa is a country on the and it appears that it always has However, the peace of the l era and the improvement of that accompanied it meant that places increased in number, e amount of travel to and from ing increased vastly, and there- e bush telegraph worked with and better efficiency.

kets are, throughout that part continent to which they are in- us, organized under political ity. Indeed, in those parts of nd South Africa to which they een introduced, it was colonial ment that introduced them. In tribal areas of West Africa, retain direct control over the s and either themselves or h special deputies maintain the place and keep the peace with- In other areas, committees of representative in whatever way sidered important to the com- , take it as one of their most civic duties to maintain a place so that their part of the can be "kept on the map" and rity can reign.

All African market places are policed by someone. In many areas, this task has gone to the policemen of the regular local government. In others, however, they are policed by special appointees, by kinsmen of the chief, or special groups designated by the chief or by the elders. These policemen are always subject to the authority of somebody who is the headman (it may be a committee) to whom they can refer wrongdoers and disputes that occur in the market place. Disputes inevitably arise in market places, because people may cheat each other, and because they may meet their enemies and their debtors. For this reason, every ordinary African market has, as a necessary concomitant, some place in which a court is in session. It may be no more than a market court concerned with arguments over shortchanging, quality of goods, and petty theft. In other market places, however, the judges of the local government may set up their courts.

In some parts of Africa, the market authorities enforce quality control. They disallow the sale of rotten meat or other unsatisfactory goods. The usual approach to questions of quality is *caveat emptor*, but some control is maintained, the degree varying with the personalities and power of the market officials.

These administrators are usually rewarded. They may be paid salaries by the local government. They may, on the other hand, be allowed to make a levy on the goods sold in the market. Sometimes entry fees are demanded from marketers who intend to sell goods. The amount of the levy or entrance fee is itself subject to what the market will bear. If the levy is too high, traders and marketers will avoid such market places and establish new ones nearby. The only way to avoid this is for governments to demand control and licensing of market places—a situation that was fairly widespread in colonial Africa and is found in a few of the new African states.

Market places can "die," which means merely that people cease to come to them. They can also be "stolen," which means that one gains popularity at the expense of another. In short, the location of market places, their organization, and their popularity are all highly volatile and subject to quick change. Since it is to the advantage of individuals and government officials to control large popular market places (by so doing they are able to see and influence large numbers of people), few petty tyrannies can be kept up for long.

In traditional Africa, almost all market places were associated with religious activities. That is to say, they were consecrated in one way or another, and to this day, most African market places have shrines associated with them. Such consecration guaranteed that supernatural sanctions would back up the political authorities in their maintenance of peace in the market place. These sanctions, and the shrines that were their symbols, varied with the particular tribal religion in question. They may have been no more than a bundle of "medicine." In many areas they were specially consecrated trees. In some, there were special small huts with carved figurines in them. It is well recognized that it is impossible, in even the best-policed market place, to be sure that all who cheat or steal or water their beer or sell bad meat will be caught by the mundane authorities. Therefore, it is best to reinforce vigilance with supernatural sanctions.

Violence can still occur, however. Today weapons are forbidden—and usually were so even before colonial governments reinforced the practice. Moreover, throughout the indigenous market area of Africa, people sit in the position in the market place closest to the path leading to their homes—this is particularly true of women marketers. Such seating arrangements keep the escape routes open. Yet, market places are, at the same time, often legal sanctuaries, because of their position of political neutrality and their consecrated shrines.

MARKETS are also fun. Each displays an element of the fair or the carnival. In West Africa and the Congo they are major centers of entertainment. Dancers come to the market and display their skills. Work parties, wedding parties, christening parties, and spur-of-the-moment parties come to the market to dance and sing and to announce their good news to enlarged audiences. In all these regards African market places are reminiscent of those in Europe during the Middle Ages (and indeed up into the eighteenth century), which were also fairs held in the shadow of the church and policed by the bishop and the market-master and their officials.

Different market places specialize in

different goods and in different activities. One market is a good place to buy Y and sell Z. The next one may be well known for its beer drink, and the one after that for its wise counselors and judges. Such specialization, when combined with the fact that markets do not meet every day, lead to two vital points about the marketing system of western Africa and the Congo particularly. First, every community is at the center of a group of markets that meet every fourth, fifth, or seventh day, depending on the tribal area. There is, therefore, an association of market places with time as well as with special products. In a neighborhood with markets that meet every five days, each community is likely to be either at or near the center of a ring of five markets, each of which meets one day of the five-day "market week" that results. These market rings overlap in a chain-mail fashion, and spread across the countryside. With a few gaps they run from Dakar almost to the Nile, and south well into the Congo Basin.

The other major characteristic of the market system is that goods can move through market places and traverse very much greater distances than can people themselves. Every different African product that goes through a market place follows a route based on the specialization of market places and the successions through which the product passes. A large number of "middlemen" add to the price, but the markup is amazingly small, considering the number of intermediary links that may separate a producer from a consumer.

Thus, market places provide another map, based on a different institution, by means of which space, time, and social structure are co-ordinat This market map permeates differ tribes, different cultures, and cros national and language barriers. I market place is commonly used several tribes, the consecrated shri and the ritual that surrounds th contain elements from each tribal ligion. There may be, indeed, v highly original rituals consciou created and especially performed order to get in the vital elements fr several religious systems.

One of the first reactions to color control was the vast expansion in number of market places in Afri and of the goods that went throu them. Only later did the market pla themselves begin to dwindle as th task was taken over by modern tra port systems and expanding firms a thousands of entrepreneurs, so petty, some handling large volume.

Tailor in the Bida market, Nigeria, presides at sewing machine under tree.

Disputes are dealt with by offici in a market place in southern Moroc

ortance of market places grew the importance of the market le also increased. The "market" its senses was spreading.

pean governments encouraged wth of market places, and by cing coinage and demanding es be paid in it (and abetting ation of goods that could be with it), they actively hastened rgement of the social scope for rket principle.

ey is probably the most impor- gle item in the changing of an y. Money is a cultural trait that n discovered several times in tory of the world, including places in Africa. However, money and money.

ca had some examples of general money—cowrie shells in a few n West Africa and the Congo ch. Most African money, how- rved only one purpose and can ed "special purpose money." mple, the metal "hoes" of the Guinea and Liberia were used ly for bridewealth: aboriginally, one could not use them to acquire subsistence; during the era of the slave trade, many of the items included in the "sortings" of goods with which slaves were purchased were limited to payment and were not standards of value; they were also the prerogative of certain political figures.

Modern economic change in Africa is the result of the victory of general purpose money and the concomitant spread of the market in both senses. When that economic situation is combined with the kind of polity known as the nationalist state, we see three fundamental tools that have helped create the African revolution.

ONE vivid example of the spread of the market principle in Africa must suffice. In many parts of the continent, a man had to purchase rights in his bride. Those rights could be paid for only in a special purpose money—if such were not the case, the transaction would amount to a monetary *evaluation* of the bride, a situation that Africans both joke about and seriously deny. Bridewealth in East Africa was paid in cattle; in central Africa in spears; in West Africa in cowries, metal rods, or some other special purpose money.

When special purpose moneys were undermined by government introduction of general purpose money, it often happened that coinage came to be used to pay bridewealth. For the first time, brides "entered the market." One could work, or trade, or sell produce, and then save coinage and buy a wife. Wives traditionally never entered the same market as farm produce, because there was no "money" that could evaluate both. The spread of the market, here and in many other areas of life, has created great moral problems.

In rural Africa, the noisy, colorful market place is a growing phenomenon. But a reverse trend has also set in: in urban centers, the market principle and its institutionalization in the firm have begun to take over. The market principle is becoming dominant, and the market place is being turned into the supermarket.

By FREDERICK J. DOCKSTADER

Totem Poles: Family Trees

thwest Coast Indians symbolized their histories in wood

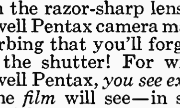
rthwest Coast Indians are well for their sculpture, and these utstanding examples represent ions of totemic art. They are larly interesting for what they their owners. All are from the , one of the three branches of mshian Indian peoples living the Skeena River, in British bia. Thanks to Dr. Marius Barbeau, the great Canadian ethnologist, records and names of many of the carvers have been preserved.

The segments of design present a "family tree" or narrative history of the owner and are placed outside his home. The famous Skaimsem Pole at Gitwanlkul *(far left)* was carved about 1870-80 by Hesemhliyawn, one of the greatest of Kitksan sculptors. The design shows the mythical character Woodpecker perched atop the children of the legendary Mountain Eagle, who in turn protects the many children of Git'weedzarat, who holds his favorite son in his arms. These were all ancestors of the Wolf family, of which Weerhe—in whose honor the pole was erected—was head chief.

Also fronting Chief Weerhe's home is the Kaohdihgyet Pole *(third from left)*, carved somewhat earlier by an unknown Nass River artist. It is a complex repeat design of the mythical Split Person with Weerhe's children—a tribute to his large family.

Two basic forms of totemic symbolism occur in the Tsemelih Pole at Gitsegyukla *(second from left)* and a pole at Kitwanga *(below)*. In the Tsemelih Pole, the design of an animal with a flat tail curled against the body, chewing on a stick, identifies Tsemelih the Beaver. The Kitwanga Pole shows Gyedemranptaw, a legendary forebear, holding a song stick or a chief's staff, an indication of prestige.

Thus one can "read" these poles, and gain an introduction into the family of the owner. But knowing such symbolic designs is not enough, for the reader must also be familiar with Tsimshian legend. For example, Tsiwiladaw, an ancestor of Chief Weerhe, secretly adopted a woodpecker as a pet and hid it in her house, where it grew into a mysterious monster. This episode is merely suggested in the design. Just recognizing a woodpecker on the pole would not suffice in reading such heraldic insignia—one must also know why the design was included.



About the Authors

Mr. Robert H. Dyson, Jr., author of "Sciences Meet in Ancient Hasanlu," is Associate Curator of The University Museum at the University of Pennsylvania. Mr. Dyson, an archeologist and anthropologist, has specialized in the area of Asiatic prehistoric archeology.

"Rarely Seen Songbirds of Peru's High Andes" is the work of Dr. William G. George, Assistant Professor of Zoology at Southern Illinois University. The illustrations that accompany Dr. George's article are by Mr. Arthur Singer, who is recognized as one of the leading bird painters in the United States.

The preparation and uses of topographic maps are the subject of Messrs. Morris M. Thompson and Julius L. Speert, civil engineers with the U.S. Geological Survey. Mr. Thompson is Deputy Assistant Chief Topographic Engineer for Research and Technical Standards. Mr. Speert is Chief of the Operations Research Unit of the Control Surveys Section.

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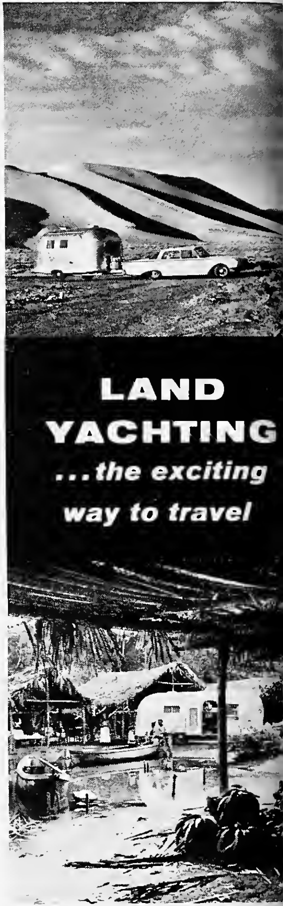
Drs. John J. Lee and Hugo Freudenthal wrote their article "as a by-product" of studies on planktonic foraminifera made in the Department of Micropaleontology at The American Museum, under a National Science Foundation grant to Dr. Freudenthal. The authors are respectively Director and Associate Director of the Living Foraminifera Laboratory. Dr. Lee is Assistant Professor of Biology at New York University. Dr. Freudenthal is Associate Professor of Biology at C.W. Post College.

Mr. Paul J. Fournier, author of "Migration in Maine," is sports editor of the Bath *Times*. He has long been interested in natural history, was a registered Maine guide at the age of eighteen, and has published many articles on natural history and the outdoors.

African market places are discussed by Dr. Paul Bohannan, Professor of Anthropology at Northwestern University, and a Fellow in 1963-64 of the Center for Advanced Study in the Behavioral Sciences, Stanford University. Dr. Bohannan has spent approximately three years in Africa doing field work in central Nigeria and in Kenya. The article was excerpted from his book *Africa and Africans* (Natural History Press), © 1964 by Paul Bohannan.

Dr. Frederick J. Dockstader, author of "Totem Poles: Family Trees," is Director of the Museum of the American Indian, Heye Foundation. He is also the Chairman of the Indian Arts and Crafts Board, U.S. Department of the Interior.



nature and the croscope

reparing your own lood slides

y Julian D. Corrington

D DIFFERS from other tissues in
t it consists of discrete cells and
icles floating freely in a complex
e plasma. It circulates about the
rough the blood vessels and per-
imerous vital functions, grouped
ansportation and protection. The
roach to understanding this all-
nt tissue is to prepare and study
n blood slides; even the beginner
ke first-class specimens.
ials needed for this fascinating
clude blank slides and cover
an alcohol lamp, lancets, mount-
le labels, and one bottle each
buffer, and alcohol. All of these
purchased from biological or
l supply houses.
microscope slides are made of
l grade of non-corrosive glass.
bubbles or striations. The regu-
ize is 3 x 1 inches, with other
special purposes, and they are
in boxes of one-half gross. A
type has a portion of one end
o permit writing on it with pen
il. The slides appear sparkling
hen unpacked, but they should
be cleaned before use and then
only by their edges, which are
round to prevent cuts. Cover
come in various sizes and shapes;
ended for studying blood are 22
ares, thickness 1. They are sold
containing one ounce of covers.
lcohol lamp is a squat bottle
wick and cap and gives a low
Bunsen burner may be used
if it is turned low. Blood-letting
are of many sorts—needles,
plungers—but by far the simplest
olets, tiny little points of stain-
l, each sealed in a paper. They
posable, and their cost is low.
gedorn blood lancet, a straight
eedle 70 mm. long, is also used.
referable stain is Wright's blood
est purchased as a solution ready
because preparing it is somewhat

complicated. It is customarily furnished in a small bottle with a ground-glass top equipped with a dropper, and must be kept closed when not in use. After a while precipitation may occur; to remedy this, add a few drops of pure methyl alcohol. This alcohol is an extremely poisonous fluid and should be handled cautiously. The McJunkin-Haden buffer solution contains phosphates, has a *p*H (hydrogen-iron concentration) of 6.4. and is stable. The best alcohol for the individual experimenter is the commercial grade of isopropyl alcohol, which is tax-free, as it is not potable. The mountant may be Canada balsam or one of the newer synthetic neutral resins. Slide labels are one-inch squares of gummed paper, to be affixed to the left end of finished slides. The pertinent data should be printed on the labels, preferably in black India ink.

Preparing the Slides

CLEANLINESS is of paramount importance in this work. Wash the slides and covers in a thick, creamy paste of household powder cleanser mixed with a little water; then, without rinsing, set them away to dry. As they are needed, polish them with a clean, soft cloth or moist chamois; the residue of powder comes off, leaving the glassware shining and clean. An alternative is to bathe them in alcohol before wiping, then prop them slantingly against some object such as a book or slide box so that they may be picked up rapidly by the edges.

To obtain a blood specimen from your finger, use the following procedure: first,
wash one finger tip with soap and
blot dry, then sterilize with a
cotton dipped in alcohol. Pass the l
through alcohol or, better, throug
flame of the lamp. Pinch the fing
from the two sides until it is suf
with blood, then puncture with a s
light jab. Pinch the finger tip ag
produce droplets of blood.

Reject the first drop and use th
ond. Place a single small drop i
middle and toward one end of a
and immediately hold a second sli
a 45-degree angle to the first, so th
drop of blood is within the acute a
As the drop is touched, the bloo
spread out along the line where th
slides meet. Immediately push
number two along number one, dra
the blood out into a thin film. The

be pulled out (not pushed ahead nclined slide), a process accom- by capillary attraction. In this a thin film can be secured with- ishing the corpuscles. Wave the the air to dry; this fixes the blood 'hen again place the slide in a position, film side up, where it main until further processing.

are several smears in this manner, amine one under the microscope. ed cells are massed or clumped, p of blood taken was too large; are fairly large circles of empty containing no scatterings of cor- , the slide was greasy and im- y cleaned. If most of the slide ems to contain only innumerable puscles and few, if any, white les, the drop was too large, and tes all followed the pushed slide nd of the first one. In a correctly d smear, the corpuscles are uni- distributed.

take two cover glasses. Place a rop of freshly drawn blood in the of one, and immediately cap it e other, so that the corners of the project. Then quickly slide the art sidewise without lifting or g. When properly done, there be an even, thin film on both Wave them in the air to dry, and lm side up, against some object. aking these films, on either slide r, speed is essential to prevent ortem changes of the blood cells. n all actions quickly, but remem- t you may have a number of fail- fore you achieve satisfactory re- nother essential is sterilization. be certain to sterilize the skin e lancet before the puncture is and sterilize the wound again ithdrawing blood samples.

Staining

a number of slides and covers epared with dried blood smears, ready to proceed with staining. a counted number of drops of 's stain on the smear. Use quite or the slide, one or two for the glass—enough to cover the area h to stain, but no more. You may this stain with a toothpick or a p tube of fine paper. Allow it to ne minute, but bear in mind that t batches of Wright's stain vary at and one can never tell the ming until a few trials are made. without draining or disturbing the add twice as many drops of the solution for twice the length of xample: two drops of Wright's minute; four drops of buffer for nutes. Next, drain into a waste cle and flush with distilled water further action. Now examine the under the microscope. The red les, which cover the field and are

enormously in the majority—625 reds to one white—should be a salmon-pink; the whites should show a nucleus that is blue to purple. In order to check your staining, have handy a colored plate of human blood corpuscles under Wright's stain. This can be found in any histology textbook. If the nuclei of the white cells are not sufficiently stained. the duration of staining was not long enough or the destaining with the buffer was too long.

This microscopic examination must be done quickly, as the distilled water on the slide will continue to destain. When judged satisfactory, blot the preparation gently with filter paper and wave it about to air-dry. With films you wish to keep only for a short period, use films on cover glasses. These may be examined by placing the cover, film side up, on a blank slide. Films made on slides should be neither covered nor labeled; they are to be used only with oil-immersion lenses. The reason for allowing them to remain uncovered is that the preparation keeps better and the stain does not fade as rapidly. After each use, flush off the oil with benzene.

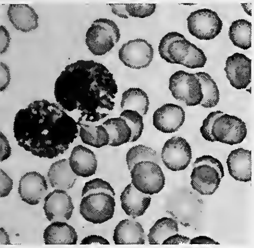
To make a permanent mount of films made on cover glasses, invert the cover, film side down, over the center of a clean slide on which a medium-sized drop of mountant has been placed. Gently lower the cover, first touching one edge to the slide, then letting it drop, allowing the mountant to spread out evenly. Label and keep flat until dry, then store or proceed to study. Should you have a good film, but an unsatisfactory staining, use buffer until the slide is destained and then repeat the staining procedure.

Studying the Slides

Blood is composed of a fluid plasma and a solid content, not all of whose materials are cells; hence the term "formed elements" is usually employed. Erythrocytes, or red corpuscles, comprise by far the largest percentage of these formed elements. Their function is to transport oxygen from gills or lungs to tissues and cells all over the body. They are biconcave, circular discs in all mammals except members of the camel family, in which they are oval. In all mammals erythrocytes lose their nucleus during the final stage of their formation in the bone marrow, causing the profile shape to change from biconvex to biconcave. Lacking nuclei, they are not complete cells and some histologists prefer the more precise term of erythroplastids. In vertebrates below mammals they are true cells, nucleated and oval.

In a film of fresh blood, red corpuscles are not red, but a faint greenish yellow. In mammals, the bright red color results when these corpuscles are piled up in a layer of appreciable thickness. Then they transmit the red end of the spectrum and absorb the blue end, because presence of the pigment hemo- the characteristic element of s iron. In most arthropods the is hemocyanin, with copper as inant element, which combines ygen to impart a blue color.

ost effective way to study eryth- is to place a medium-sized drop blood in the center of a slide it immediately with a cover he shape and size of these cells n be examined in fresh condi- te that because of their adhesive- ey tend to stack up in overlap- ws, like a spilled-over pile of hese stacks are called rouleaux. few minutes, as the film begins t the edges, cells with spiked —crenated corpuscles—will be l, their change in shape caused kage from loss of water. If dis- ter is added at the edge of the it can run under and dilute the asma, the corpuscles will absorb r, swell up, and become faint . In this swollen condition, they ed "blood shadows." If the ab- continues, they will burst. In stained blood the center of each will appear either darker or han the periphery, according to th to which the microscope is ; the uninitiated may mistake the or a nucleus. But as the focus ed, this appearance also alters, results merely from the bicon- pe of the cell. In sections of stained with a combination of ylin and eosin, the red cells are in a properly stained Wright's ey are salmon-pink, a color that sed as a guide for judging when is correctly stained.



HILS in a field of red blood cells.

Leucocytes

hite blood corpuscles, or leuco- , are the only true cells in the ecause they possess nuclei. When ing they are spherical, but they remarkable power of changing sending forth pseudopodia, like ba, so are said to progress by d movement. They may force y between adjacent cells in the capillaries and pass out into the ling connective tissues, then re- he blood via lymph channels. In a dried blood smear white cells become flattened and their size is larger than when they are circulating—the reverse of the erythrocytes. They may be kept alive for some time on a warm microscope stage. Although the precise function of most of the different types is still not well understood, leucocytes have been called the police force of the body. This is because, in addition to their amoeboid movement, some white blood corpuscles form food cups of pseudopodia, like an amoeba, and ingest such solid particles as bacteria. This ingestion process is known as phagocytosis, "eating of a cell," and is one of the methods by which the body combats infection.

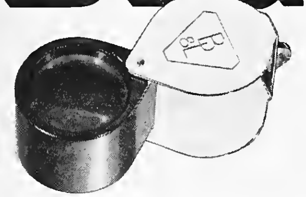
Leucocytes are divided into two main classes, the agranulocytes and the granulocytes—those without and those with numerous distinct granules in the cytoplasm. The agranulocytes, in turn, include two kinds, lymphocytes and monocytes. Lymphocytes embody the smallest of white cells—the average size is 6 to 8μ in diameter, although they range up to 15μ. It is believed that their main function is the production of antibodies following infection. They make up 20 to 25 per cent of the white corpuscles.

When stained, the small lymphocytes appear to be almost entirely composed of a spherical, dark purple nucleus. A thin rim of cytoplasm that has stained robin's-egg blue surrounds the nucleus. As the cells increase in size, the relative amount of cytoplasm also increases. An indentation in one side of the nucleus, scarcely evident in small lymphocytes, becomes more prominent. The cytoplasm may contain a few large granules, but these are not constant.

Monocytes are scarce. They comprise only 3 to 8 per cent of the white cells, and range in size from 15 to 20μ, becoming the largest corpuscles of the blood. In color, the nucleus is lilac, rather than purple, and its form varies—it may be oval, kidney-shaped, horseshoe, or twisted. The cytoplasm is grayish blue and somewhat granular.

Granulocytes always have large numbers of specific granules in the cytoplasm, and a nucleus that is spherical in young cells. As the cell ages, it shrinks and divides into increasing numbers of lobes connected by thin strands.

Most numerous of all leucocytes are heterophils, called neutrophils in man. The granules in this type are so numerous and fine that they cannot be counted. Heterophils are neutral in staining, and take on a lilac coloration with Wright's. The nucleus is three- to five-lobed and stains a deep blue. Recent investigation has discovered an amazing sex difference in the cells. Those of females show a small knob, called the drumstick, at one side of the nucleus, connected to the main mass by a slender stalk. The drumstick is thought to represent the sex



Dr. Corrington, who is well known in the field of microscopy, recently retired as Professor of Zoology at the University of Miami in Florida.

chromosome and to be present in all female neutrophils, although it has been observed in only about 3 per cent. The cell must be flattened in just the right plane for the drumstick to be visible.

Eosinophils comprise only 2 to 5 per cent of the white cells and average 12μ in diameter. In a properly stained smear they may be spotted instantly by their many large, bright red, cytoplasmic granules, large enough to be counted. They often obscure the nucleus, and seem at times to project from the periphery of the cytoplasm. The nucleus is bilobed, often C-shaped, and blue.

Basophils are so uncommon that they are encountered rarely and with difficulty, for they make up only one-half of one per cent of leucocytes. The granules are like those of eosinophils, but stain a dark, purplish blue. The function of basophils and eosinophils is unknown.

Blood Platelets

Blood platelets are bits of cytoplasm broken off from the pseudopodia of megakaryocytes, the giant cells of bone marrow. Their enumeration is difficult because they adhere to each other and to every surface with which they may come in contact. Some authors believe them to be present in the ratio of 250,000 per cu. mm. of blood; others give a figure as high as 750,000. Their shapes vary from circular to irregular, and their diameter ranges from 2 to 4μ. With Wright's stain, a platelet has a purplish-red, granular color body or chromomere—either central or peripheral—and a pale blue, refractile, clear hyaloplasm. Platelets occur only in mammals, and function as part of the blood-clotting mechanism.

The study of blood can furnish many fascinating hours to the careful microscopist. This article has tried to provide an introduction to technique and identification. There are many other aspects of the subject we shall undoubtedly touch on in future discussions of microscopy.

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Arthur Singer
16-25— R. H. Dyson, Jr., except 16-bot., Courtesy of British Mus.; 19-AMNH after R. H. Dyson, Jr.
27-28—Arthur Singer
29—AMNH after William G. George
30-36—U.S. Geological Survey, Dept, of Interior except 31-bot., Ansel Adams
36-37—Bot., Fairchild Aerial Surveys, New York
38-43—Leonard Lee Rue III—Annan Photo Features
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54—Colin Turnbull
55—Rada Dyson-Hudson except bot. right, Robert M. Netting
56—Colin Turnbull except center, Robert M. Netting; top left, AMNH after Paul Bohannan
57—Colin Turnbull
58-60—Robert M. Netting except 58-bot. right, Marilyn Silverstone—Nancy Palmer Photo Agency
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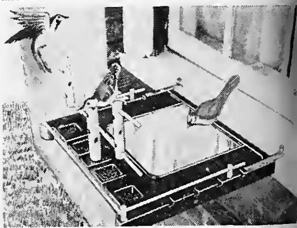

A gathering of gifts to place beneath the Christmas Tree...

ELAND The serenity of this sculptured doe with fawn is universally appealing. Carved by Kenya tribesmen of indigenous Mvuli wood, no two pieces are exactly alike...$5.50

ONYX HORSEHEAD BOOKENDS The luster, translucence and beautiful grain of these matched pieces from Mexico highlight the classic lines of the handcarving. 7″ high... $11.00 pair

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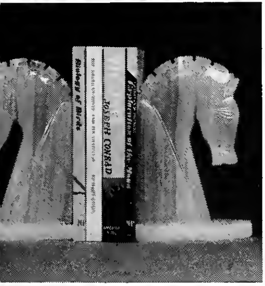

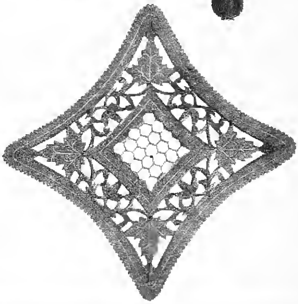

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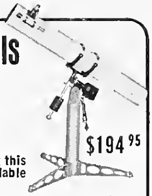

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THE HERITAGE OF PERSIA. Richard N. Frye. *World Pub. Co., Cleveland. 1963.*

IRAN FROM THE EARLIEST TIMES TO THE ISLAMIC CONQUEST. R. Ghirshman. *Penguin Books, Ltd., Harmondsworth, 1954.*

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RARELY SEEN SONGBIRDS OF PERU'S HIGH ANDES

THE BIRDS OF COLOMBIA. R. M. de Schauensee. *Livingston Pub. Co., Narberth, Pa., 1964.*

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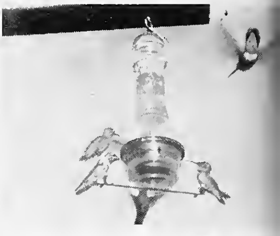

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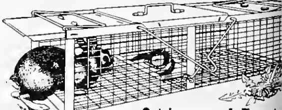

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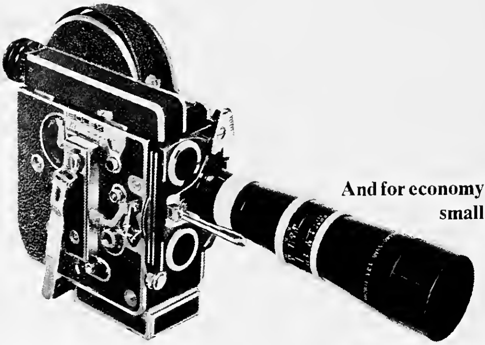

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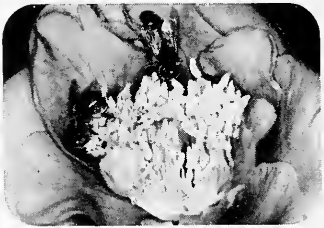

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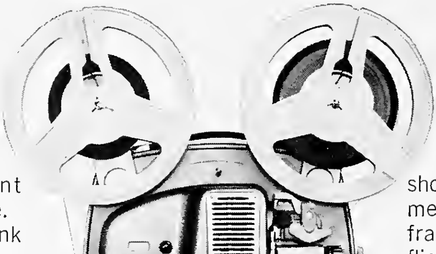

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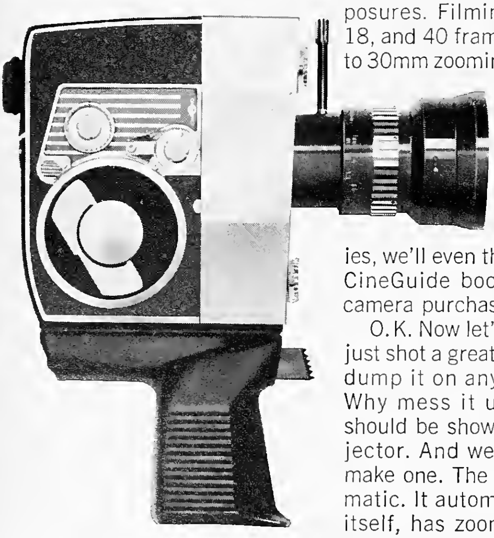

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Vol. LXXIII NOVEMBER 1964

ARTICLES

DEPARTMENTS

COVER: The water scorpion, seen impaling a guppy in a laboratory tank, an interesting combination of characteristics. First, it is not a scorpion; it i insect. Second, it looks like a walking stick. Third, its habits are very sin to those of the carnivorous, cannibalistic praying mantid. *Ranatra fusca* Beau the most abundant species in its North American genus, can be found in m fresh-water ponds. Its fascinating life history has been studied in detail by Syd Radinovsky, whose article begins on page 16. He took all the photogra accompanying his text, in addition to the extraordinary portrait on the co

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APPRENTICE

These young men are preparing for important careers with General Motors. Under the GM apprentice plan, they are learning the diemaker's skills. Once they have mastered this craft—and it will take them four years (8,000 hours) of on-the-job training and classroom study—each will be a skilled journeyman, qualified to make the complex dies, jigs and fixtures so vital to modern industry.

This year, 2,753 General Motors apprentices are being trained for this and other trades—more than 30 in all. They are learning to be pattern makers, pipefitters, bricklayers, toolmakers, diesinkers, electricians and millwrights, to name a few. From the time they start training they are paid good wages on a regular rising scale.

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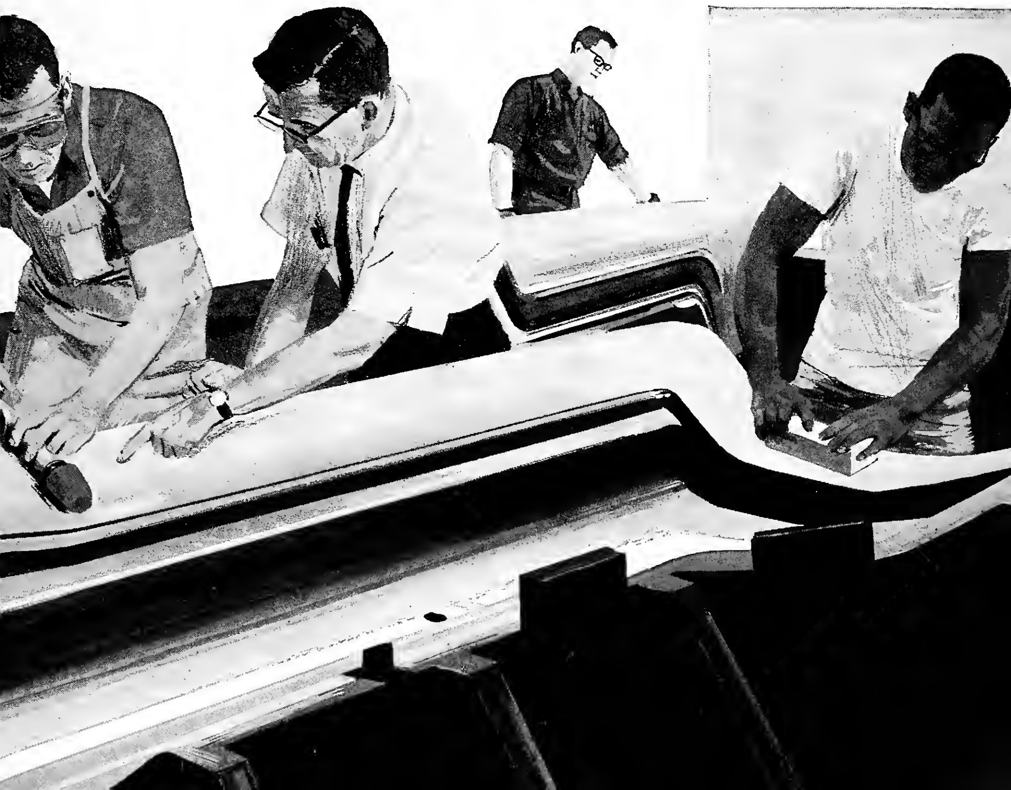


Natural History's 1964 Surv

For the past four years, this magazine has printed in its December issue a review section devoted to books in the biological sciences published for young people. The appearance of the fifth annual survey in this issue reflects a direct response to a demand.

During the last two years or so, an increasing number of teachers and librarians have asked us to schedule the review at an earlier date. Their reasons are twofold: first, schoolbook purchasing time takes place during the months immediately after the fall term reconvenes; second, school purchasers sufficiently respect the opinions of our reviewers to want to check their comments before buying. We hope this year's change will be of help to those members of our school systems who are faced with the enormous responsibility of weeding out the mass of available science literature. We also hope it will give a little more time to the Christmas gift buyer.

As in previous years, the survey has been prepared by reviewers who are members of the scientific staff of The American Museum of Natural History. The 71 books reviewed all deal with the biological and earth sciences or with astronomy and space—disciplines that are either directly or peripherally related to work carried on in the scientific departments of the Museum or The American Museum-Hayden Planetarium. As a result, many excellent books in the physical sciences must automatically be eliminated from our consideration. This is regrettable but necessary in view of the Museum's frame of reference.

It might be of interest here to mention the symposium on science books for young people that was in the planning stage as this section went to press in 1963. Sponsored jointly by the Graduate School of Library Sciences at Rutgers University and Natural History, it attracted over 300 men and women from several states to New Brunswick, N.J., generated much heat, and may even have shed a little light on the question of how to judge a science book.

Although it is impossible to speak here for the others who attended the full day's meeting, it *is* possible to speak for the reviewers who participated. All felt the exchange of opinions among authors, publishers, librarians, teachers, and reviewer-scientists was extraordinarily stimulating. All felt an increased responsibility to the reader.

As in previous years, reprints of this year's survey will be made available without cost to teachers and librarians who write us on their official letterhead and include a stamped, self-addressed envelope. Any other readers who wish reprints may obtain them at the cost price of 20 cents apiece.

All requests should be sent to: Reviews, Natural History, Central Park West at 79th St., New York, N.Y., 10024.

Anthropology

This year it has become evident that it is impossible for a social anthropologist adequately to review the archeological books now being written for young people. This is partly because of a rise in the level of sophistication and abstraction in the books concerned, and partly because of the ever increasing complexity of the field—each branch of the general anthropological discipline is turned further within its specialized self. Particularly with books for young readers, who lack the critical facility of more-advanced students, one must be sure of the facts, and one must be able to separate opinions from those facts. Therefore, I have consulted with Shirley Blancke on the general archeology books and with Dr. Junius Bird on the book dealing with Peru (both are with this Museum), and this review includes their opinions on those volumes.

Adventuring in Archaeology, by C. A. Burland (Frederick Warne), is written to create an interest in archeology, and it will probably succeed. It consists of one- or two-page synopses of various archeological topics accompanied by many good illustrations. Unfortunately, however, much of Mr. Burland's information is inaccurate or misleading. His plan of Stonehenge bears little resemblance to the monument, and his description of its use by prehistoric stargazers is completely unfounded. To build a model of a house on pilings sounds like fun, but the author leaves one with the nineteenth-century misconception that the Swiss Lake Dwellings were erected high over water, when in fact the pilings were deep foundations in marshy lake shores.

Curiously, the pile-dwelling myth has also crept into a book that is on a much higher level scholastically. Dr. Gordon C. Baldwin, in *The World of Prehistory* (Putnam), provides a great deal of detailed information about man's past in his descriptions of various "firsts"—first inventions, and so on—but the book is rather dull. It could have been leavened considerably by good illustrations, but apart from one or two maps the pictures are restricted to small drawings above the chapter headings.

A more lively, if semifictional book is *Worlds Lost and Found*, by Azriel Eisenberg and Dov Peretz Elkins
ard-Schuman). It is a collec
stories, half of which deal with
literary sources, and half with tl
vation of biblical towns. These
are anecdotal, along the lines
am's *Gods, Graves and Schola*
contain some fictional conve
based on fact. They are told in
sorbing fashion, and the descri
the method by which Egyptia
glyphics and cuneiform script v
ciphered is interesting and not i

The Search for Early Man, I
E. Pfeiffer (American Heritage
vivid and arresting account of Ol
Age man and some of the mode
who have dug him up. It prese
kinds of problems archeologis
when probing the distant past,
nature of the evidence on whi
base their deductions. The illus
of sites and archeologists at w
excellent, but some of the recon
scenes of Old Stone Age life shou
been omitted, for they give the
sion that Paleolithic man wa
lievedly moronic. However, this
worth reading and conveys the
phere of genuine archeology.

Gold and Gods of Peru, by Ha
mann (Pantheon), is a specific
tailed book dealing with P
archeology. It is richly illustrat
highly attractive. It does have
small errors, but these do not o
book's value, as it is not writ
specialists. Mr. Baumann's book
stimulate an interest in Peruvian
tory and the Spanish Conquest.

Various events are described
the eyes of witnesses and partic
some real, some fictional. An
boy, captured by the Spaniards,
Pizarro's arrival in Peru. Guamá
De Ayala, the remarkable sixtee
tury writer and artist, tells of t
toms and past of his people, and e
of his drawings are used to il
his comments. The color plates
cellent and the Andean spe
scenes, and people were well ch

Moving into the realm of con
ary peoples, and in particular tl
the North American continent, v
first mention two books that do n
erly fall within the scope of this
but should nonetheless be me
Monuments in Cedar, by Edw
Keithahn (Superior), has a t
contents that suggests the auth
a juvenile audience in mind. I
text and arrangement of the bo
this. The art and religion of the
west Indians, described by m
personal reminiscences and c
chosen pictures, taken by p

f Science Books for Young People

graphers, complement the work. is would reward a serious student, ould not attract a young reader no prior interest in the subject. Keithahn and the same publisher produced another book, *Eskimo ture*, a readable autobiography. It well stimulate young people to a r interest in. and more serious of, Eskimo life. The photographs, at the turn of the century, could been better in content and quality, e tantalizing. I wish a few more photographs had been offered.

) very disappointing volumes are f a series published by Lyons and han. *Indian Legends of Eastern ca* and *Indian Legends of the West.* Both cite Johanna R. M. k as author. but give no indication ow she came by the legends or the ations. Both volumes also carry the same extraordinarily conding introduction by G. Waldo e, full of such paternalistic nonas: "The Indian, like a child, had l remarkably acute in one direcbut undeveloped in others. He grasp but one truth, and that withy abstract reasoning."

tales are not arranged in a way onvinces us of the abstract reasonower of those responsible for the contents. Regardless of Indian nts such as tribal origins or con- role, the legends are lumped unrious states as they exist today, om which we can only guess—since e not told—they were collected. nimaginative, strictly geographiangement deprives the tales, all of are full of intrinsic interest, of ely the background against which would have had full impact and . The illustrations by Richard who is himself an Indian, help the books somewhat less unattracut as science they are worthless. ther book that does not make the is *The Art of the North American*, by Shirley Glubok (Harper & It is lavishly presented with ex- photographs, type, and other hing minutiae, but the text is not the space it takes. Miss Glubok ritten some descriptions of the graphs that do not make a reader wiser than had there been no text And where the text is more genwith information, it is frequently lized to the point of being misintion, or is couched in unfortunate Even with the few words allowed s primarily photographic book, a deal more could have been said of direct significance. As for the picthemselves, they are presented merely as a museological gallimaufry.

There are, however, two good books about North American Indians. Needless to say, one is by Robert Hofsinde. His *Indians at Home* (Morrow) follows his usual, straightforward, simple format. The type is bold and the author's line drawings show something important. In making the home his central theme, Hofsinde again limits himself to a subject he can handle with ease and clarity in a short book. He talks of the Algonquian wigwam, the Iroquois long house, the Seminole chikee, the Mandan earth lodge, the Pueblo adobe, and of the plank house and the Indian home of today. He tells us in a few pages more of the real Indian, his life and thoughts, than all the books above put together.

Also good, but written at greater length, is *Home of the Red Man*, by Robert Silverberg (New York Graphic Society). Early in the book the author writes: "If anything, white men, with their pinkish skins, deserve the name of 'red men' more than the Indians!" I, therefore, wish another title could have been chosen. The book deserves it, for it is a sensible and sensitive general introduction to a study of North American Indian peoples. It covers early history and attempts to depict the different groups of Indians as they were before the coming of the pink man. It is as attractively illustrated—by Judith Ann Lawrence—as it is written, and no attempt is made to pander to lazy young people. This book should interest and inform any intelligent student, and there is a useful index.

Turning to Africa, we are faced with another problem book. *Stories from Africa* (Duell, Sloan and Pearce) are "retold by Shirley Goulden" and gloriously illustrated in color by Maraja. There are only six tales, and although each stands fully on its own, I again wish we could have been told more about how the tales were collected and from where. A short introduction to each tale would in no way have detracted from this book, and I think would have added enormously to its value. Such facts might interest the young reader without lessening the pleasure given by the folk tales.

Africa: Adventures in Eyewitness History, by Rhoda Hoff (Walck), claims to tell us about African history through the written word of observers from Herodotus on. It does nothing of the sort. Presenting African history is not without problems, but there are much more reliable ways of doing it than by citing miscellaneous individuals whose only common qualification seems to be that they have at one time or another set foot on the African continent. Many of the authors are bigoted, ignorant, or idiotic, and it is difficult to see what one can derive from this book except the jaundiced vision and understanding of most of those quoted. Rhoda Hoff's brief introductions to each section only tell us about the writers, who in turn tell us more of themselves than of Africa.

The Vikings, by Frank R. Donovan (American Heritage), with Sir Thomas D. Kendrick as consultant, is as finely illustrated and as attractively presented as one would expect of a Horizon book. The sensible use of consultants enables these books to be presented uniformly, yet with a reasonable assurance of authenticity. They do not set out to be academic but stimulate a healthy interest by arousing a healthy imagination. *The Vikings* does not skirt controversial areas, such as the alleged Viking "discovery" of America, and cites differing points of view.

Finally, having begun by disclaiming the right of a social anthropologist to review books on archeology, it is a pleasure to welcome a book on contemporary peoples written by an archeologist. Dr. Baldwin— who also wrote *The World of Prehistory*, reviewed above—gives us another book, *Stone Age Peoples Today* (Norton). It is a fine offering. It covers hunters and gatherers from all over the world, thus bringing together in one volume a wide cross section of different peoples who can be sensibly compared. Dr. Baldwin chooses not to make the comparisons, but we must certainly be grateful to him for setting forth the necessary material in the way he has.

There are a number of points with which I could take issue. Some of them are quibbles, such as the use of the colloquial term "blackfellows" for Australian aborigines. Dr. Baldwin's insistent use of the term "dwarf" for pygmy peoples is a little more serious for it is an important and significant fact that, while short, they are *not* dwarfed. Generalization is inevitable in a book of this kind, and its limitations must be accepted. Some of the author's generalizations are apt to be gravely misleading, however, as in the statements that most Bushman dances are "purely for pleasure," and that the Andaman Islanders have "the unique" custom of exchanging presents.

A map showing the distribution of hunters throughout the world would have been an asset, but there is a good index, a glossary, and a short bibliography. Dr. Baldwin crosses from one branch of anthropology to another with ease and understanding, and he has given us a real science book that can be used as such in teaching young people.

Just as important, those young people can read it profitably and enjoyably.

Colin M. Turnbull

Astronomy

SPACE exploration is continuing steadily, as expected, and the number of books on the subject is growing even faster. Unfortunately, the viewpoints of most of the authors and publishers are as limited and unimaginative as ever.

One of the worst in this regard is *Gemini and Apollo*, by Gardner Soule (Duell, Sloan and Pearce). It seems to be an exercise to determine how little narrative is required to hold together a collection of forty photos and art pieces acquired from the National Aeronautics and Space Administration and the publicity departments of twelve corporations engaged in spacework. The effort fails.

A better enterprise was undertaken by Irl Newlan, Manager of Technical Information of the Jet Propulsion Laboratory of the California Institute of Technology. He has written an authoritative account of *First to Venus* (McGraw-Hill) apparently aimed at the young space buff who already has a command of space language. It is written about the preparation, launching, and flight of the *Mariner II* mission to Venus, so it ought to be a milestone. Adventure tales should begin dramatically, and this starts as the launching countdown resumes at T-minus-five-minutes after a long "hold" or delay. If a team of psychologists was told to invent some activity that would steadily increase tension and excitement, it could not do better than to use a countdown broken by occasional unexplained and frustrating holds. To understand the reason for tension, one must know what can go wrong, what *has* gone wrong, and how much depends on all going well. I suspect Mr. Newlan lived through much of the adventure he reports, and his editors may have shortened his tale. Throughout the book I have the feeling that editors and a predetermined number of pages forced him to omit much impressive detail, and that the omissions have not been successfully smoothed over. For instance, we read: "Ten seconds until shut-off of the Atlas main engines. Then crisis! She begins to roll! The seconds tick off. 'Mark One, on time!' The booster engines shut off. 'Mark Two, on time!' The booster engines separate. On the thirty-fifth roll, Atlas recovers, stabilizes; only three degrees to spare. Sustainer engine is burning normally." That's nice; but what would have happened if another three degrees of roll had occurred? We'll never know. After one further weak reference to this "crisis," it is forgotten.

This is an excellent idea for a book and might have succeeded had it not been rushed onto the market.

More rocketry is treated in *All Rockets and Space Flight*, by Ha Goodwin (Random House), As Director of the Office of Scientii Technical Information of NASA. not criticize Mr. Goodwin's techn formation about rockets, but I can celestial mechanics are faulty. " velocity is just enough to carry a craft beyond the point where gravity can bring it back agai spacecraft is barely moving as it the point of no return." Many pa used to explain this incorrect idea ally, at the instant of burn out- tion into orbit—the craft may have velocity. *This* is the point of no

The author also misuses Newton of mechanics to "balance" for achieve orbits. The great misfort that the wrong explanations are easier to write and visualize, bu are always those readers who reall to understand, and they will find possible to follow these wrong-pa

One of the better reviews of p post-sputnik rockets and space re is *Our Work in Space*, by Wil (Macmillan). It is written by an plished author, and one who wa ciated with much of the German research in the 1930's. Thus it is re and should be considered author While I feel some of the celesti chanics could be improved, I ca recommend this book for its p

Works concerning astronomy r complete range this year. Two se graphical books are included. *F Astronomers*, by Navin Sullivan neum), is a good book. Mr. Sulliv cusses the accomplishments of ei astronomers from Copernicus to s cent times that four of them ar active. The author has expended a amount of time in research for this and it shows. His dramatic accou discoveries by my contemporaries accurate as my personal knowledg must have been obtained by firs interviews—or secondhand ones at Evidence of Sullivan's control of h terial is apparent in that the tale of the earlier astronomers are j readable as those of living pionee

The Quest of Johannes Keple tronomer, by Barbara Land (D day), shows Kepler to have been more than an astronomer. Any s of science has known of some of h tributions to science, although G his contemporary. has received more attention from biographer historians. It is important to ha "quest of Kepler" chronicled fo younger reader so he may become iar at an early age with this truly mental figure of science. While ce not a biography or even a reasonal count of the life and times of Keple book can be recommended as a cle e statement of his contributions ce in general and to astronomy in ar. I would not recommend it as xposure to science, however, for, . many histories of science, a und knowledge of the subject is if the significance of the devel- s described is to be understood.

e introduction of *Star Maps for rs*, by I. M. Levitt and Roy K. ll (Simon and Schuster), the au- laim a history of over twenty experience with these maps. Ap- it has been worth it. The star e designed for someone quite un- with the sky and, despite their ntional outlines, they succeed ell in giving the user a sense of ensions of constellations relative other and to the terrestrial scene. onth's map is accompanied by a cussion of the mythology pecul- at part of the sky. Although the ive no more (mercifully, even an the unaided eye can see, the pter is devoted to a useful dis- of the practical properties, mer- demerits of binoculars, monoc- nd amateur telescopes. This es the desire of many individuals ate from constellation study to g, thus to advance from a rather inning to a more serious enjoy- the marvels in the sky.

ave been reaching for the moon e they knew it was there; now it lly within grasp. Viewing it r, we have learned much about est world outside of the earth, h of what is known is reviewed *oon*, by Virgilio Brenna (Golden The strikingly realistic and beau- strations will catch the eye first. real photographs of lunar sur- lels built in Milan, Italy. They fully planned to illustrate chang- ination over a lunar "day" with ect to the appearance of the d the background sky. The ex- d relief and stark shadows, re- ly by earthshine, are all there ss the reader with the mood of n world. However, the models jagged to conform to the true the heights and lengths of such Surprisingly, the models also give evidence for stratification, sedimentary rocks exposed in rican Southwest. It is true that elmaker could ask how else the ould be seen in the detail he pre- d we would be forced to shrug. nly beginning to know.

it is possible to criticize the is necessary to praise the book. na has not been dogmatic, he een condescending, gratuitous, s at any point; he has not mini- at is not known, nor that which t to controversy. He has dis- he two extreme hypotheses of crater formation with arguments for and against each. And herein lies the great value of his work: Mr. Brenna has explained the scientific method in the formulation of a hypothesis and in the testing of it. In so doing he is not afraid to use words that should be in the vocabulary of any good high school student.

When, then, will Golden Press abandon its incongruously puerile, gaudy, washable plastic covers in favor of those that might indicate the respect due a young adult audience? When my three-year-old daughter was given a cloth-bound book for Christmas, she exclaimed with awe and quiet pride: "A grown-up book!" Are those in this book's intended audience any less responsible?

The earth is a rotating ball revolving about the sun. S. Carl Hirsch, author of *The Globe for the Space Age* (Viking), introduces the young reader to this fact with enough discussion to prove how inadequate any flat map must be in the representation of large areas. Some critics may remark that his explanations are incomplete, but others will point to the virtue of not telling too much. Anyone will get the feeling of space and sphericity, which the author has intended, and the reader may well wish to learn more of the problems of cartography, geophysics, or astronomy.

And now we come to the less palatable fare. Astronomically, *The Solar System*, by Angelo Rocca (Duell, Sloan and Pearce), is acceptably correct (only about three minor errors of fact were noted), probably because the book is superficial. One usually cannot go far—right or wrong—in fifty-eight pages. But I wonder why this Italian book was translated into English. It may have been useful in the Italian market, but it seems to fill no significant void in America. As gaudy as *The Moon*, the illustrative material is all artwork. The artist is good and, as such, enhances the verbal exposition. This is often necessary, but if a good artist merely abstracts excellent photographs, what is the purpose?

All astronomical observation is conducted through the gathering and analyzing of electromagnetic energy. Light and radio waves are all-important to the astronomer, and must be thoroughly understood. *Light*, by John Rublowsky (Basic Books), is no help in spite of a positive statement by Willy Ley in the foreword. Perhaps he didn't read the book. The author insistently shows his ignorance of Galileo's chronology. He also clearly misunderstands stellar structure and evolution, and how the cosmic abundance ratios of the elements were determined. In one paragraph he says, "Color can exist only where there is strong light." He follows in the next with, "Actually, colors are not really colors at all. Ordinary sunlight, as is shown by the rainbow, consists of all the colors of the spectrum." He never says that color is a physiological response to the wavelengths of the light entering the eye. Mr. Rublowsky also must misunderstand how a prism deviates and disperses light or he would not have allowed his name on a book with an incorrect illustration of the subject.

Passing on to the glossary at the end, I count twenty-one wrong or misleading definitions out of seventy-five attempts. This book cannot be recommended.

Another work in my growing collection of horrible examples is *A Short History of the Universe*, by Arthur S. Gregor (Macmillan). Mr. Gregor writes well, but with frequent errors. On one page he misplaces the Magellanic Clouds by over 40 degrees. A 600-foot radio telescope is pictured, although the construction of this instrument was canceled in 1962, two years before the copyright date of the book. Later, Mr. Gregor begins a tale of stellar evolution, which is quite wrong, and which he uses again in the book. In another example, he says, "Stars differ in size, color, brightness, temperature, and chemical composition. Such differences indicate that stars evolve from one stage to another." No one who thinks can understand how the one statement can be related to the other. Yet there it stands in a book, and "books contain all knowledge" school children are trained to believe. "Since this is science, and I cannot understand it, I cannot understand anything scientific," a student might say, using perfect logic. What a pity!

It is beginning to appear to me that some bad authors read other bad authors and perpetuate the same faults. As only one of the many examples I could mention, the 600-foot radio telescope error appears in both *Short History* and *Light*. Perhaps some writers do all their research at high school science fairs. Popularization does not mean "write a book with drama and small words." It means that an author must understand his subject and explain it competently to interested but untrained people to the satisfaction of audience, editor, and scientist.

K. L. Franklin

Botany and Ecology

The seven titles I have reviewed this year include five books in the general field of conservation, one on microbiology, and a biography of an important but little-known American naturalist of the nineteenth century. It is a pleasure to note that most of these books are excellent in their coverage, interestingly written, and reasonably free of technical or interpretational errors. The matter of errors in scientific information has been a particular point of criticism in previous reviews in this series. Although this year's books indicate a much more careful approach to scientific information, and the subject matter is for the
part applied biology, the texts c
few basic biological facts or con
It seems to me that there is a con
attempt to avoid rather than to p
such facts and concepts accurat

Microbes and Men, by Harold J.
(McGraw-Hill), one of the series of
tas of Science Books" produced b
National Science Teachers Assoc
with support from the National C
Institute, is an exception to this
alization. It considers important a
of basic and applied biology, pr
them concisely and lucidly, and ap
to be well researched and car
written. (Since I am not a microbiol
this evaluation is that of an inf
layman.) There is a brief introd
to the history of the discovery of
organisms and of their roles in b
chemical cycles and diseases, and d
sions of the size range of micro
isms, their phylogenetic relations
their astounding reproductive capa
and unbelievable populations—"A
ful of soil contains more bacterial
than the total number of human b
that have ever lived on the earth."
ogenic bacteria, methods of preve
infection, structures and processes
human body that inhibit or destro
croorganisms, methods of transmi
and techniques for detecting and i
fying microorganisms are lucidly
ered. An especially interesting ch
concerns chemotherapy and anti
Teachers and students will also ap
ate the list of projects and experin

Three books—*Conservation: The
lenge of Reclaiming Our Plun
Land*, by C. William Harrison (
ner); *Conservation and You*, by
S. Hitch and Marian Sorenson
Nostrand); and *Ours Is the Eart*
Allan A. Sollers (Holt, Rinehart
Winston)—are complementary cove
of conservation in the United S
Harrison's approach is historical
other authors limit their texts larg
contemporary problems and prac
The history of a subject can be m
dynamic, fascinating analysis of i
philosophies, contemporary leaders
selected cause-and-effect case hist
Harrison adopted this approach, a
tells of a pristine continent that wa
washed by thin breakers of explor
and then by a tidal wave of exploit
that passed rapidly over the land
left eroded and depleted soils, rav
forests, and exhausted mineral de
in its wake. However, his objective
to damn our despoiling ancestors.
understand the shifting philosop
natural resources. This philosophic
ysis of the times may be the mos
portant concept of the book. The u
lying thought of each era is con
stated, and clarified by real or,
conversations were unrecorded, ficti
quotations from a man of the time.

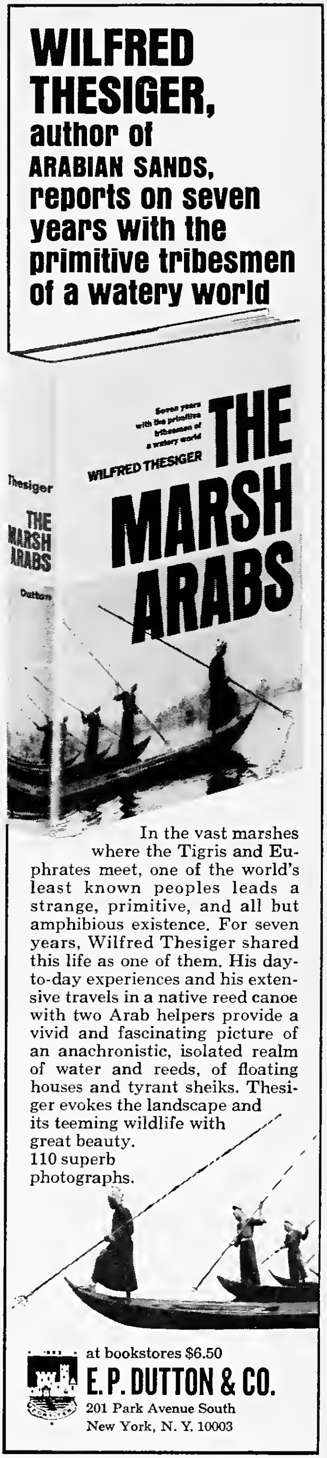
o have some criticisms of Harri-
text. For example, he underesti-
the effect of the pre-Columbian
ı population on the landscape. In
he devotes too much space to
ıs matters (the hypothesized per-
:e of mammoths in the Middle West
he sixteenth century) and to mat-
ıat have little relation to his theme
chapter is a fictional rundown of
tivities of various North American
ı tribes on the day Columbus
d land in the Caribbean).
basic biological facts are men-
in the text, which is probably for-
, since several that are presented
ated poorly. For example, tran-
on, the evaporation of water from
tissues, is defined as "the exhala-
f water vapor by living plants."
xt is illustrated with photographs,
ey lose some of their appeal be-
the paper used in the book is yel-
and thin enough to allow type
he reverse side of the page to show
;h. Also, the photographs some-
do not correlate with the text.
s Is the Earth, subtitled "Apprais-
atural Resources and Conserva-
treats water, soils, forests, range-
wildlife, and minerals in separate
rs and concludes with a discussion
ture conservation planning." Al-
ı the organization of the book is
ıtforward, the author makes fre-
interpretational errors—even using
heading declaring that "Trees
ıe." He consistently personifies na-
nd generally conveys a superficial
tanding of his subject. Among the
reviewed this year, this one is out-
ng for its lack of technical editing.
s especially unfortunate, because
pe of Sollers' treatment is broader
ıat of most books on conservation
s age group.
servation and You is a review of
recent or contemporary conser-
problems—including city smogs,
ent and pesticide pollution, radio-
fallout—rather than a comprehen-
verage of all aspects of conserva-
The organization of this text,
red with that of *Ours Is the Earth*,
dgepodge. But its timeliness and
nversational presentation largely
nsate for its lack of order.
problems are presented factually,
than emotionally, with the solu-
hat have been applied or proposed.
ces, the authors are surprisingly
For example, they admit that
ervation, in many places, means
g more than good hunting and
; available to sportsmen." The text
strated by well-chosen and well-
luced photographs.
principal criticism of the text is
nature" is personified throughout.
criticisms include the use of the
"food" for fertilizers, the state-
that there are no young saguaro cacti in Saguaro National Monument, and the implication that lichens were the first terrestrial plants.

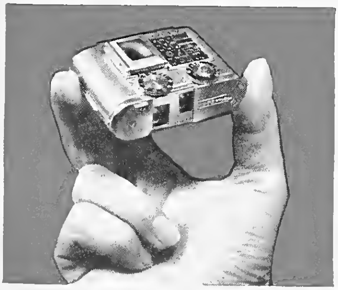
I also disagree with the statement that ecological studies can be carried out only in places "untouched by man's design." Ecologists have comprehended, and in the future must give much more attention to, the interrelationships of organisms and environment in the man-dominated landscape. Although the study of natural areas will always be of vital importance in assessing ecological baselines and potentials, the rapidly maturing science of ecology must be focused on the altered environments and biotas that have developed as a result of human modification. Let's face it, man is here to stay—at least until his ignorance of, or disregard for, ecological principles results in his self-annihilation.

A fourth book in the general field of conservation is John Upton Terrell's *The United States Department of the Interior* (Duell, Sloan and Pearce). This is an informal, brief description of "the chief conservationist of the nation." The Department houses the National Park Service, Bureau of Land Management, Geological Survey, Bureau of Mines, Fish and Wildlife Service, Bureau of Indian Affairs, and a number of other agencies that administer the natural resources of our country. The Department is large but this book is small, lacks details, has no index, and is not too well organized. The result is an interesting introduction to the activities and responsibilities of the Interior Department, but one that leaves the appetite unsatisfied.

Another book on conservation is a career guide, *Foresters and What They Do*, by John and Jane Greverus Perry (Watts). This couple wrote the excellent book, reviewed in last year's column, *Exploring the Forest*. The present volume is based on interviews with foresters on the job, made in the course of an 8,000-mile trip during 1962, and it also includes a great deal of other information provided by federal and private agencies. It is a broad account of the many facets of the modern profession of forestry, including range, wildlife, and recreation management, and should allow a high school senior to gain a better concept of the variety of work, responsibilities, and remuneration associated with the job of forester.

By far the best biography of an American naturalist to come to my attention is *Plants in His Pack, a Life of Edward Palmer*, by Janice J. Beaty (Pantheon). Palmer, the son of a Norfolk County farmer, was born in eastern England about 1830. Early in his life he developed a great interest in birds, insects, and other living things. In 1849, Palmer immigrated to the United States and became a protégé of the famous naturalist, Dr. Jared Kirtland, of Cleveland. His first major collecting trip was as a mem-





ber of the crew of the *Water Witch*, which sailed to Paraguay in 1853 to explore the La Plata, Paraná, and Paraguay rivers. Palmer made many other journeys—throughout the newly opened American West, to Mexico, and to other areas—during the next 57 years, and he collected more than 100,000 plants, many new to science, as well as thousands of birds, mammals, insects, shells, and Indian relics. Mrs. Beaty relates the adventures, the disappointments, and the intellectual rewards of these journeys in a manner that gives the reader vicarious thrills of Indian uprisings, Civil War battles, and lonesome treks through uninhabited wildernesses, but she never overwhelms the reader with involved botanical descriptions or overdetailed route outlines. Palmer is properly assessed as one of the most active collectors of natural history specimens of the nineteenth century, and as an avid collector of the plant lore of the Indians. He was not a botanist, as were his contemporaries Asa Gray and George Engelmann; he only collected specimens and did not care to spend time in the laboratory studying and classifying them. *Plants in His Pack* will provide absorbing reading for anyone interested in American natural history or in the conditions of travel and living in the Western Frontier region of a century ago.

JACK McCORMICK

Geography, Geology and Paleontology

TWELVE books are reviewed in this section. The first six are excellent, one is adequate, the rest are poor-to-disastrous. Comparing this score with those of previous years, I feel there has been some progress. The excellent books are diverse in subject matter, and include material on deserts, polar regions, dinosaurs, and caves. They are also diverse in their levels of sophistication.

An excellent biography in depth has been written by a non-scientist. Oliver Warner presents a tremendous amount of information in *Captain Cook and the South Pacific* (American Heritage), with Dr. J. C. Beaglehole of New Zealand acting as consultant. There is enough historical and scientific background to enable the reader to sense the scholarly contributions of Cook the scientist and to appreciate the stature and growth of the man. Captain Cook was made of hero's stuff and he makes excellent copy. Of humble origin, he made his way to the top through the quality of his mind and the steadfastness of his purpose. His major contribution was the exploration of the Pacific Ocean, accomplished during three voyages between the years 1768 and 1779. As this book makes abundantly clear, Cook's achievements can be viewed in two ways: as the culn
tion of the early epoch of explor
that began in 1513 when Balboa
"stout Cortés") first gazed at the P
Ocean; or as the beginning of
modern, scientific epoch of explora
Either way you have a good story,
an important one from the viewpoi
man trying to get information about
eventually to understand, his world

The striking illustrations, com
by the editors of this Horizon boo
clude many reproductions of cor
porary drawings, paintings, and ma

Speleology, by George W. Moore
Brother G. Nicholas (D. C. Heath),
authoritative, soft-covered book o
natural history of caves. In additi
descriptions of caves and a discu
of their complex origins, the scie
authors point out some little-known
ets of their geology and biology.
some caves "breathe" in and out is
cussed, and the origins of this phe
enon are tracked down and event
expressed in the form of a simple e
tion. Here, in capsule form, the inte
tual adventure of physical scien
presented: the odd observation,
analysis, and the final quantit
theory that can explain and predic

The biology of caves is examined
similar manner and interesting
abound. There is some error, how
For instance, recent studies have s
conclusively that vampire bats
blood—not lap it, as stated by the
thors. Lapping noises would wake
sleeping victims. The special chara
istics of cave animals are used as a
point to explain their evolution.

The small size and relative simpl
of the cave community make it eas
delve into important ecological conc
the interdependence of organisms,
the cycle of nutrients through produ
consumers, and decay organisms.

Another good biography, this on
a professional writer, is *The Dino
Hunters*, by Robert Plate (McK
Two highly interesting men domin
the scene of American paleonto
from the Civil War years to the en
the century: Othniel C. Marsh and
ward D. Cope. During these years
quest for scientific knowledge of
American West commenced. Among
most dramatic fruits of this harvest
discoveries of vertebrate fossils-
simply new species or genera, but
types of mammals, birds, and rept
Fossils of giant dinosaurs, huge and
likely mammals of long-extinct ty
and toothed birds, all were discovere
Marsh and Cope in two decades.

The two principals in this history
came engaged in a titanic battle
scientific recognition and compete
make the first discovery. Both men
fortunes in the task, and each drove
self at a high pitch. As the battle
tensified it became more underhan

spies, informers, and all-but-pitched s among the contenders or their collectors. This book demonstrates lthough the history of science is y of discovery, it may also involve reers of men seeking something in ion to pure truth.

arctica, by Carl R. Eklund and Joan nan (Holt, Rinehart and Winston), best book for the general reader I seen on the subject. The senior au- Dr. Eklund, was a scientific leader ilkes Station during the IGY Ant- program, and the book is filled interesting and accurate informa- nd up-to-date theory. Key problems tarctic research and their relevance whole fabric of science are clearly rth. Pertinent material from many ces is included—biology, meteor- , geology, and geophysics.

e arid lands of the earth, including reat deserts, have a perennial al- for those of us who live in wetter . *The First Book of Deserts*, by l C. Knight (Watts), examines regions from a scientific point of (although the author is not a sci- t), and the reader is rewarded with k that is accurate, informative, and written. The illustrations are strik- and are integrated with the text. y aspects of deserts are covered, in- ng their origin, the life that dwells , the formation and migration of s, and mirages.

an Villiers is a well-known author ocean adventurer and in *The Ocean* ton) he has given us a record of s efforts to learn to travel on the sea. uch it is a success, beautifully writ- y one who knows ships, sailors, and time matters. The title, however, is eading. The book is not about the ns as objects of scientific study. Only slender chapter even attempts to r this voluminous material.

ral Reefs, by Lois and Louis Dar- (World), is an adequate presenta- of a scientifically important subject. pity is that, with a little more effort, ight have been excellent. The au- s do explain what a reef is and how evelops, but the reader who has not rved a reef under water will not ly be able to picture how the whole munity is knit together, and what the tion is between the living reef and rest of the reef complex.

he following books are in the "poor- sastrous" category and are, there- , reviewed only briefly.

hree books that seem to have no real pose are *Wonders of Snow and Ice*, Christie McFall (Dodd, Mead); *The nders of Water*, by James H. Win- ster (Putnam); and *When the Ice ne*, by David O. Woodbury (Dodd, ad). The first cannot really be called , but it is certainly pointless. We are n facts and photographs of ava- ches, nuclear submarines, Eskimos, icebergs, and glaciers, but that is all.

The Wonders of Water is smoothly written, but is a mixed bag of scientific and historical items pertaining in some way to water. Subjects include the Spanish Armada and the use of water in fire fighting. Why not water's crucial role in the manufacture of soda pop?

In *When the Ice Came* David Woodbury writes well enough when he has nothing but anecdotes to relate, but is confusing when he treats matters of scientific importance. Many of the illustrations are crude and unclear.

Planet Earth, by Gerald Ames and Rose Wyler (Golden Press), is poor: there are too many topics covered in too short a space, and the illustrations seem to come directly from the French Impressionist school. As patterns they are interesting, but as science illustrations they are confusing and often misleading.

The Boys Book of Mountains and Mountaineering, by E. C. and M. E. Pyatt (Roy), is unfortunate, as it consists of a good book on mountaineering history and techniques juxtaposed with a poor section that purports to be a scientific study of mountains. The chapter on great mountain ranges is dull and the rest of this section is filled with half-truths and equivocal statements.

John Imbrie

Zoology

Of the twenty-four books reviewed for this section, the majority concern aspects of the natural history of various animal groups, while others deal with general biology, either from a historical perspective or as a synthesis of recent research. Some, at least, stimulate the imagination and may even entice the young reader to look with new eyes at life around him and to carry out experiments on his own. Several volumes, however, are dull and pedantic—they give facts, but are hardly worth the reader's time or the publisher's costs.

In *A Short History of Biology* (Natural History Press), Isaac Asimov briefly surveys achievements from the beginnings of biological science to contemporary research in molecular biology. The book—not written specifically for young readers—is fast-paced and lucid, and Asimov presents biological concepts logically, clearly, and with a minimum of extraneous detail. The influence of his own interests in biochemistry, and the highly publicized current developments in this field, however, have led to a somewhat biased coverage. He leaves the reader with the impression that the study of evolution concluded with Darwin; neglects such fields as ecology and paleontology after Cuvier; omits recent research in the mechanisms of embryonic development, endocrinology, and animal behavior. Such omissions would be understandable in a short
history, if Asimov had not used appr
mately the entire last third of his bool
review details of recent discoveries
biochemistry and molecular biology.
example, two pages are devoted to ra
active isotopes as tools in biochemis
but no mention is made of their us
paleontological dating.

For the intended readers of this b
for whom illustrations and diagrams
most important, the few line drawi
assist the text but little. There is
index, but there are no references
anyone who might wish to pursue
ther the history of various discipli
within the science of biology.

A timely volume on *The Reproduc*
of Life (Basic Books) is by Rober
Lehrman, a high school science tea
and a writer of considerable skill.
author stresses the fundamental na
of life as the reproduction of self-org
izing systems. Here is a wealth of
formation woven into a fine accoun
reproduction on a number of leve
molecular (DNA, RNA, and protei
cellular (mitosis and meiosis), org
ismic (development of the organism
the physiology of reproduction), and
cial (mating and parental behavi
The level of writing is fairly soph
cated—it would seemingly have to be,
the ideas covered—and even persons
some knowledge of biology and che
try could profit from its unifying conc

I do have some objections to this b
however. The illustrations were execu
by the author, and while they are
quate, many should have been lar
Additional diagrams, especially for
lustrating the ideas of the control
development, would also have been h
ful. The author's explanation of
processes of mitosis and meiosis will
be easily grasped by the naïve rea
Mr. Lehrman erroneously states
chromosomes split during mitosis,
this is not rectified by his later treatm
of DNA replication. There are also
eral factual errors of greater or le
importance. There is an index but th
are no references.

In spite of these shortcomings, I
recommend the volume because of
tacit insistence that each level of
logical reproduction is to be underst
from an analysis of the organizatio
that particular level, and thus that
understanding of life cannot be redu
solely to an understanding of molecu

A relatively new area of scien
study is nicely illuminated by the sn
volume *Animal Photoperiodism*,
Stanley D. Beck (Holt, Rinehart and W
ston). In recent years, it has become
creasingly clear that internal rhyth
processes are vital for the life of an
ganism. Such processes appear to be
ordinated and synchronized with e
other by the daily rhythm of dayli
and darkness—in other words, by
photoperiod. Photoperiodism is relev

many and varied processes investi- by such biological disciplines as gy, behavior, endocrinology, neu- y, and biochemistry. This extremely and well-written text, together with e but appropriate and enlightening rations, shows the importance of periods to the activities and inter- rocesses of mammals (including , birds, and insects. There is also a er on biological clocks, which seem temperature-corrected and rhyth- hemical processes that are regu- by environmental cues.

e volume is indexed and has a list lated readings. *Animal Photoperi-* is highly recommended as an in- ction to this subject. The publishers d be congratulated for obtaining an excellent manuscript and for cing such a fine little volume.

graphies of three famous biologists appeared in the "Immortals of Sci- series published by Franklin . They are *Louis Pasteur: Founder crobiology*, by Mary June Burton; *es Darwin and Natural Selection*, ice Dickinson; and *Gregor Mendel leredity*, by Robert N. Webb.

e volume on Mendel is the simplest he dullest. Its limited appeal will those of junior high school age who not yet heard the familiar story of el's experiments with garden peas. beginning biology textbooks ex- with greater clarity and interest rinciples of heredity Mendel de- from his horticultural work. Men- s a person, never seems to come in this telling.

e biography of Pasteur is more suc- l. It is aimed at a slightly older nce that might have had a bit more e. It starts slowly, but gains mo- m as Pasteur conquers disease disease. The reader is caught up e excitement as Pasteur devises for the diseases of silkworms, , and men. The realization that mi- s are the cause of disease is grad- impressed upon the reader as it pon Pasteur. The spirit in which ught many of the leading scientists time for acceptance of his theory sease is sympathetically portrayed, ouis Pasteur emerges as a real and ring person.

ce Dickinson's biography of Dar- vill be difficult reading for all but ost-advanced high school students. letails of the voyage of the *Beagle* kimmed over rapidly, and more is devoted to Darwin's struggle illness, his difficulties in writing, he raising of his family. It is diffi- o see why it was necessary to write ook at all, for the type of student might enjoy it is capable of reading njoying Darwin in the original or of ng any of the multitude of books articles about him that were pub- l for the centennial, in 1959, of the publication of *On the Origin of Species.* In addition, the book contains one glaring error: Darwin's contemporary, Alfred Russel Wallace, is repeatedly referred to as Arthur Wallace!

In spite of these objections, Darwin's theory of natural selection is presented in an accurate manner, and the difficulties Darwin experienced both from the religious and the scientific personalities of his day are well told.

All three of these biographies are sparsely illustrated with lackluster drawings that add little to the clarity or intent of the texts. All are indexed; the Pasteur book contains a glossary.

Although advances in molecular biology may make headlines and fire the imagination, there is still great excitement and, of course, escape (particularly for city dwellers) in reading about the confrontation of raw nature as written by naturalists and scientists from personal experiences. A sampling of such writings is found in *A Sense of Wonder*, compiled by Dorothy Shuttlesworth (Doubleday). This anthology, as stated in the introduction, "may be said to touch on earth, sea, sky, and the animal kingdom," and includes works from the able pens of W. H. Hudson, Maurice Maeterlinck, Rachel Carson, Charles Darwin, William Beebe, Albert Einstein, and others. I especially enjoyed the selections concerned with fossil hunting (Roy Chapman Andrews), ocean waves (Henry Beston), April in the Antarctic (Richard E. Byrd), wasp ways (Jean Henri Fabre), auroras (John Muir), and tracks and trailing (Ernest Thompson Seton). For those readers who want more, there is a bibliography of other writings by the same authors.

Adventure with Freshwater Animals, by Richard Headstrom (Lippincott), is a guide to observation of, and experiment with, a variety of invertebrates and vertebrates from protozoans to turtles—forty-seven adventures in all. Mr. Headstrom, who illustrated his work with line drawings, gives some insights into the lives of these aquatic animals and provides hints on where to find them and how to maintain them in a home laboratory. Aside from a microscope, which is sometimes required, the necessary equipment is easily obtained or made. There are a few minor errors and an unfortunate lack of an index and reference list. However, the book can be recommended as a good source of information for the student who wants to know more about the fascinating animals that inhabit lakes, ponds, and streams.

Four other books deal with invertebrates—one with spiders and three with insects. Laura Barr Lougee has supplied the text for a very attractively designed book, *The Web of the Spider* (Cranbrook Institute of Science). The author skillfully, and with a minimum of words, touches upon spider anatomy,

how spiders spin out silk, silken webs and traps, how orb webs are made, and how spider enthusiasts can collect webs. The drawings and photographs are both of excellent quality. In short, this small volume is a delight to look at and to read. It should convert many of all ages to an appreciation of spiders and their webs.

Butterflies, by J. F. Gates Clarke (Golden Press), is an introductory text. It briefly describes the external anatomy and the development of butterflies and then treats of 187 familiar North American species, arranged and described according to families. The beautiful color illustrations by André Durenceau go far toward making this a successful book. And successful it is, for it does what it intends to do—invites "young and old to learn about the more common North American butterflies." The book is indexed and has a reference list.

A book on *Beetles*, by Wilfrid S. Bronson (Harcourt, Brace & World), treats these insects as "machines-plus." The author's analogy of a beetle to an automobile does not come off well, especially when he makes such errors as comparing a beetle's stomach to a car's motor, and stating that the radio antenna on a car is sensitive to sound vibrations. His discussion of beetle behavior is sophomoric and sometimes anthropomorphic. His discussion of the beetle's brain, mind, and feelings is plain nonsense. All of this is unfortunate, because the book has a certain charm, and the author's many illustrations are fun and enlightening. References and an index are provided.

From the standpoint of interpreting behavior with precision, by far the best volume of those reviewed is *An Ant Is Born*, by Harald Doering and Jo Mary McCormick (Sterling). Miss McCormick, the author, gives a good, brief account of ant life history and some aspects of behavior. She does not resort to anthropomorphisms and instincts to explain their behavior, but instead shows that ant colony organization, at least in part, is dependent upon reciprocal stimulation between worker and worker, worker and queen, and worker and brood. Mr. Doering's many superb photographs and the legends accompanying them excellently supplement the text material. (One photograph shows an aphid responding to tactile stimulation from an ant by exuding a drop of "honeydew.") It is a treasure of a book.

Either of two books on fishes could fill a gap in the young ichthyologist's or fishing enthusiast's library. *Boy's Book of Fishes*, by Edward C. Migdalski (Ronald Press), and *Fishes and Their Ways*, by Clarence J. Hylander (Macmillan), deal with fish anatomy, physiology, reproduction, and habits. Both describe the common species, particularly the game fishes, of streams and lakes, and of the seas bordering the United States.

Mr. Hylander's book is more com
hensive, and I think by far the b
volume, although it contains its q
of minor errors. The many good draw
of fresh- and salt-water fishes are a
cided asset. There is no index, but
fish species are listed with refer
pages under their respective famili

Roy Pinney's *Animals, Inc.* (Do
day) is a slim volume on zoos and an
collecting. The reason for its exist
seems to be as a vehicle for nume
photographs, many by the author,
certainly are not outstanding. Mr.
ney tells some of the adventures of
animal collectors as Frank Buck, Ar
Jones, Carl Kauffeld, and Henry
flich; he boringly, but fortuna
briefly, discusses past and present z
he relates the *modus operandi* for
turing, transporting, selling, and ca
for zoo animals; he speaks, though
very energetically, about the wo
vanishing wildlife. There is a short
liography and a list of current p
paid for animals.

The World of the Red-Tailed Haw
G. Ronald Austing (Lippincott), is
only bird book reviewed this year,
it is a recommended addition to
amateur ornithologist's or natura
library—no matter what his age.
of the author's striking photogr
show red-tails on the wing; others de
the home life of red-tails and the d
opment of the young. The author
his own observations and other cu
data on the red-tail through the
seasons of the year. His long hour
observation and many encounters
this bird make his text a stimulating
The red-tail is on the point of exterm
tion in many parts of the country,
this is pointed out, but not with s
mentality. However, red-tail behavi
often explained in anthropomor
terms or by the concept of insti
Bibliography and index are inclu

Of the eight volumes on mammal
ceived this year, six are for the
part disappointing. *Mammals*, by
ald F. Hoffmeister (Golden Press),
a text that starts out as a pretty
introduction to the biology of mamm
but quickly falls into a run-of-the-
encyclopedic treatment. Description
various species and groups of mamm
are dull, and very little, if anything
included about mammalian commun
tion, social behavior, or ecology. S
of the colored illustrations are good,
many are poor. The book has some
tual errors and is poorly edited.

The less said about *Meet the M*
mals, by C. H. Keeling (Watts),
better. It is poorly organized and is fi
with inaccuracies and fundamental
rors. Nature is considered willful,
Lamarckian theories of evolution cr
in. The author gives tips on how to
for various wild mammal pets and se
to have a genuine concern for anim

her in captivity or in the wild.

imal Servants of Man, by J. J. oy (Lothrop, Lee & Shepard), con- s the domestication of dogs, cats, es, cattle, and other animals. The might have some appeal, but I'm uite sure to whom. There are many s, especially in the chapter on keys and apes. (I think the author ches the point when he includes the on, orangutan, and gorilla as serv- of man.)

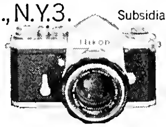
F. Beebe's *American Wolves, Coy- and Foxes* (McKay) is a sort of do- urself guide to killing coyotes, es, and foxes by shooting (from the nd, airplane, and snowmobile), ing, poisoning, trapping, running hounds, driving, and den hunting. rrect scientific names, many anthro- orphisms, textual errors, poor ng, and dreary writing further mar book. Miss Beebe also has written *rican Lions and Cats* (McKay), but no better.

ild Cats, by C. B. Colby (Duell, n and Pearce), is a dull treatment ie world's large and small cats. It ributes nothing to what has already better written elsewhere.

vo mammal books that can be recom- ded for young people were not writ- specifically for that audience. *Gara- a*, by Desmond Varaday (Dutton), tale about a pet cheetah, who is ribed as being passionate, sensitive, capricious. The author, a game len of a private African reserve, s an interesting account of life in the can bush and sidelights on the lives he animals in his domain—lions, ards, crocodiles, vultures, jackals, ias, antelopes, and elephants. The is suspenseful and has an unex- ed climax. The accompanying ographs supply local color. Unfor- tely, the book is laced with anthro- orphisms, and I cannot believe ything the author says, but his con- over the plight of many African ials and his sense of drama make his worth reading.

wealth of fascinating information it beavers is found in *The World of Beaver*, by Leonard Lee Rue III pincott). It stems from the author's onal observations of the animals over imber of years and through every on. Mr. Rue refutes much of the sense written about beavers as skilled neers with the knowledge of how to trees so they fall into the water. A l account is given of the ecology of beaver and how this animal—the ld's second largest rodent—affects an in which it settles. The author's tographs clarify many points (he swam with beavers in order to get erwater shots of their swimming hods). The few anthropomorphisms iot mar the volume's excellence.

Kenneth K. Cooper



Cannibal of the Ponc

New study elucidates biology and behavior of water scorpio

By Syd Radinovsky

THE WATER SCORPION, *Ranatra fusca* Beauvois, is not a scorpion at all. It is an insect belonging to the family Nepidae of the order Hemiptera. Despite its name, it bears little resemblance to the true scorpion, which is terrestrial and has a long, segmented abdomen with a potent sting at the tip. In appearance, the water scorpion resembles a walking stick—that familiar, large, sluggish insect whose common name is so apt. However, the walking stick is an orthopteran and a member of the family Phasmidae. Functionally, *R. fusca* is much like the well-known praying mantid, also an orthopteran, of the family Mantidae. Both are predaceous and both exhibit cannibalism. Both have peculiarly modified raptorial front legs that strike out
swiftly to grasp prey. Endowed wi
infinite "patience," both lie in wait f
their prey almost motionlessly, fro
legs in an upraised position, and bo
are capable of slow stalking. Both al
have functional wings, but are r
strong fliers.

Water scorpions comprise only o
of a number of families of aqua
Hemiptera, each of which is distincti
in structure, biology, and behavi
Water scorpions, or nepids, are d
tinguished from all other water bu
by their slender and elongate cau
respiratory tube, which consists of t
filaments with middle grooves. Wh
these filaments are pressed togeth
the grooves form a tube that condu
air to two spiracles situated at
caudal end of the abdomen. Anoth
distinguishing feature of the wa
scorpion is the presence of three pa
of small, oval, disklike, static se
organs at the sides of the second, thi
and fourth visible ventral segme
These probably aid in orientation
water and in depth perception. T
anterior legs are raptorial; the mid
and hind legs are slender and lo
Thus, the insect is better adapted
move among aquatic vegetation th
to swim in open water where, althou
the legs thrash alternately and viole
ly, it makes but slow progress forwa

Three easily separable genera
water scorpions are known in re
rimmed, fresh-water ponds in No
America. The genus *Nepa* is stri
eastern and *Curicta* is a Neotropi
genus, only two species of which re
into the southern part of the Uni
States. *Ranatra* is distributed throu
out North America, and *R. fusca* is
most abundant species in the genus

All water scorpions are predat
utilizing their environment both
a source of food and as a place
hide. Their dark, brown-gray colo
tion blends perfectly with the veg
tion. Water scorpions commonly pl
themselves in an optimal predation
based on at least three factors: cam
flage, light, and prey traffic. Pla
provide cover and an oviposition s

ADULT WATER SCORPION, which greatly resembles the familiar walking stick, uses raptorial forelegs to seize box-elder bug that has fallen into water.

cal habitat of the water scorpion *Ranatra fusca* is a
rimmed, fresh-water pond, such as that seen at top.

After first molt, nepid hangs head down from the reeds, as at left center. Other insects are the larvae of mosquitoes.

: areas may aid in camouflage, as
ısects' sticklike appearance is con-
ıbly more enhanced in a dark
tion, and this might deceive both
and possible predators. They sta-
themselves in areas of the great-
rey activity and eat a wide variety
ther aquatic insects, even includ-
small fish. Nepids, in turn, are
ed upon by the predaceous diving
e *Dytiscus*, the dragonfly nymph
hna, and are also parasitized by
tic mites.

) take advantage of prey traffic,
ds suspend themselves head down-
l, at an angle of 35 to 45 degrees
ı the vertical, by clinging with
the middle and hind pairs of legs to the stems of rushes, reeds, grasses, or other vegetation. Their raptorial forelegs are held in front of them, poised and ready to strike out at any moving object that chances by. The tibia and tarsus of the forelegs are scythelike and razor-sharp. They fit into the grooved femur like the blade of a pocketknife fits into its handle, and can form a viselike grip. Often the nepid uses one leg to catch a leg of its prey; the victim can escape only by leaving its leg in the predator's grasp.

Periodically, a nepid's need for oxygen compels it to walk backward up the vegetation, thrusting its snorkel-like caudal respiratory tube through the water surface. Long periods of submergence are found in many aquatic Hemiptera. *Ranatra fusca* can stay under water for periods of 30 to 35 minutes before surfacing for air.

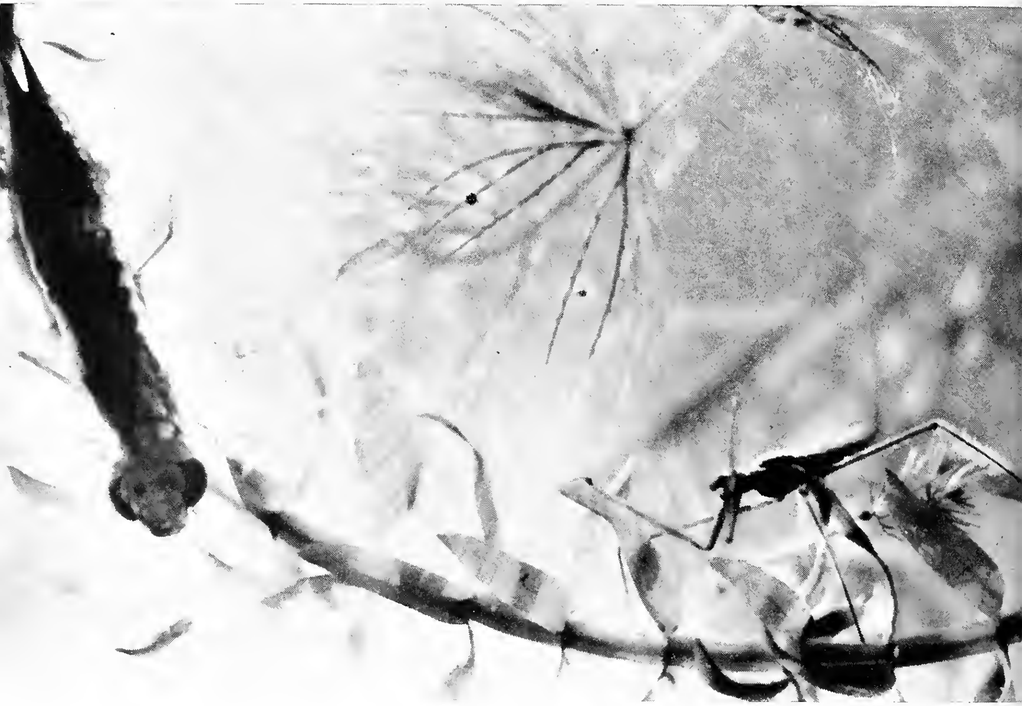
During the past six years at Corvallis, Oregon, and in Lawrence, Kansas, I have studied aspects of the biology and behavior of *R. fusca*. Insects were collected from fresh-water ponds and brought into the laboratory for close and constant study. Life history and behavioral data accumulated in my Corvallis studies are almost identical with those from Lawrence.

In general, water scorpions overwinter as adults and lay eggs in the spring. The mating appears to be in-

Body of nepid, at left, carries a l
cluster of parasitizing aquatic m

One mosquito larva is eaten by a
nepid, which holds another by for

Dragonfly nymph, at left, *belo*
a principal predator of *Ranatra f*



fluenced by time of day. On occasion I have seen mating occur in the afternoon, but in the majority of cases it takes place in the early morning or late evening. On one occasion, duration of mating was 20 minutes, although the process might have been prolonged or shortened as a result of the disturbing influence of the light that was used to photograph it.

During mating, the male positions himself beneath and to the side of the female. The dorsal aspect of the posterior portion of his body faces the ventral part of the posterior portion of the female. The ventrally situated aedeagus is brought upward to a dorsal position, where it is clasped by the female genital sclerites. Transfer of sperm presumably takes place at this time. The two halves of the male's respiratory filaments are spread apart to permit the aedeagus to make this migration upward.

The fertilized female climbs ou
the water and onto a horizontally fl
ing, soft, dead reed. She then elev
the front part of her body while fir
grasping the edges of the reed with
second and third pairs of legs.
forelegs are held together on a
with the body, which slants down f
the head at an angle of about 35
grees. The ovipositor is then extru
and the tip is pressed into the reed
a downward, backward, and forw

movement, while the respiratory filaments rest on the reed. After piercing the reed, the female partially withdraws her ovipositor. Then she opens it laterally, and inserts the egg into the newly made hole.

The long, respiratory filaments of the egg come apart in a V-shaped fashion as the ovipositor is withdrawn. The female then moves forward about one-eighth to one-quarter of an inch and repeats the process, inserting an egg as before, until as many as 50 eggs are placed in a straight line. In those I observed, the female usually returned to the row of eggs several days or even a week later to continue ovipositing. The eggs are elongate oval and about 3½ mm. long; the respiratory horns are about 4 mm. long.

Recent research by H. E. Hinton on the structure and function of the nepid egg indicates that each of these horns consists of a central meshwork that contains gas. This is connected, according to species, either directly or through aeropyles (fine canals or tubes), with a peripheral plastron meshwork. The plastron itself is an air storage mechanism in the form of a thin film, so held by a system of unwettable or water-resistant hairs or scales that its volume remains constant. The plastron meshwork may cover most of the respiratory horn or may be confined to its tip, and provides a large, water-air interface when the egg is immersed. The gas-containing meshworks of each horn are joined basally to the gas-containing meshwork of the egg's inner shell wall, making the air film of the former continuous with that of the latter. The egg shell fills with air only after the egg has left the common oviduct. The plastron is resistant to wetting by excess pressure, and so provides a wide safety margin against such contingencies as heavy rains, floods, or submersion of reeds by other animals. As long as adequate oxygen is dissolved in the water, the plastron can act as a permanent physical gill that needs no renewal, and eggs so equipped can remain submerged for long periods of time.

Eggs normally are laid so that the respiratory horns and sometimes part of their apexes project above the surface of the water. The remainder of the egg is below the surface, so from this point of view, respiration is essentially terrestrial. Presumably the plastron becomes functional only during

MATING takes place in the spring and seems to be influenced by the time of day. It usually occurs either during the early morning or the late evening.

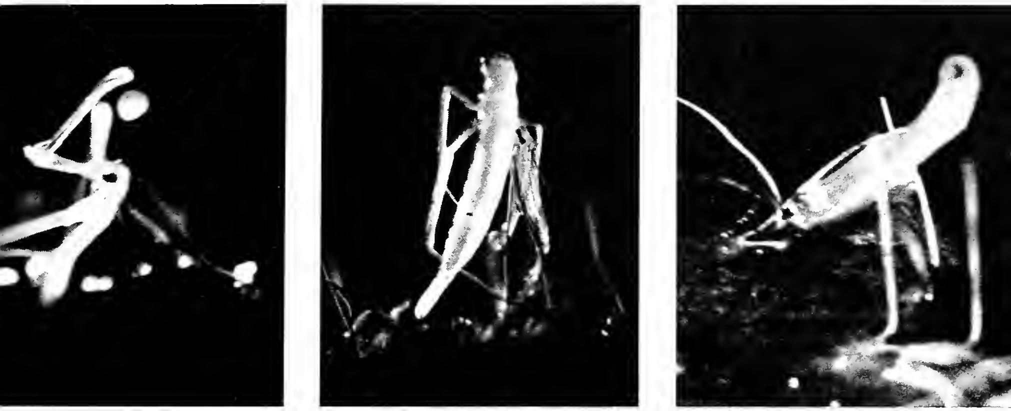
FEMALE inserts ovipositor into a soft, dead, floating reed and deposits eggs.

TWO-FORKED respiratory horns on egg rise above surface of the water, *right.*

heavy rains or when the egg is ot
wise immersed in water. From my
experience. eggs purposely submer
for as long as three or four days de
oped apparently normally and hatc
in the normal time into nor
nymphs. There is a possibility, not
investigated. that there is a critical
riod of incubation during which e
must be at the water surface—with
respiratory horns projecting above
water—after which they can be tot
submerged and still develop norma

In life history studies. it was fo
that a time lapse of 17 days
curred between mating and ovip
tion (data based on 19 individua
The incubation period lasted from
to 19 days (data based on 18 i
viduals). Following egg hatch th
are five nymphal instars. each look
like miniature adults. The first
second nymphal instars lasted appr
mately 8 days each. the third in
about 8½ days. the fourth instar
days. and the fifth and final instar—
longest of the five—22 days. A tota
76 to 80 days was required from
to adult. The first instar nymphs m
ured 6 to 7 mm. from tip of beak
end of respiratory tube: the second
to 12 mm.. the third 18 to 20 mm.,
fourth 26 to 27 mm.. the fifth 45
46 mm. The adult was 63 to 68 m

The first nymphal instar emerges
forcing open a small round cap at

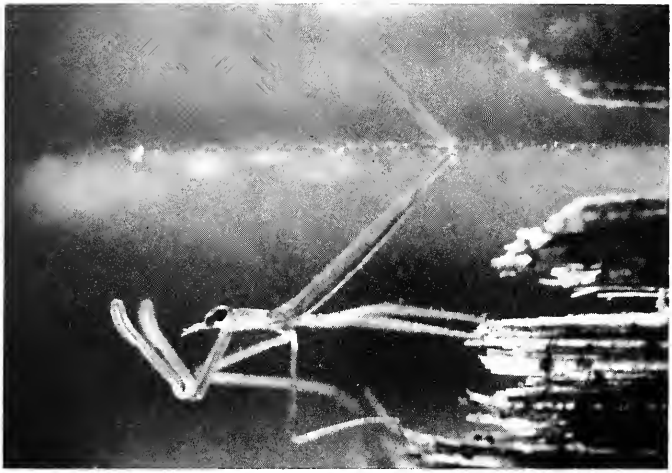


RICATION of a nymph from egg is seen in three stages.
s at first are close to body. but they begin to unfold when about two-thirds of the emergence is complete. Nymph occasionally becomes entangled in sibling's horns and dies.

nent end of the egg. Hatching is a
inating process to watch. The soft,
ile, bright yellow, red-eyed nymph
ly emerges from the egg case, get-
larger and larger, like a genie from
agic lamp, until it is about twice
length and width of the egg that
ained it. When the nymph is about
thirds of the way out of the egg its
which until this point have been
very close to the body, begin to
ld. This first nymph utilizes its
y freed legs almost immediately;
ves the floating reed and heads for
the water. Sometimes it becomes entangled in the respiratory horns of other eggs, is unable to extricate itself, and perishes. Soon after entering the water it assumes the typical head down. angled position and uses the hind and middle pairs of legs to cling to the reed it has just left.

To survive. first instars must have floating vegetation that reaches almost to the water surface. The animals may periodically leave their islands of support, but they always return, particularly when they catch prey. I placed first instars and small bits of the aquatic plant *Elodea* in 34 x 24 mm. plastic zipper vials filled with pond water or tap water that had aged for 48 hours. The *Elodea* either floated or partially submerged in an almost upright position, and the young nymphs readily gained a foothold and assumed their typical "resting-questing" stance (head downward at about a 45 degree angle to the vertical plane and with outstretched forelegs). Occasionally, the *Elodea* would slip down to the bottom of the vial. and the young nepid would remain for a time near the water surface. floundering and thrashing and apparently unable to orient to the resting-questing position. Eventually the nymph would also slip down, thrash around the bottom of the vial and. if not given assistance in the form of new floating *Elodea* (or even a piece of toothpick), would drown. Early morning checks sometimes revealed mortality from this cause.

In addition to serving as a support upon which the nymph can back up to get its life-giving supply of air, and to increasing the camouflaging stick effect. vegetation also provides a necessary anchor upon which the nepid braces its hind and middle pairs of legs to facilitate the lightning-fast movements of the forelegs when making a strike. On several occasions I have observed the attack and capture of a late instar mosquito larva by a first instar nepid that had become separated from its vegetation refuge. The struggling larva, about the same size as its attacker, pulled the latter all



First nymph, just a half-hour after it has left egg, assumes preying position.

Nymphs, ***right,*** **at 3½ days old, hang from surface debris and wait for prey.**

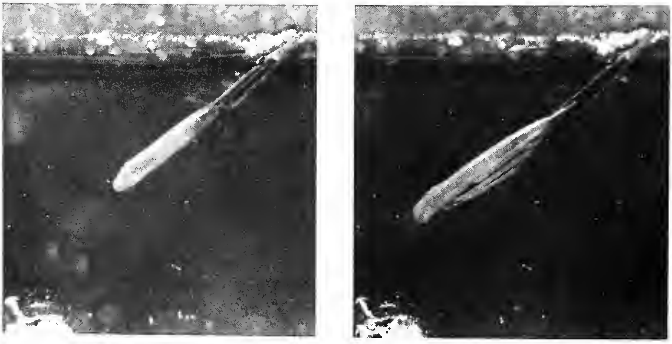
over until the nepid encountered some *Elodea*, which it immediately grasped with one or both pairs of posterior legs. Once firmly anchored to the plant, the nepid assumed the 45 degree angle position, grasped the mosquito larva with both its raptorial front legs, and then inserted its beak. Sometimes the nepid held the struggling, wriggling larva under the water until it subsided, doubtless because of anoxia, before it began feeding.

OFTEN the water scorpion cleaned its scythelike forelegs with its middle legs when mosquito larvae were first introduced into the zipper vials. This pattern of behavior was observed in all instars. Several times the same behavior was observed after an insect had managed to escape the clutches of the nepid.

Generally, a first instar nymph in its typical prey-awaiting position would strike and capture an active mosquito larva within seconds after the larva was introduced. The nymph would affix the larva to its beak while feeding, thereby freeing the two forelegs for further prey capture. If another larva came by, the nepid would often strike again, and if successful would hold the second larva in one of its forelegs while feeding on the first one. Occasionally I have seen an adult nepid use its only free appendage to strike out and capture still a third larva.

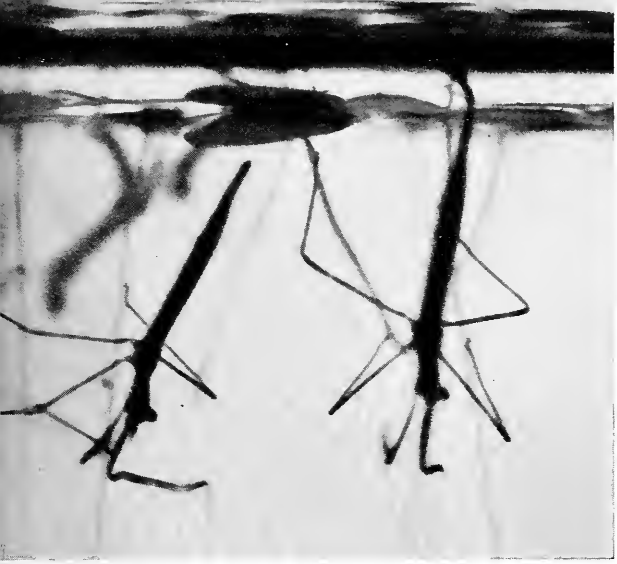
Prior to molting, the first instar nepid becomes enlarged, inactive, and unresponsive to introduced prey. The

increase in over-all size is proba
caused by a combination of feed
and the extra intake of air and,
water in preparation for the molt.
molting begins, the skin splits alo
the posterior head region and the
closed second instar begins a slow
steady movement forward and out
its cast skin, or exuvia. It does
use its legs as it moves forward; t
remain tight against the body
appear to be enclosed in a thin, tra
parent sheath. Waves of body sw
ings that move slowly backward se
to aid in the extrication. Presuma
blood, air, or water is accumula
anteriorly and then forced posterio
along the outer margins of the bo
When the second instar nymph
about four-fifths out of its exuvia,



Molting process, *above*, in which second nymph frees itself from its cast first nymphal skin, took about 2½ minutes.

At right, the third and larger nymphal instar emerges fr
its old skin, and is humped at lower left of the photogra



t-colored legs are freed from the y and used in the final extrication n the exuvia. This second nymph early twice as long as the first and ppreciably larger in girth.

put second instar nepids into er containers (85 x 55 mm. baby l jars) and added larger pieces of *lea.* Stalking of prey was first ob- ed at this stage. When the prey beyond its reach the nepid occa- ıally moved almost imperceptibly ard it, in a manner reminiscent of stalking movements of a praying ıtid. This controlled movement was ›mplished by means of the long, od-like middle and hind legs. The les of extension and flexion of the to the body slowly changed, with result that the water scorpion moved forward, upward, downward, sideways, or backward, ever so slowly, until it was in a striking position.

The second nymph, when ready to molt, becomes quiescent and enlarged and, like the first instar, is indifferent to prey. It was not observed to feed within four hours prior to molting. On two occasions I saw two large and relatively inactive second instar nymphs strike out at passing mosquito larvae, but they were unable to hold them, even though contact was made. Of these two nymphs, one molted 5½ hours, the other 6¾ hours later. The molting process for the second nymph is essentially the same as that described for the first instar. Feeding does not take place for several hours after a molt has been completed.

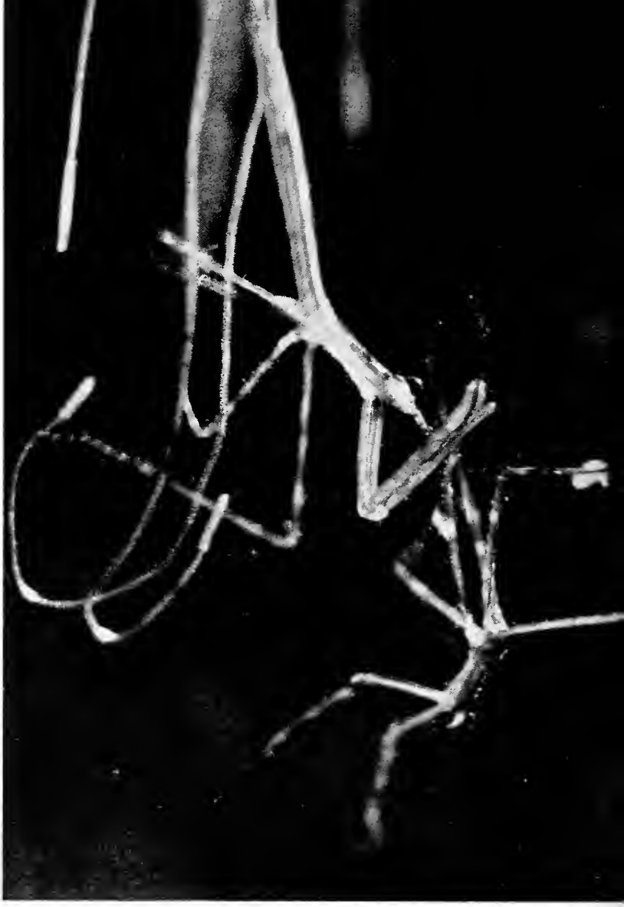
The third nymph is again appreciably larger in size, and wing pads appear for the first time. Feeding, stalking, and other patterns of behavior are generally the same as in the preceding instars. The molting process differs only in that more use is made of the legs in earlier stages of extrication from the exuvia.

Other than increases in size and appetite, the fourth and fifth stages of *R. fusca* exhibit no significant behavioral differences from those of earlier nymphs. I began feeding these later instar nepids damselfly and dragonfly nymphs, water boatmen, backswimmers, small hydrophilid and haliplid beetles, and other live material.

A hungry adult water scorpion will strike at virtually anything that crosses its path. One that had not eaten in many days struck at my finger, which I held above the water, and actually positioned itself so that it could break through the water surface in an attempt to capture aerial prey. In this manner they can grasp terrestrial insects that have fallen into the water and pull them below the surface before beginning to feed.

ASLEEP or awake, the water scorpion assumes virtually the same resting-questing position. Sometimes, after I had introduced mosquito larvae or other prey early in the morning, the nepid, aroused by the activity, apparently woke up, made a feeble stab at the prey, and invariably missed on the first two or three strikes. Subsequent strikes were speedier and more accurate, until the action was lightning-fast. Hence, a kind of warming-up period is exhibited in the early morning. Once awake the nepid usually will capture the introduced prey with one strike if it comes close.

After the prey is caught, and if it is not struggling too violently, the nepid grasps it in both forelegs and brings it up to the elongated, three-segmented beak that houses the four long, slender, and needle-like piercing stylets—the two mandibles and the two maxillae. The maxillae are the main stylets of the beak. They fit together to form two tubes—a salivary tube through which saliva is pumped into the body of the prey, and a food tube, through which the body fluids of the prey are drawn. The nepid presses its beak against the prey and probes around and over the sclerotized surface in search of a soft, mem-



Nepids are cannibals; second nymph here feeds on first nymphal sibling.

Adult has attacked a first nym in variation of cannibalism, *rig*

branous spot (usually an intersegmental membrane), through which it inserts the needle into the victim.

I once observed a nepid feeding on a haliplid beetle while a free foreleg clasped the midsection of a mayfly nymph. A second nepid approached and tried in vain to take the mayfly. The first nepid would not let go; the two fought, pulled, tugged, and lunged. During the melee the first nepid continued to feed on the haliplid. Finally a "compromise" was reached: the second nepid began to feed on the mayfly, while the first one continued to feed on the haliplid, although it did not relinquish its hold on the mayfly. Five minutes after the second nepid began feeding, the first nepid discarded the exsanguinated haliplid and began sharing the mayfly feast.

On one occasion I introduced a dytiscid beetle (three-quarters of an inch long) into an observation tank. Within five minutes, an adult nepid caught it, but could not penetrate the exoskeleton. The nepid held the active, struggling dytiscid under water for about three-quarters of an hour and drowned it, then pierced a leg (between coxa and trochanter) and began to feed. Two hours later, two nepids were sharing the meal, which lasted another hour.

CANNIBALISM is perhaps the greatest of the perils to confront a nepid. This phenomenon is manifested in many ways, and nepids are subjected to it throughout their nymphal existence. Generally in a batch of eggs laid about the same time, those nymphs that emerge first will feed on later emerging nymphs. The former will cannibalize only after their exoskeletons have undergone at least two hours of hardening and darkening (sclerotization and melanization). More often, the newly emerged first nymph becomes the victim of older nymphs and adults.

Most of the egg hatch occurs some time during the evening and early morning. Probably there is survival value in emerging in the dark, where some protection from older siblings may be afforded during the first critical hours. Perhaps this means that a circadian rhythm exists that has evolved to trigger the hatching process at an optimum time.

When we add cannibalism to the predation of other aquatic insects, we can appreciate the high fecundity of nepids. Wherever I found adults in the spring and summer, I always observed thousands of eggs imbedded in the reeds. Yet later in the season I never collected more than nine or ten adults at one time. In fact, only in the spring and early summer have I collected as many as a dozen. When one considers that an adult water scorpion can cannibalize any immature individual, and that each nymph can successfully attack any other younger or smaller nymph, each adult that we do find may represent a number of "nepids that could have been." On the other hand, scarcity of adult nepids might reflect either flaws in my collecting techniques or late summer dispersal.

There is much more to be learned about *Ranatra fusca*, such as the mechanism of orientation and the sense organs involved, feeding physiology, learning ability, rhythmic activities, dispersal, and overwintering sites have found adult nepids overwinteri in mud and water in Oregon (wh the temperature usually stays ab freezing), but I have not been a to find the overwintering site in La rence, where winter freeze-ups prevalent. The nepids apparently survive under the ice and perhaps b row into the mud where the tempe tures are above freezing. The ad nepid probably goes into some ki of winter diapause, or dormancy, which respiration is consideral slowed down. Or perhaps the adu crawl or fly to another site, where th spend the winter.

This type of study permits one to a few steps beyond biology per se i biological and experimental behavi It is a step that leads to the ultim satisfaction of seeing, thinking, a ing, doing, and drawing conclusio

Strangler Fig, Nativ

By Virgil N. Argo

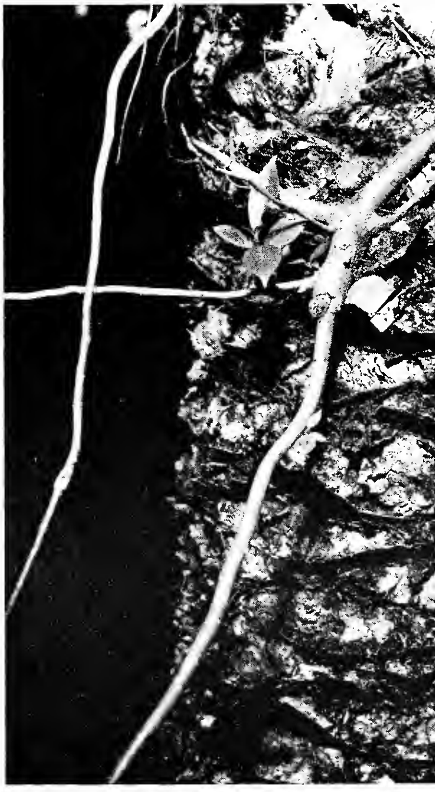
A northerner driving south along the Atlantic Coast for the first time becomes aware of an increasing number of plant species that are living full and normal lives perched on the trunks and branches of roadside trees. These epiphytes appear in about this order: mosses, polpody ferns, Spanish moss, larger bromeliads, and orchids. The last two classes are not to be seen in abundance until the traveler reaches the latitude of the Everglades in Florida. Manifestly, they are all plants that do not grow in cold weather and need frequent rains and humid air. They have special leaf and root adaptations for obtaining water directly from the falling rain or from atmospheric humidity.

Not until one reaches the coastal margins of the southern half of Florida will one encounter the most interesting of our native epiphytes, the strangler fig, *Ficus aurea.*

The genus *Ficus* is one of the most remarkable aggregations of closely related plant species in the world. As of 1930, the *Index Kewensis* listed 1,580 apparently valid species that are worldwide in distribution. There are 895 listed for tropical continental and insular Asia, 378 for continental Africa, 257 for tropical continental and insular America, 12 for continental Europe, and 38 species are listed without locations. They vary in size and form from large trees to creeping vines, but all exhibit certain unmistakable characteristics. The most significant and recognizable is the syconium, the fig-type fruit (the flask-shaped end of a stem or receptacle) lined with a large number of minute, one-seeded, closely crowded, reduced flowers. This fruit structure is always recognizable and is unique to the genus. Incidentally, the Roman name for fig was *ficus* but the Greek name was *sykon,* hence "syconium." This will explain the common name sycamore, which we give to species in the genus *Platanus,* because they have leaves that resemble those of *Ficus sycomorus,* the mulberry fig of the Near East and the "sycomore" of the Bible. (Luke 19:2-4 tells of Zacchaeus, chief of the publi-

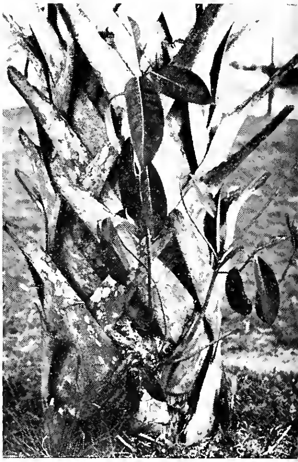
piphyte

Leaves and small, immature fruits of the *Ficus aurea* are seen in close-up of the twig, *above.*



Seedling, which began on bark of a palm tree, has quickly developed roots, stems, and leaves.

Masonry of East Martello Tower in Key West, Florida, furnished the support for *F. brevifolia.*



Palmetto trunk, *above*, is the host f
a fig seedling, rooted near the groun

Independent growth of fig can occ
when seedling starts at tree base, *le*

Tree roots enclose and hold up
that remains of a masonry wall, *rig*

Cypress trunk is barely visible
mass of intertwined fig roots, *belo*

cans, who climbed a "sycomore" in Jericho to see Jesus pass by.)

The edible fig of worldwide fame is *Ficus carica*, with its hundreds of recognized varieties. Incidentally, it is one of the few species that does not require a humid tropical climate. This fortuitous preference for a warm dry environment accounts for its importance to the peoples around the Mediterranean. The pollination of some varieties of *carica* presented to horticulturists of this country a problem that was not solved until after long study. The whole story of the fig and the fig wasp, *Blastophaga psenes*, is complex enough to confuse many otherwise well-oriented biology students.

Our own *Ficus aurea* starts out in life when it sprouts from a seed left by a bird in a crevice among the leaf bases of a palmetto or on the rough bark of a cypress tree. The tiny seedling rapidly develops roots, stems, and leaves. It has no special water-collecting structures, but it does have pronounced resistance to wilting, a characteristic strikingly illustrated by some of the other latex-producing

ts. In any event, it thrives and s with surprising vigor, and soon and sturdy roots have extended n the trunk of the host tree to the nd. During this period of its early th one is hard put to understand the plant obtains enough food to ort its rapid and extensive growth. fter the roots have reached and trated the soil, establishing their nections with water and minerals, growth speed is much accelerated. first roots branch abundantly and are joined by others creeping down the outside of the host. They increase in diameter and flatten against the trunk of the tree, fusing together wherever they touch, until the host is encased in a strait jacket of anastomosing roots, which suggest nothing so much as a tangle of writhing and constricting serpents. Some roots may drop free to the ground and grow into auxiliary trunks. This is the case of the banyan, *Ficus bengalensis*—a fairly close relative that often begins as an epiphyte.

The strangler fig does not absorb food from the body of the host tree; an increase in the diameter of its roots along and around the trunk of the host causes them to squeeze against it so strongly that any subsequent increase in trunk diameter is prevented. As a result, the vascular cambium cannot produce new xylem and phloem to accommodate the water and food transport needs of normal growth, which, of necessity, stops. Palmettos are monocots and do not have expanding trunks

Serpentine effect of encroaching root structure is seen on palmetto.

since they lack a vascular cambium. Instead, they produce new conducting tissue at the growing tip of the trunk. If the strangler fig has its start at a low point on the palm trunk, the host may live a long time without injury, but if the interloper starts among the bases of the green leaves of the crown, it lives up to its name and does some strangling of the terminal bud. It also produces shading, which interferes with the host's photosynthesis. In any sequence of events, the strangler fig will grow faster than the host and will become a large tree with spreading branches and heavy foliage. Its trunk may be five or more feet in diameter, completely enclosing the host's trunk. It may take considerable searching to find traces of the dying or dead host inside the meshwork of the fig.

Ficus aurea is native to southern Florida and the Caribbean, but another strangler fig, *Ficus brevifolia*, the shortleafed fig, occurs in the extreme southern part of the Florida mainland and the Keys, and in the Caribbean. Its appearance and habits are almost the same as *aurea*, but the outline of the leaf is slightly but consistently different, and the small fruit is distinctly stalked in contrast to the sessile *aurea* fruits. *F. brevifolia* is not as abundant as *aurea*, and many Floridians do not separate the two species. (One fine specimen of *brevifolia* grows down over the surface of an irregular fragment of brick and mortar construction against the north wall of the East Martello Tower, adjacent to the municipal airport at Key West.)

Strangler fig increases rapidly in diameter and will ultimately kill host.

Huge fig, *right,* encloses cypress tr
which is now completely rotted aw

All species of *Ficus* produce latex. The India rubber tree, *Ficus elastica*, was the first source of commercial rubber, but it has been replaced by a member of the Euphorbiaceae, *Hevea brasiliensis*, and has now been retired to the passive position of being one of our most popular foliage plants for the home. The most revered tree in the world is undoubtedly *Ficus religiosa*, the sacred Bo Tree of Burma, Ceylon, and India. Tradition says that the species was born the same year as Gautama Buddha, and that he sat unc
its shade for six years while he dev
oped his philosophy. Bo Tree mea
literally "Knowledge Tree." This
minds one of the legend that Alexa
der the Great camped with an arr
of seven thousand soldiers under o
banyan tree, *Ficus bengalensis*.

The Moraceae, the family to wh
Ficus belongs, is one of the "Fi
Families" of the flowering plants, c
sidered to be contemporary in ori
with the Magnoliaceae and other ea
floras. This ancient lineage helps
explain the multiplicity of species a
variety of life habit in *Ficus*, and a
to the integrity they all show in adh
ing to the basic genus pattern. Fr
may be produced in bizarre fashio
They may grow along the m
branches and the trunk from buds
reduced twigs that push out thro
the bark. They may develop on und
ground parts of the plant. But t
are always recognizable figs. Rela
genera of the Moraceae—mulberr
paper mulberries, breadfruit, a
osage orange—all have received att
tion because of their value to man,
the number of species in these gen
is extremely small compared to th
that have evolved in the genus *Fi*

Long Journey of th

By Walter N. Hess

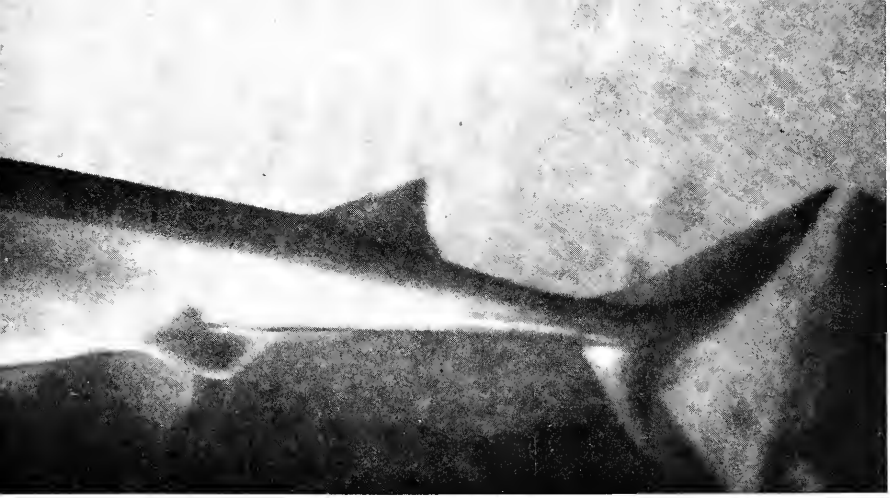
The migration of animals has interested man from earliest times, and there has been much speculation regarding its nature, including its causes and meaning. Some animals migrate because of seasonal scarcity of food, others because of severe climates, and still others to find a suitable place for rearing their young. In all cases, it is a periodic movement between summer and winter homes. The master migrant of all animals is apparently the Arctic Tern, which nests north of the Arctic Circle and winters in the Antarctic regions, completing a round trip of over 20,000 miles yearly.

Among fishes of the sea, one of the great migrants is a small species of shark known to scientists as the spiny dogfish, *Squalus acanthias.* It makes a round trip each year from the Carolina-Virginia coastal waters, where it spends the winter, to Labrador. Probably few fish excel this shark in speed and in distance traveled. In order to cover such long migration distances, certain physical characteristics, such as streamlined bodies and long, powerful tails, are essential. These dogfish, which favor water that is between 42° and 58° F., frequent the shore waters of the coasts of North America, Europe, and the Mediterranean. While they are usually found one or two feet from the bottom of the ocean, they may be anywhere between the surface and a depth of 100 fathoms or more. However, they have never been found in the deep ocean and do not enter fresh water. Unlike many common fishes they do not have swim bladders, which may account in part for their ability to move from considerable depths to the surface and back again at frequent intervals. It is remarkable that they can withstand such great changes in pressure in so short a time.

The name dogfish evolved because sharks hunt the prey in "packs." A single pack may be composed of more than 1,000 sharks, all chasing a single school of fish, usually herring. It has been estimated that as many as 27,000,000 spiny dogfish are caught unintentionally by fishermen along the Massachusetts coast in a single year. If one adds to this the number caught along the remainder of the New England and Canadian coasts, the total annual catch may exceed 100,000,000.

Of all the fishes in the ocean, spiny dogfish are among those most hated by professional fishermen because they are destructive both to edible fish a to fishermen's nets. In Maine coas waters in late June, we have oft found recently molted lobsters in t stomachs of large dogfish sharks. other times, however, the lobster apparently able to defend itself agai them. There is every reason to belie that this shark is also destructive Canadian lobsters during their mo ing period, which occurs in July a coincides with the time that the lar dogfish are abundant in Canadi waters. Of the dogfish not discard when caught, a few are eaten by ma but by far the greatest number—abo 50,000 each year—are dissected college and university laboratori throughout this country and Cana because in some ways their anatom bears a resemblance to the structu of the human embryo.

Unlike our common edible fishe fertilization and embryonic develo ment in spiny dogfish are intern When the eggs leave the ovaries th resemble in size and appearance t yolks of large hens' eggs. From o to seven of them usually pass into ea oviduct, where a thin, horny shell secreted around them, forming what often called a "candle." At this tim the elongated shell is transparent an



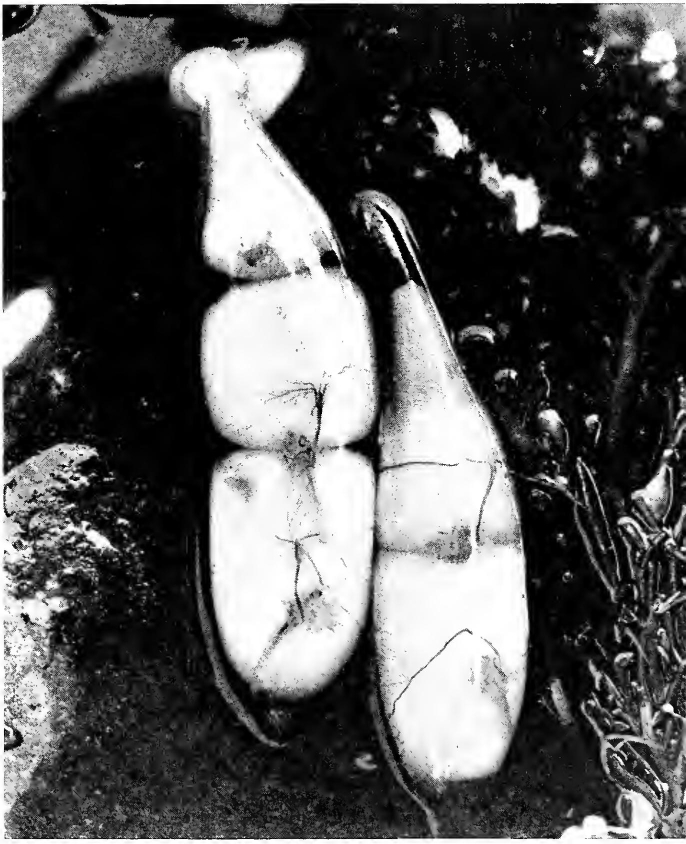
A STREAMLINED BODY and powerfnl tail aid dogfish in swimming long distances. Annual round-trip migration covers 2,500 miles.

ogfish

ɔle. Each of these clear, protective s usually contains more than one or embryo.

hen the embryos are about nine ths old and about 6½ cm. long, ıorny shell disappears; from that until they are born they are free ove about in the mother's uterine :ies. Food for growth is available eir yolk sacs, but they must obtain ed oxygen and get rid of body es through the wall of the mother's ıs. When hatched the pups are ıt 28 cm. long and are able to care hemselves. Most adults range from to three and a half feet, and weigh n to ten pounds. Females are lly from three to eight inches er than males.

a pregnant female is removed rom the water within three or four ths of term, the pups often are ı in a few minutes. When placed in vater, they quickly swim away unıey find a kelp plant or some simiɔrotection under which they can . The pups have enough food in yolk sacs to last until they can in their own, and the sea provides ;en even more abundantly than do mothers. Nevertheless, because lelicate sacs are easily ruptured, it



TWO TRANSPARENT EGG CASES, or candles, contain total of five eggs. When embryos are about nine months old, candles dissolve.

Delicate yolk sacs provide food for the pups until they can get their own.

is very doubtful whether these premature pups can survive for long in the sea. But if they are placed in glass or plastic containers so that their yolk sacs are not injured, and are provided with gently running sea water, they will mature in the same manner as in the uterus. It takes 22 months for the pups to develop inside of the mother. Apparently this gestation period is one of the longest known among animals, and as a result a female dogfish gives birth to pups only every other year.

Scientists at the biological laboratories at Woods Hole, Massachusetts, have known for years that a northern migration of the sharks passes through the coastal waters of that region in April and May and that a southern migration takes place in October and early November. I have observed the northern migration in May and June in waters near Mount Desert Island, Maine, and the southern movement in September and October. Their arrival in Newfoundland and southern Labrador coastal waters—the limit of their northern range—in June and July and their departure south in the autumn has also been reported.

Our studies indicate that the pups are not born during migration but after the arrival of the dogfish in the Carolina-Virginia coastal waters, and that female dogfish also become pregnant in these waters. F. L. Hisaw and A. Albert state that when sexually mature females arrive at Woods Hole during May, they can be divided into two distinct groups, depending on the stage of development of their embryos. Embryos in the earlier periods have barely begun to develop and are all in the late blastoderm stage; those in the later period are fully formed and have reached an average length of about 16 cm. Furthermore, examination of large pregnant females during their southern migration in Maine waters in early September reveals embryos that are either about 5 cm. long or pups that are approximately 22 cm. long. If pregnancy occurred throughout the year, two distinct groups such as have been observed would not exist. Moreover, since all embryos in the early period are in the late blastoderm stage in mid-May, it may be calculated that pregnancy occurred about two months earlier, at which time the sharks were in the Carolina-Virginia coastal waters. This evidence is corroborated by the observation that the 16-cm. embryos are in approximately the fourteenth month of development.

Studies also show that between 8 and 9 per cent of large female dogfish sharks that we have caught during migration in Maine coastal waters carry no young. When pregnant dogfish, either with early or late embryos, are placed in "live cars" and anchored in ocean water, they abort their embryos in a short time. It is probable that abortion sometimes occurs when the sharks are caught on trawl lines or are otherwise injured during migration. There is no placental attachment to the mother, so abortion is easily accomplished. Whenever the pregnant females are in such trouble for any extended length of time, their uterine sphincters apparently relax and they discharge "excess baggage." From these observations it appears that nonpregnant mature females either do not become pregnant at all or have aborted their embryos during migration.

In the northern migration of b
it is often the male that arrives
at the destination, but this conditic
reversed in dogfish migration.
largest females, which are usu
pregnant, precede all others. Then
two- and three-year-old females ar
somewhat ahead of the mature m
and last are the immature one-year
males and females. Perhaps they
leave their winter quarters about
same time, but when they reach
Massachusetts and Maine coasts,
are more or less spread out and se
ated into these different groups v
of course, some overlap. The orde
migration appears to be largely a
ter of the strength and enduranc
the older and larger dogfish. S
mature females are much larger
mature males of all ages, it is t
expected that they would reach t
destination sooner. Weak or yc
dogfish may turn back before reac
their destination. As far as we are
to determine, there is no evidenc
sex attraction during migration.

When the sharks reach the C
lina-Virginia coastal waters
in October, the number of female
ceeds the number of males by a
five to one. By late November
early December the species becc
much more abundant, and the perc
age of males near shore is fu
reduced. Our studies show that
pups are born during late Decen
and January in protected places
shore. Perhaps pregnant females n
sure that males, as well as other l
carnivorous fish, are not around v
the young are born, for at this
most of the mature males and the
mature males and females are som
to 40 miles offshore. Undoubted
contributing factor to this segrega
is protection of the newborn from
nibalism by others of the species

Studies lead us to conclude
early in March, about two month
ter the pups are born, the sex
mature females that are not preg
come into some sort of oestrus.
mature males that have been
"bachelor" quarters now come t
coastal waters. Commercial colle
of dogfish in these areas tell us
this is the only time during the
when the proportion of female
males in the Carolina-Virginia co
waters is about equal. By April 1,
of the mature females seem to
become pregnant, and at this

N HATCHED, dogfish pups measure
oximately 28 centimeters in length.

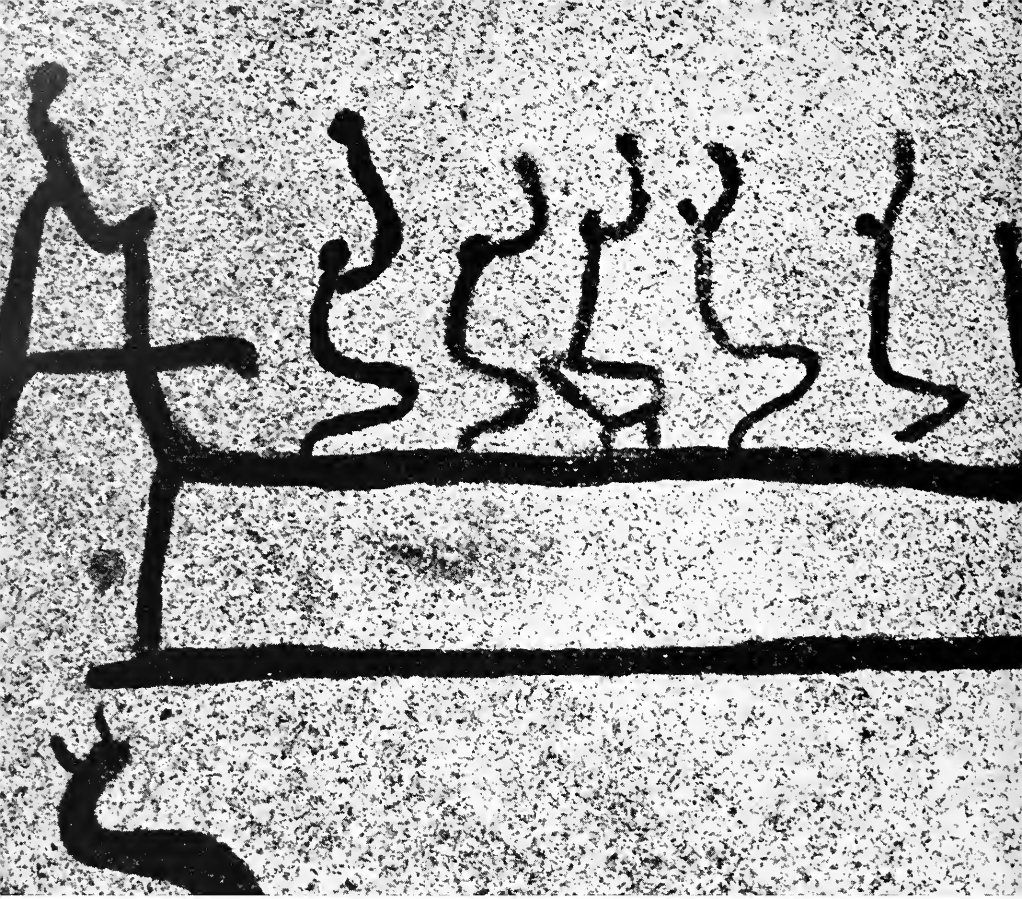
SHARKS leave wintering sites around April 1, and return in late October.

ıorthern migration is under way. ıe of the great mysteries about ıigration and feeding activities of small sharks is how they keep her in packs, since the sea is so ous and is relatively dark at the ıs where they are usually found. their larger shark relatives, *anthias* have an exceedingly keen of smell and a lateral line sense etecting vibrations in water; these help them stay together.

Hamilton College in central New State one expects to see robins larch 14 and rarely is one disap- ted. Year after year the swallows n to Capistrano on March 19. believed that the regularity of ation by certain birds is con- ed in part by length of daylight by the hormones associated with reproductive organs. No such rs regulate the migrations of dog- because their arrival in a given n along the coast varies as much o or three weeks from year to Changes in water temperature available food have a decided and are probably the controlling derations in their migrations.

we have said, the fish migrate ıward to Labrador in the spring return to the Carolina-Virginia in the autumn—a round trip proximately 2,500 miles. To ac- lish this it is necessary for them ravel, on an average, about miles each day—certainly a exceptional feat of migration.

ISH CATCH may end in laboratory issection by students of anatomy.

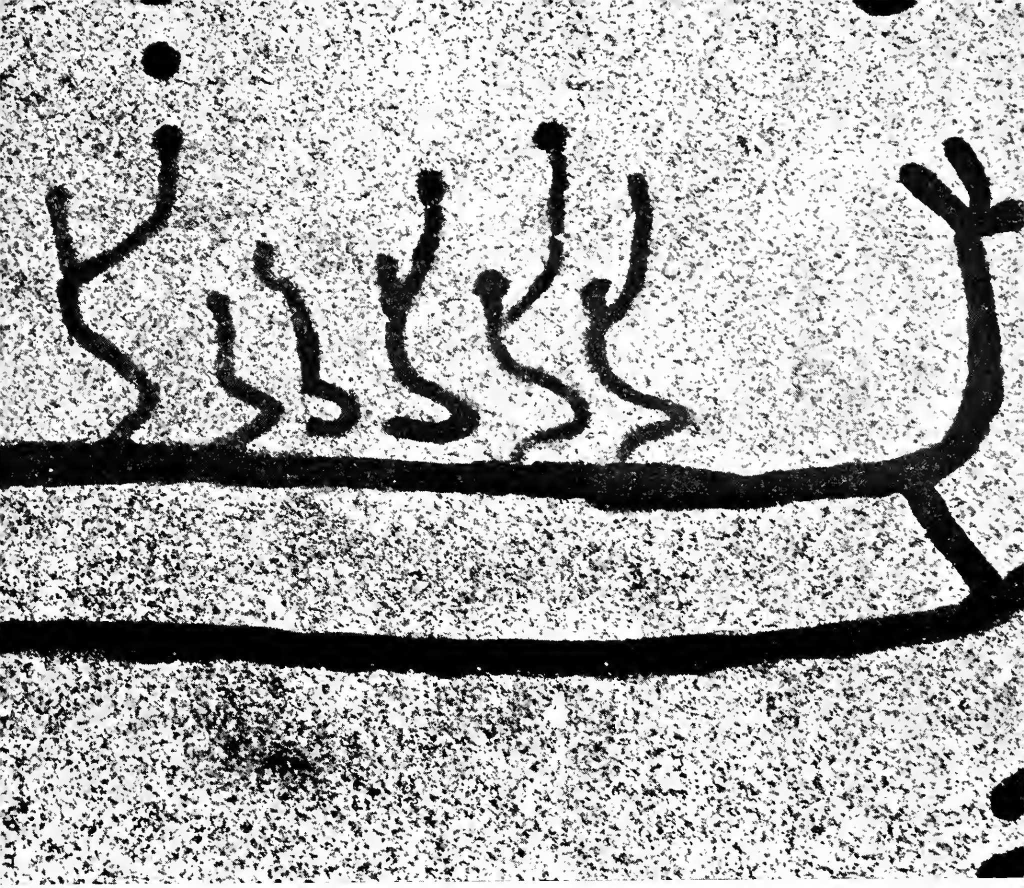


Bronze Age Seen in Granite

Early inhabitants of Sweden left images carved in rock

By Holger Arbman

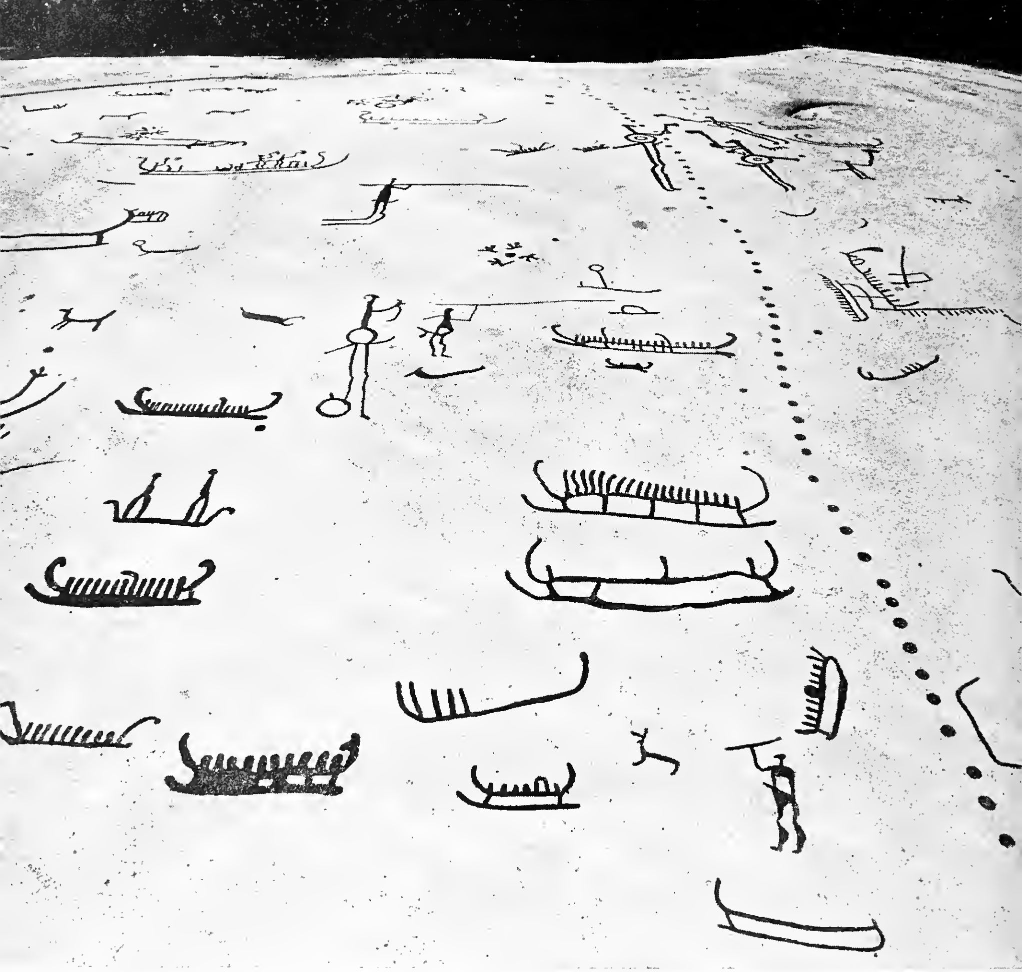
Rock carvings and paintings in caves, on rocky m
tain slopes, or on loose stone blocks occur in r
parts of the world. The oldest of them date from Paleol
times, and the latest were made toward our own time,
ranging from perhaps 1,500,000 years to about a hun
years ago (Natural History, June-July, 1964). Sch
and amateurs have speculated on the meaning of thes
tures, and artists have found in them a source of ins
tion. But apart from the most recent carvings we are r
able to find reliable information about the probably r
cal significance of these pictures and the powers that
were intended to influence. When confronted wit
carvings we must admit, more often than not, that sc
and knowledge have their limits. A rock carving is l
picture book without a text, and although a carving
contain symbols of an apparently magical or reli
character, the concepts to which the symbols were o
nally linked have long since vanished, and it is fair t



CARVING at Vitlycke, near parish of Tanum, Sweden,
group probably performing ritual dance aboard ship.

RECUR OFTEN as design motifs in incised pictures
ill the surface of sloping rock expanse at Vitlycke.

we shall probably never be certain of the meaning.
ere are two groups of rock carvings in Scandinavia.
older group, which is found in Norway and northern
en, depicts reindeer, elk, bears, whales, water birds,
almon. The oldest date from as early as the Stone Age,
oximately 3000 B.C., but the majority may be of a con-
ably later origin.
rther south in Scandinavia, in scattered areas center-
n Bohuslan, southern Norway, Uppland, Ostergotland,
outheast Skane, we find quite different carvings, with
ns that represent ships, sun wheels, soles of feet, people
ferent positions, weapons, and other motifs. These are
the more recent Bronze Age, and their date is approxi-
ly 1300–500 B.C. To judge from the content of the
res, they are evidently connected with fertility magic,
ulture, and cattle raising.
e greatest concentration of these carvings is in the
nce of Bohuslan, Sweden, where thousands are found

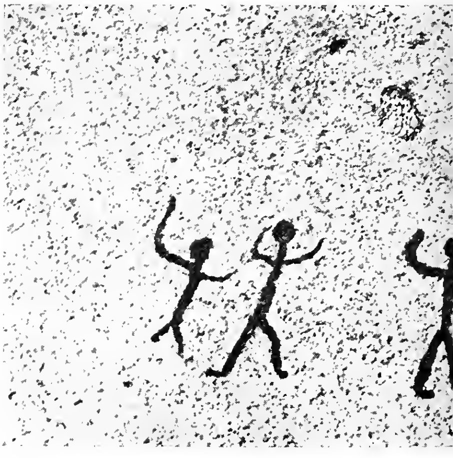


Style of figures differs from that of rock carvings in other areas, and group appears to be work of a single man.

on cliffs that were worn smooth by the inland ice. In some places there are large areas covered with figures; in others the pictures occur only sparsely and are often rather casually drawn. It is probable that the areas with many carvings, often of high artistic quality, were originally sites of important "public" cults, whereas isolated pictures may represent a more private cult associated with a particular homestead or family. We know that one or two thousand years later, sometime between the pagan and the Christian eras, private cults existed on farms in Scandinavia. The master and mistress of the house officiated as priests and only the family and members of the household participated in the ceremonies.

The largest groups of carvings and those that are best in quality lie within a fairly restricted area in the parish of Tanum, in Bohuslan. Many of them are on a slope above an open plain, across which flows the Alnan River. When the carvings were cut into the cliffs some 3,000 years

Seven humans with arms raised in a devotional atti walk behind object that may be doll carried in proces



the plain was marshy with rich water meadows—excel- pastureland but impossible to cultivate. Higher up on lry, sandy soil lay the farming strips.

T us examine one of the rock-carving sites near Vitlycke, a farm lying about a mile south of Tanum. The gns are cut into an exposed, light-colored piece of a ite hillside that slopes gently down toward the plain. veen the carvings and the valley where the river flows e is now a sparse curtain of deciduous trees, but these of recent origin. At the time the carvings were made, rock sloped straight down to open pastureland.

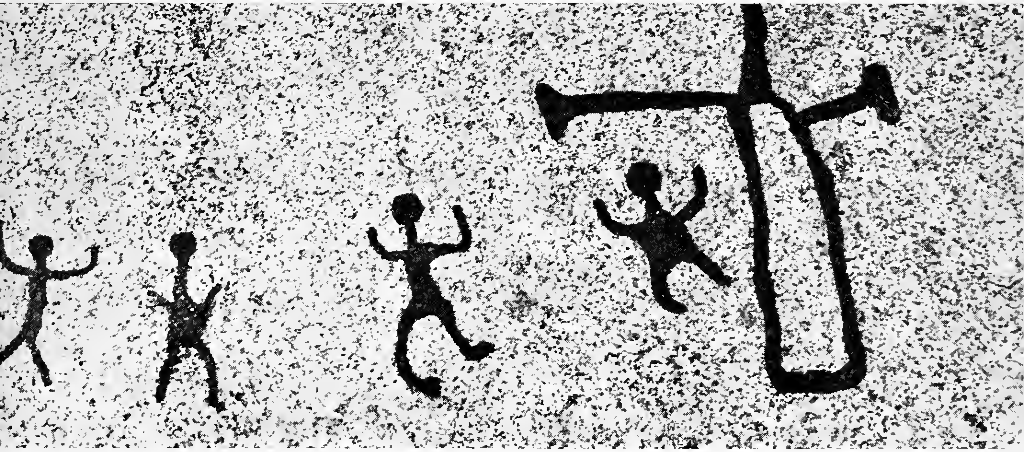
n a sunny day it is difficult at first to distinguish any- g on the white stone apart from the shadows of trees. gradually, as one's eyes adapt to the light, the pictures rge and are seen to fill the whole surface of the rock. first thing we notice is a row of small holes punched the surface, crossing it like the tracks of a marten in y fallen snow. To the sides of these tracks are warriors lifted axes and shields. They are tall and slender and almost to float. Then one design follows another: a of stylized ships, human figures, animals, and unin- ible signs. One discerns no formal arrangement of the res, but there is somehow a certain rhythm as one s the surface. The figures, however, were not placed azardly, and one picture seldom cuts into another. uld seem that one and the same man cut all the pic- , and his style differs clearly from that of carvings in areas. Yet, the carving was not executed as a planned osition or a huge, homogeneous mountain picture, pparently developed by degrees as figure was added gure. The origins of such carvings, which probably ng to a particular, limited period of time, must be dered in connection with their probable significance, h was almost certainly magical.

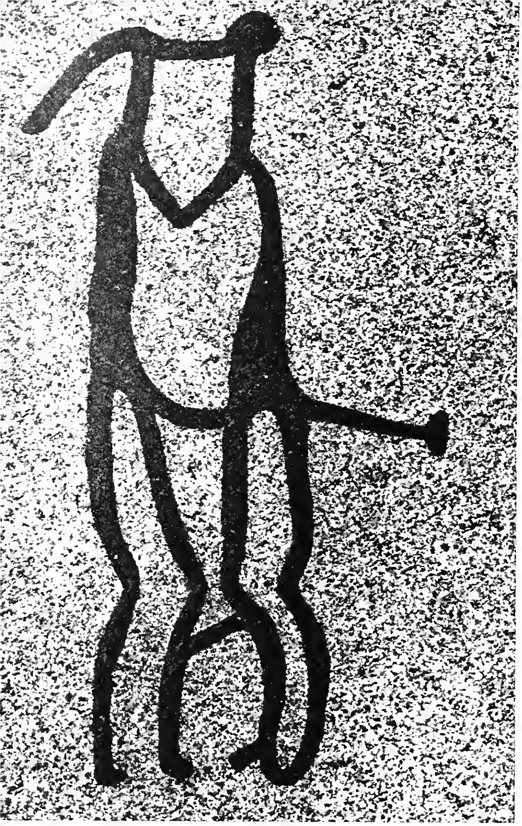
e Vitlycke carvings, like most others of their kind, dominated by pictures of ships, which are usually n without human figures, but with small, closely drawn es that may represent crew members. The forms of hips vary a little, but they all depict the same general of boat: high stemmed, with a projecting keel that have been an underwater ram. Sometimes the prows are topped with an animal head (*page 37*) that is reminiscent of the dragon's head that later came to be associated with Viking ships.

Some of the Bohuslan rock carvings are in coastal areas and others are near watercourses farther inland. Because they depict many weapons similar to ones shown on objects —especially razors—found in graves, we have been able to assign them to the Bronze Age. This was a time when Scandinavia had a lively trade with other countries, and all bronze used for weapons, ornaments, and tools was imported. It is reasonable to suppose that the Northmen of that period had a considerable navy, although it was perhaps not comparable with that of the Greeks in the Mycenaean era or with that of the Phoenicians. Thus, it is quite natural to find ships among the rock carvings, but what they symbolize is harder to discover. Are they boats of the Sun or some other god? Do the pictures depict cult-boats, or are they symbols for a god? We do not know.

On one boat at Vitlycke we can see thirteen people. They are kneeling, and all but two are holding up objects that have small round hollows at the top. It is an elegant drawing, very suggestive in its repetition. One might guess at its being a picture of oarsmen with raised paddles, but this seems rather improbable; it is more likely to be a group of people doing a ritual dance on a ship. Their attitude indicates that they are dancers, and this would jibe with what we already know about the importance of dancing in cults. A connection with a cult is more clearly seen in the representation of a procession, which is shown below. There, seven small human figures, with arms raised devotionally, walk in line behind a larger object, which appears to be a doll carried in procession (only the lower part shows in the photograph). One cannot help thinking of carnivals in our own time, in which huge figures of different kinds play an important part. Today carnivals are fairly detached from any deep meaning, but they are remnants of religious or magical traditions. Even if we cannot actually trace a line from the rock carvings of the Bronze Age to the carnivals of the present, it is interesting to think that there may have been connections between them.

We can see human beings in action in many other situa-





Marriage scene is common in rock images throughout the province of Bohuslan, and links carvings to fertility cult.

Vibrant depiction of charioteer and two-wheeled vehicle provides a tantalizing glimpse of life in the Bronze Age.

Posterior appendages of combatants were probably tails of animal skins worn as costume by participants in rites.

tions, too, on these Vitlycke carvings. The man and the woman in a wedding scene (*page 40, top*) represent a common motif in Bohuslan. It is one of several pictures that give us at least some idea of the meaning of the rock carvings—their association with a fertility cult. In many different parts of the world harvesttime has been the occasion for popular rites that include an ancient, symbolic performance of a marriage. A well-known example is the ritual marriage ceremony, *hieros gamos,* that was performed at the feasts of Dionysus in Athens. This celebration marked a stage in the drama of the seasons, and in the Vitlycke carvings we can interpret marriage scenes and also battle images (*on pages 40 and 43*) as having a similar meaning. In fact, marriage ceremonies and struggles between the representatives of summer and winter were both elements in various popular festivals of recent ages.

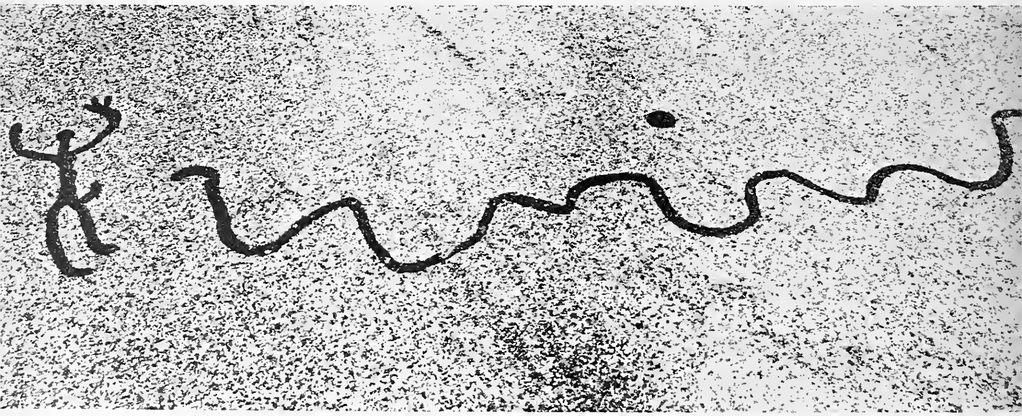
A prominent feature in rock-carving pictures is that combatants often have tails, and even the man in the marriage scene in the Vitlycke carving is thus adorned. The tails have sometimes been interpreted as representing swords, but it is hardly likely that warriors armed with swords should always be shown fighting with other weapons, such as axes, spears, or bows. Furthermore, it would seem strange that men who are plowing fields or participating in wedding scenes should be armed. Often, the men shown with tails have horns, too, which resemble those of a bull. It seems probable that these pictures represent groups of celebrants costumed in animal skins and tails. Instances of rites participants who wore animal skins or tails are to be found in many parts of the world and occur particularly in connection with fertility rites. For example, Pan, the fertility god, was usually shown tailed.

We are much more uncertain about how to interpret the picture of a huge snake advancing upon a small man who stands in a devotional attitude with upstretched hands (*below*). It is clear that the picture is connected with the concept of fertility, since the man is ithyphallic. It is possible that he may be worshiping the snake, which represents some power, perhaps the earth.

A dramatically rendered charioteer (*page 41*) is even more difficult to interpret. He stands balanced on a two-
wheeled chariot drawn by an elegantly stylized but ra
static horse. The only thing that indicates any connec
with a cult is that the man has horns—unless these ap
dages are actually meant to be large ears. Otherwise
scene appears to be a genre picture from everyday
In any case, it is very interesting for us to have a pictu
a chariot from the Bronze Age.

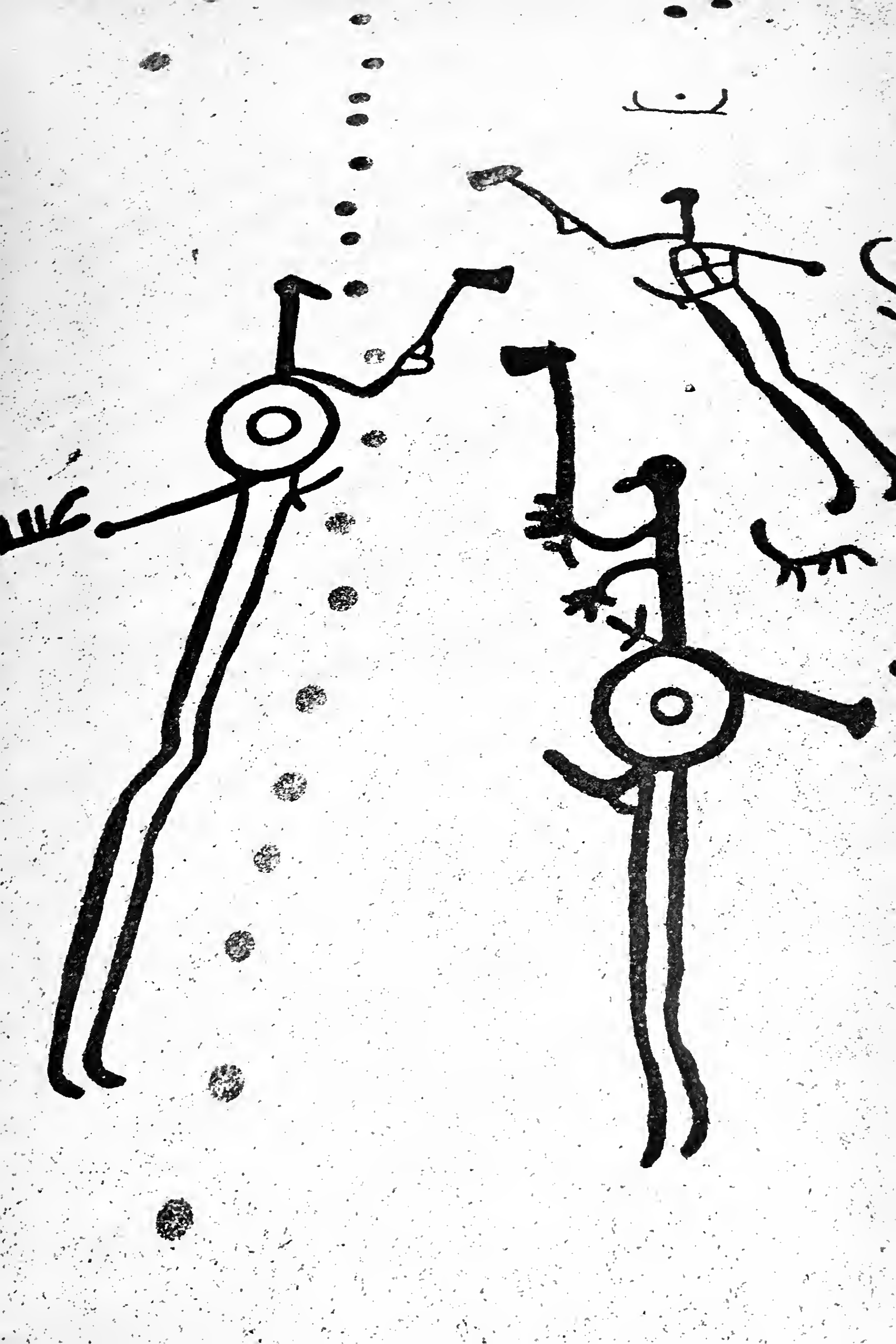
The rock carvings at Vitlycke are typical of the
mountain pictures at a cult center in Bohuslan. The fig
on the cult-center rocks nearly always include certain
bols, such as ships, hollowed-out basins, soles of feet,
wheels, with meanings we cannot fathom. Perhaps
represent gods that were not allowed to be depicted in
other way. This is known as aniconism and is a prim
form of worship of a sacred object that symbolizes, b
not meant to resemble, a god or supernatural power.
also possible, however, that they were drawn as sym
for certain rites occurring in the cult. Apart from the
bolic signs, there are pictures of cult ceremonies and
connected with crops, fertility, battles, and death, w
mark the beginning of the next year's cycle. It is pos
that these scenes were cut into the cliffs at the same
the cult ceremonies were performed on the site in o
that the power should continue to work after the ceremo
were over. It is very doubtful that any of the rock carv
portray myths, and it is also uncertain whether or no
can point to any of the figures as being images of goc
has been suggested that the very large human figures
meant to be such images. This is possible, but it is r
likely that the figures are an epiphany—an apparitio
manifestation of the divine power and its way of disclo
itself to the faithful who are represented in a cult cerem
As yet we have not been able to find proof for the exist
of gods in human form during the Bronze Age.

DESPITE the difficulties of interpreting the content
the rock carvings, and the certainty that it wil
impossible to penetrate deeper into the world of ideas
lies behind them, these pictures will always have a fasc
tion for modern man. When we stand by them, we
come nearer than at any other place in Scandinavia tc
people who inhabited the area some three millenniums



ITHYPHALLIC MALE and giant snake are hard to interpret. Man may be worshiping snake that symbolizes a great power.

SCENE OF BATTLE may be associated with a fertility
representing strife between personified summer and wi



The Great Nebula as photographed through the 200-inch teles

SKY REPORTER

Orion has provided man with beauty and mythic inspirati

By Thomas D. Nicholson

In the star-studded sky, there is one region more remarkable than all the rest—the region of Orion. Through the ages, the stars of the Orion group have suggested to men everywhere the erect figure of a great giant, hunter, or warrior. In Greek mythology, the mighty hunter Orion was the son of Poseidon. According to many accounts, he was slain by the goddess Artemis for making love to Eos, and after death was changed into a constellation. It remains the best-known figure among the stars, and it has become one of the most interesting to modern astronomers. For these and other reasons, Orion is the third of the Seven Wonders of the Universe chosen by astronomers at The American Museum-Hayden Planetarium.

Each year in the month of November, Orion—the most brilliant constellation of the sky—rises in the east about three hours after sunset. Although best-known as a winter
constellation, Orion is a prominent feature of the
evening sky from late autumn—when the nights are gro
longer—to the early spring, when it is setting in the
as darkness comes on during the shorter nights of
and May. Even when the constellation is low in the sk
it is before midnight in November, the brilliance and
of its stars can readily be observed by the city dw
for Orion's stars are among the brightest we see.

The seven brightest stars of Orion are gathered
an area of about 17 by 8 degrees in arc and easily at
attention by their striking arrangement. Six are
white in color; the seventh is red. The difference in c
is caused by surface temperatures, blue-white stars b
many thousand degrees hotter than red ones. Four
form a large, slightly irregular rectangle, and the other t
are in a nearly straight line in the center of the

le. This grouping suggested “the tallest and most beau- of men” to the Greek poet Homer. The three bright in line at the center of the figure—Alnitak, Alnilam, Mintaka, from left to right as we see them in the sky [in the upper photograph at right)—represent the tline of the figure and are known as Orion’s Belt. A p of fainter stars extends down and to the left of the from the Sword of Orion.

ie two bright stars above the Belt of Orion are Betel- e—the brightest—to the left, and Bellatrix to the right. represents one of the shoulders of Orion; usually geuse is at his right shoulder, when the hunter is red as facing the sky-watcher. Below the Belt, Rigel, e right, is the brightest star, and marks Orion’s left . Saiph, to the left, is the figure’s right knee.

HE names of these stars are Arabic words, derived from descriptive terms that identified the stars’ positions in maginary figures pictured in the constellation by the ents. Betelgeuse, for example, is a corruption of an ic term referring to the armpit of a figure; Rigel ns the foot or the knee. Among the three Belt stars, the Alnitak is an Arabic synonym for a belt; Alnilam is an Arabic term referring to a string of pearls, which an early symbol for the Belt stars; Mintaka refers, in ic, to a girdle or belt. As mentioned earlier, six of principal stars are blue giant or supergiant stars of brilliancy, some among the most luminous stars we . The seventh is an enormous red supergiant star with l, dull red surface, but so large—about 900 times the of the sun—that the total amount of light it radiates emendous. The following is a description of the prin- characteristics of each of the brightest stars in Orion:

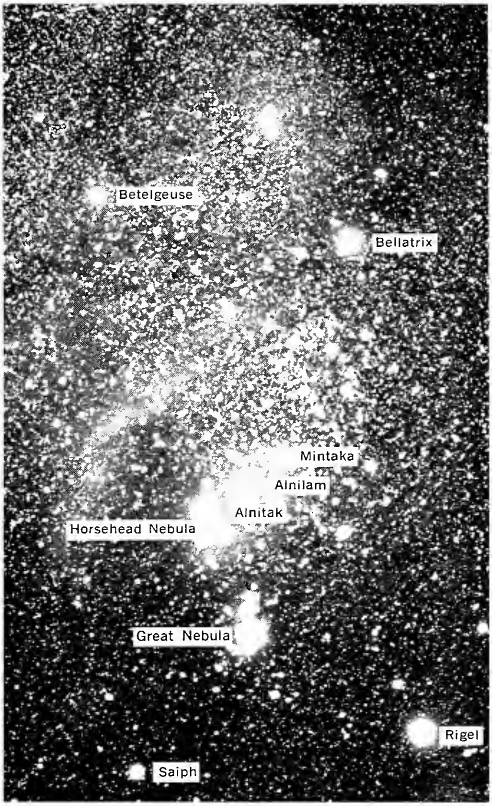
telgeuse is a red supergiant star known to be a spec- opic double. It is also a long-period, irregular vari- star, changing about 0.9 magnitude over a period of years. It has a surface temperature of about 5,400 ees F., a mass about 40 times the sun’s, a luminosity l to 25,000 suns, and is about 900 times the sun in eter. Betelgeuse is about 600 light-years away.

llatrix is a blue giant with a surface temperature t 63,000 degrees F. Its mass is roughly five suns; its nosity equals 10,000 suns. It is some 80 times the sun ameter and about 470 light-years from earth.

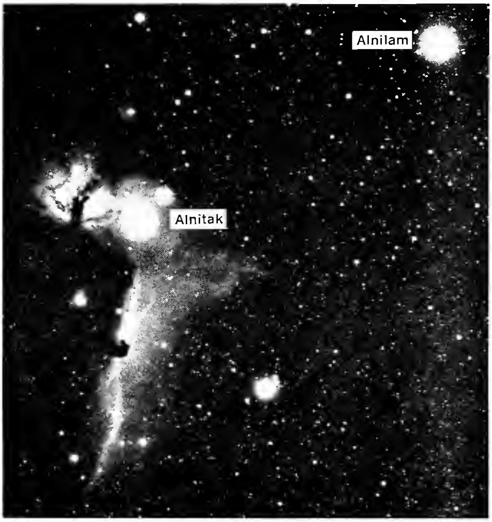
nitak is a blue supergiant star—actually a visual double The brighter component has a visual magnitude of and the fainter, separated by about 2.4 seconds of is 4.2 magnitude. Alnitak has a surface temperature),000 degrees F., a mass of 15 suns, a luminosity of)0 suns, and is about 20 times the sun in diameter. about 1,600 light-years from the earth.

nilam is another blue supergiant, similar in tempera mass, luminosity, and size to Alnitak, and about the distance from earth.

intaka, a very hot blue giant star, is a visual double, a brighter component at magnitude 2.5, and a fainter onent—distant one minute of arc—about magnitude The brighter component is also an eclipsing binary of the Algol type, with components separated by about illion miles, revolving around each other in a period 7 days. Mintaka has a surface temperature of about)0 degrees F., a mass equal to ten suns, a luminosity),000 suns, and a diameter of about 12 times that of the It is at a distance of about 1,500 light-years.



Glowing clouds of interstellar gases surround the seven bright stars that make up the figure of Orion, the hunter.



Horsehead Nebula near Alnitak is formed by a dark cloud intervening between earth and distant field of bright gas.

GREAT NEBULA was sketched from visual observation. The four bright stars in the center constitute the trapezium.

EXPOSURE REQUIRED for photo has obscured the trapezi
Energy from four stars causes surrounding clouds to g

Saiph is a blue supergiant star similar in characteristics to Alnilam and Alnitak, but more distant, probably at about 2,100 light-years from earth.

RIGEL, the brightest star visually of the seven, is a blue supergiant star, with components 0.34 magnitude and 7.0 magnitude separated by about 7.2 seconds of arc. The fainter component is also a spectroscopic binary star with a period about 9.9 days. Rigel—the bright component—has a surface temperature of about 36,000 degrees F., a mass of 20 suns, a luminosity of 50,000 suns, a diameter 30 times as great as the sun's, and is about 900 light-years away.

Four of the seven stars described above are separated from the earth by various distances, while the three Belt stars are about the same distance away. Clearly then, the figure formed by the seven stars in our sky is an effect of the direction from which we observe them. If we could see the same stars from some other point in space, their arrangement might bear no resemblance at all to the familiar and spectacular group we see in our sky.

The entire region of Orion, as can be seen in the upper photograph on page 45, is surrounded by diffuse, faintly glowing clouds of gas. These bright nebulae are especially apparent around the star Bellatrix, the Belt stars, and in the region of the Sword, but other faint clouds surround the entire constellation. The most prominent of these is the one around the star Theta Orionis, the brightest star in the Sword of Orion. Known as the Great Nebula in Orion, the beautiful cloud is shown in the photograph on page 44. The nebula is about a degree across, and bright enough to be seen by the unaided eye. Visually, or in a small telescope, it has a faint green color. Nearby hot stars, whose radiation is rich in ultraviolet, supply the energy that causes the cloud to glow in visible light. About 1,000 light-years distant and about ten light-years across, the Orion Nebula contains gas, mostly hydrogen, equivalent in mass to about 10.000 suns.

The very bright clouds around Alnitak are illuminated and supplied with energy by that star. These clouds are about 1,200 light-years distant. But there is apparently another cloud of dark gas and dust between the earth and the more distant bright clouds. This intervening dark cloud, some 300 light-years distant, is silhouetted by the bright clouds beyond, forming a very beautful pattern of bright and dark regions in the sky. One small dark patch extends into the brightness in a shape that has evoked the name Horeshead Nebula *(see lower photograph, page*

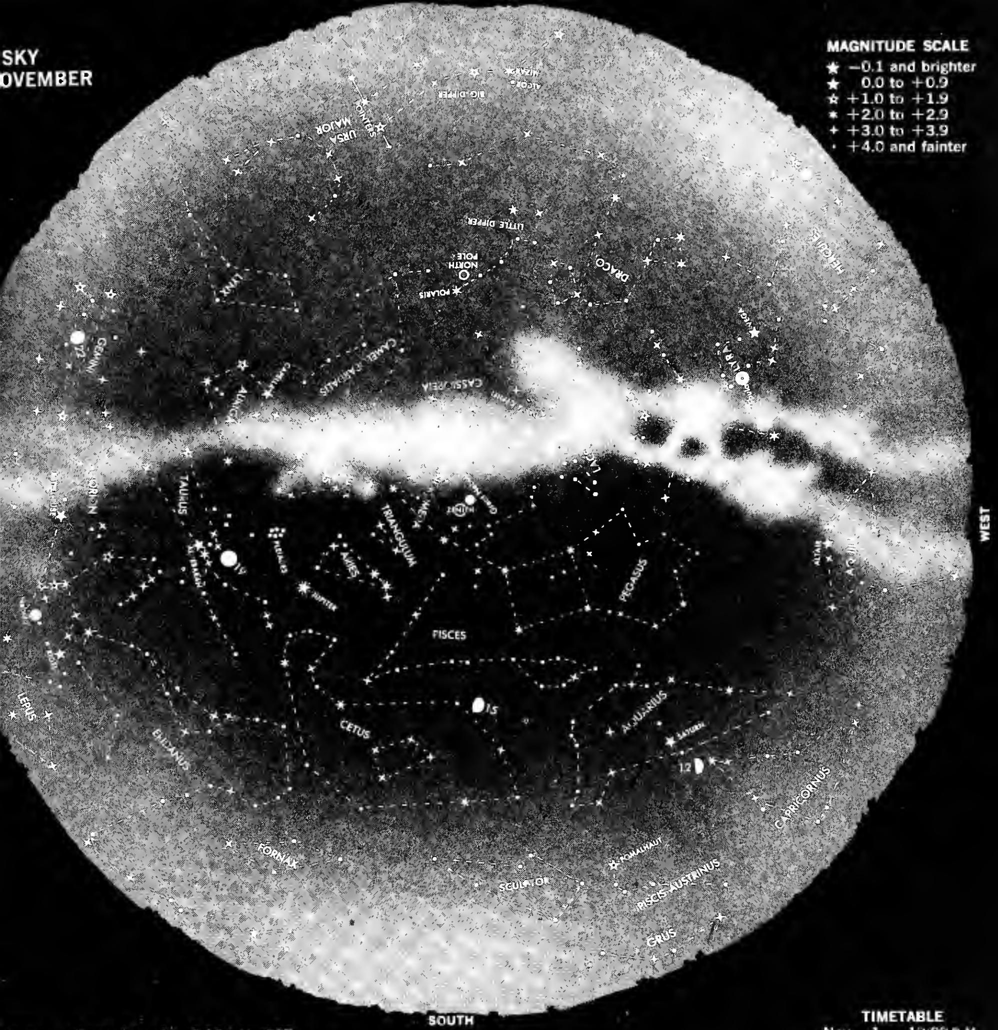
Some of the stars in the central region of Orion,
the Belt and the Sword, comprise a very rich associa
of hot stars of the spectral classes O and B, which nun
in the several hundreds. There are also many short per
irregular variable stars of a peculiar nature near the O
Nebula. These variable stars are of a type often found
ciated with nebulae, and they may be unstable star
study of the color and brightness of the stars in the O
association, as related to the theoretical evolution of
sive stars, indicates that the system is made up of
young stars. A subsystem in the region of Orion's Belt
been estimated to be about five million years old; ano
subsystem of stars in the Sword region has been estim
to be about half a million years old.

The motions of some of the stars in the Sword re
have also been used to estimate their ages. The stars ap
to be dispersing from the system at a speed of about
miles per second, which would indicate that some are i
order of 100,000 years old. However, three appare
"runaway" stars have dispersed from the system by
than 1,000 light-years. These stars—one each in the
stellations Auriga, Columba, and Aries—appear to be
ing away from the region of the Sword at about 80
per second. Their distances and velocities indicate that
are some three million years old, if part of the system.

THUS many of the stars in the Orion association ap
to be members of a very young group a few mil
years old as compared to the five or more billion years
stars like the sun. Their newness suggests that stars
still being born in that region of the sky. Further evid
that Orion is a region of continuing stellar creation is fo
in the numbers of T-Tauri type stars (yellow and red d
variables, irregular, and believed to be unstable) fo
within the nebulous regions of the constellation. In a
tion, a number of Herbig-Haro objects, named for
astronomers George H. Herbig and Guillermo Haro,
first identified them, have been found in the region. T
are nebulous, starlike images with emission spe
thought to be protostars. Both T-Tauri stars and Her
Haro objects may be stars in an early stage of evolut

DR. NICHOLSON, the regular author of this column, is a
Chairman of THE AMERICAN MUSEUM-HAYDEN PLANETARI

SKY
OVEMBER



Moon	November 4,	2:16 A.M., EST
Quarter	November 12,	7:20 A.M., EST
loon	November 19,	10:43 A.M., EST
Quarter	November 26,	2:10 A.M., EST

TIMETABLE

Nov. 1	10:00 P.M.
Nov. 15	9:00 P.M.
Nov. 30	8:00 P.M.

(Local Mean Time)

ovember 2—Saturn is stationary in right ascension and mes direct (easterly) motion.

ovember 4—Mars may be seen in the morning sky, 1.3° n of the bright star Regulus, in Leo, toward the southeast.

ovember 5—The Taurid meteors, radiating from the region e Pleiades, reach maximum today. Meteors of this shower observed for almost a month, and reach an hourly rate of 0 per hour from about November 3 to November 10. Since new moon is just past, observing should be excellent.

ovember 13—Saturn appears 3° north of the gibbous n, toward the south in the early evening sky.

ovember 13—Jupiter is at opposition, that is, on the opposide of the earth from the sun. It is then at its greatest nce from earth for the year—372,500,000 miles—and is e sky from sunset to sunrise.

ovember 16—The Leonid meteors, which were responsible he great meteor storms of 1799, 1833, and 1866, reach maximum. The present hourly rate of this shower is only t 15. Since the moon is almost full, observations of the Leonid meteors will be limited to the hours just before dawn.

November 18—Venus is 4° north of the bright star Spica, in Virgo, low in the east before dawn.

November 18—The nearly full moon and the planet Jupiter appear close in tonight's sky. At moonrise, Jupiter is above and to the east (left) of the moon. As the two move across the sky during the night, the motion of the moon in its orbit can be seen easily by observing how it changes position with respect to Jupiter. At 11:00 P.M., EST, the moon and Jupiter are in conjunction (Jupiter 2° north of the moon). Thereafter, the moon moves east of Jupiter.

November 26—Mars is 3° south of the last quarter-moon in this morning's sky. The star Regulus, in Leo, is also close by, slightly to the right (west) of Mars. All appear in the southeast just before dawn.

November 30—Mercury is at greatest easterly (evening) elongation, and may be seen in the eastern sky shortly after sunset. This, however, is an unfavorable elongation for viewing, because Mercury is situated quite close to the horizon.

Beak of ring-billed gull has band of black, which is imperceptible, *above.*

ake Erie Niche
or Gulls

ALPH S. PALMER

UARTER-CENTURY AGO, the ring-billed gull *(Larus del- warensis)* nested mainly on shoals and islands in s of the northern prairie region of North America. Its nown breeding distribution, however, was—and is— al. Aside from the main area there were half a dozen colonies along the eastern North Shore of the Gulf . Lawrence (one of which was first reported by bon), alleged nesting (now proved) at Lake Melville brador, and known breeding at Great Slave Lake in la's District of Mackenzie. Other sites also existed. past two decades, especially, there has been a popu- explosion or shift, or both. This has been conspicu- the establishment and rapid growth of ring-billed olonies in the eastern Great Lakes and their vicinity. hawk, or "Gull," Island, near the Canadian shore in eastern Lake Erie, where the accompanying photo- s were taken, mirrors this recent population change. odern ornithological history of the three-acre island een it as a ternery in 1938-41, when approximately pairs of common terns *(Sterna hirundo)* nested About 1943, a few pairs of ring-billed and herring *(Larus argentatus)* also bred. In several subsequent s, storms disrupted the nesting of the majority of irds on the island. In 1948, ring-billed gull nests ered 125, and 145 young were banded. As recently 50, the terns were the predominant species—some nests—but in 1952, about 2,000 ring-bills (not all s) were present, while tern nests numbered about

GULLS, nesting and in the air, are seen at Mohawk Island breeding site in northeastern Lake Erie.

SILHOUETTE of Mohawk Island, at left, conceals the grass and the other sparse vegetation there.

500. In addition, there were some 20 herring gull nests.

In 1954 there were about 1,200 ring-billed gull nests, some 360 of the common tern, and perhaps three dozen breeding pairs of herring gulls. In 1961, five banders put 1,582 bands on young gulls of preflight age. Today, gulls and terns continue to nest on Mohawk Island in numbers that vary from year to year.

The changing population of Mohawk Island is interesting in comparison with that of Little Galloo Island in eastern Lake Ontario. Just when ring-bills first occupied it —presumably quite recently—is unreported. On June 7, 1945, this thirty-acre island had about 2,000 breeding gulls in a ratio of ten ring-bills to one herring gull. The population increase in the next decade was enormous. In May, 1955, for instance, there were an estimated 45,000 ring-billed gull nests on a twenty-acre portion of the island. Similarly, on a five-acre island in Lake Champlain, the first definite nesting report dates from 1949. In June, 1955, about 2,000 adult ring-bills were present, concentrated on less than a single acre.

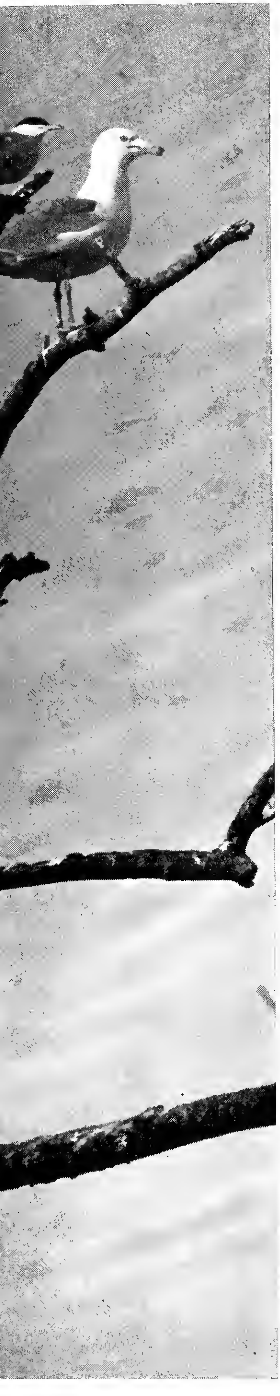
It is entirely reasonable that a gull of the prairies should occupy low islands that have extensive areas of grass or other short or sparse vegetation. Such places also are ideal for a bird whose breeding density sometimes exceeds 2,000 nests per acre. Since these new gulleries are well within the ordinary range of the ring-billed gull, and apparently there has been no competition for the islands with appreciable numbers of any other gull species, the mystery remains as to why the ring-bill did not occupy Mohawk and the other islands long ago.

For many other reasons, the ring-billed gull would be most interesting for a thoroughgoing study. It is more buoyant and agile in flight than the herring gull—a real advantage in maneuvering to catch small prey and entering and leaving crowded gulleries. Apparently its closest affinities are with the common gull *(Larus canus)*, primarily an Old World species, for this gull's immature plumage patterns are more like the ring-bills' than are those of other *Larus* species, such as herring and California gulls.

What is the ring-billed gull's future? Checks on its population include storms and prolonged inclement weather that disrupt nesting. There is also a comparatively high mortality of downies, especially in colonies subject to disturbance by man or other animals. Moreover, a chick thirty inches from its own nest is in hostile territory, in that it is exposed to often fatal attack by other ring-bills. A recent study showed that 2 per cent of the birds that were banded in preflight stage on Mohawk Island and that survived to leave the site were found dead or dying in their first fall or winter. This is a considerable recovery rate for banded individuals (a dead gull is fairly conspicuous), but probably reflects only the high first-year mortality generally characteristic of avian species.

Prior to their first fall migration, young ring-billed gulls disperse widely across country. From the prairies eastward, southerly migration normally occurs between August and early October. Some of these gulls go to the nearest water that remains unfrozen through winter, while others migrate only as far as nearby garbage dumps. The wintering coastal population of the Atlantic area, however, is centered in the Carolina-Florida area. The return migration occurs in March and early April, and at that time Mohawk Island again comes alive with nesting activity.

Common tern and ring-bill are at top of tree; herring gull is at lower left.



Downies are probably ring-bills, but even banders have misidentified young.

Ring-bills soar on black-tipped wings over the Mohawk Island nesting sites.

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About the Authors

Dr. Syd Radinovsky, author of "Cannibal of the Pond," holds an assistant professorship at Millersville State College in Pennsylvania, where he teaches entomology and zoology while continuing with research on the biology and behavior of insects and mites. A Canadian citizen, he did undergraduate and graduate work at the University of Manitoba. He received his doctorate in entomology at Oregon State University, then spent two years at the University of Kansas as a research associate working on the biology and behavior of ectoparasitic mites.

"Strangler Fig, Native Epiphyte," is the work of Dr. Virgil N. Argo, a frequent contributor to Natural History. Dr. Argo, who prior to his retirement was Associate Professor of Biology at The City College of New York, has for more than two decades done extensive photography in the field of biology, concentrating on botanical subjects. He has traveled widely throughout Mexico, Europe, and North Africa, and is especially interested in the botany and agriculture of the Mediterranean region.

Dr. Walter N. Hess, author of "Long Journey of the Dogfish," is a visiting Professor of Biology at Converse College in South Carolina. He graduated from Oberlin College, received his doctorate from Cornell University, has taught at several universities, and recently has been on the Governing Board of the American Institute of Biological Sciences. He has a summer home at Harrington, Maine, where he has observed the migrations of spiny dogfish for more than twenty years.

The discussion of Swedish rock carvings, "Bronze Age Seen in Granite," is the work of Dr. Holger Arbman, of the Historiska Museum at the University of Lund, Sweden. Dr. Arbman studied at the universities of Stockholm and Uppsala, and in 1928 became Keeper of Antiquities at the Statens Historiska Museum in Stockholm. Since 1945 he has been Professor of Medieval and Prehistoric Archeology at the University of Lund. His field work has included excavations in Sweden, Germany, France, and India, and he is especially interested in the Viking period.

Dr. Ralph S. Palmer, author of "Lake Erie Niche for Gulls," is a zoologist who describes his major interests as "ornithology, mammalogy, fine arts, and trying to 'improve' a piece of rural real estate." Among Dr. Palmer's published works are *The Mammal Guide*, which he wrote and illustrated, and Volume I of *The Handbook of North American Birds*, which he edited. Dr. Palmer studied at the University of Maine as an undergraduate and received his Ph.D. in ornithology from Cornell University.

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Art of Ajanta and Ellora

By Robert S. McCully

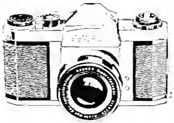
ME TWO HUNDRED MILES inland from ombay, near Ajanta in west central , there are about thirty man-made in a canyon wall. These caves were as dwellings and meeting halls by ldhist order from about the start e second century B.C. until the th century A.D., when, because of ersecution of Buddhists in India, ves were abandoned and were lost n for the next thousand or more The caves, in a desolate canyon Indhyrdri Hills, were rediscovered itish soldiers in 1817.

nta means "no man's land," and ea is indeed remote, set in a cres- of steep hills studded with strata canic rock. The cave-temples are ed near the source of the Wagura which is a mere trickle in spring, oaring torrent during India's rainy is. Over the years, the river eroded nyon in which the Buddhist caves cluded.

ny of the inner walls of the caves vered with murals that represent of finished maturity that has been ce of inspiration for all later Buddhist art. In turn, most forms of oriental art cannot be separated from the Buddhist influence that was carried from India to other countries by monks.

The caves are of two main types: "monastery," or dwelling quarters; "cathedral," or meeting halls. To enter the area of the dwelling halls one crosses a broad veranda, its roof supported by pillars. The veranda gives access to a hall, averaging in size about thirty-five feet by twenty feet. Dormitories are excavated so that they open onto this hall, and a statue of the Buddha carved from volcanic stone usually stands in a niche facing the entrance. In the larger caves, pillars support the roof on all three sides, forming a sort of cloister around the hall. The meeting halls extend back into the rock about twice as far as do the dwelling halls. Some caves are carved a hundred feet or so back into the solid rock, and at least four of the caves antedate the Christian Era. Those that contain the finest paintings date from the Gupta

MURAL of the Bodhisattva Avalokitesvara dominates Ajanta Cave I. Lotus blossom in hand is a symbol of great creative powers.



Ellora temples were carved from single mass of volcanic rock. Siva Kailasanatha Temple, in background, represents Siva's abode, central peak or axis of the world.

period, roughly within the fifth and sixth centuries A.D.

The Ajanta caves are approached by a steep, serpentine gravel walk from which one passes to a narrow rock ledge that runs along the mid-face of the cliffs. The caves that contain paintings are also richly carved, and there is constant counterplay between stonework and painting. The Ajanta colors, fresh and magnetic, are very difficult to capture with a camera. The earth colors—red and yellow ochers—play a dominant role: *terra verde*, lampblack, lapis lazuli, rich pink, orange, and white are mixed with earth colors, all of which combine to create a marvelously warm luster that has survived the passage of time. The almost luminous qualities of the original paintings are missed in most reproductions. In the amygdaloidal or laval rock along the approaches to the caves one can still see cavities filled with deposits of pink and blue-green calcite, quartz, agate, and other minerals that the artist-monks extracted, powdered, and used as pigment in mixing their paints.

At Ellora, about 70 miles northeast of Ajanta, there are other rock-cut temples dating from the eighth century A.D. Some of the caves served as monasteries, and these shrines and temples are not only of Buddhist origin; even more strongly they reflect Hindu and Jain influences. Only crumbling walls and a few blackened shrines remain of the city of Ellora itself, capital of the first Rashtrakuta emperors of the eighth century A.D. As at Ajanta, Ellora's rock-cut caves and

es are set in a crescent of hills.
great artistic achievement of El-
es in its sculpture and stone archi-
e. not in its paintings. Monks
l and chiseled the Siva Kailasan-
'emple. which is almost a hundred
ı height. from the top downward
f a single. gigantic rock. It was
to represent the paradise of Siva.
ıd the circumference are carved
ınt caryatids (supporters of the
se) that appear to bear the tem-
veight. The walls of the temple. and
ck-cut caves that surround it like
sive stone horseshoe. are intricately
l with numerous scenes depicting
roic deeds of Siva.

may see Siva portrayed as the
archer soaring in an aerial chariot
by prancing steeds. and releasing
ow to destroy the forces of evil that
en mankind. In another instance.
consoling his queen consort. Par-
who has become frightened by a
ı with twenty arms. There is no
ıess here. no feeling that one has
led on memorials of an alien time;
, one is engaged by the very human
y of the sculptured figures.

ween Ajanta and Ellora. the West-
may find considerable difference
s own responses. The masterly
y, grace, and delicacy of the human
s of the Ajanta paintings are ap-
t; nevertheless, it is not as easy
Westerner to grasp the profundity
se murals as it is for him to em-
e with the sculpture at Ellora. One
basic reasons for this lies in a
mental difference in purpose be-
Buddhist and Western painting.
hist paintings are not designed
to elicit an aesthetic response.
goal of the artist-monk is to deal
a particular idea or question in
ıist thought in the most perfect
permitted by his capabilities. In
cases. a painting may be set forth
t were a story answering a complex
on: the inspiration for this conven-
s Buddha's own teaching methods.
an artist strives for a symbolic
sentation of a given moral or reli-
problem that will be compre-
d by others. Because the viewer
ook at the painting to attempt to
the problem. the painter must
lf wrestle with the problem in order
rtray it properly in graphic form.
rtist's goal is to help the picture's
r achieve a fresh insight into his
ectual processes. beliefs. or experi-
. Thus. it becomes apparent that
must know something about Bud-
thought to feel at home with the
a paintings.

Ajanta paintings include scenes
the Buddha's life. from conception
attainment of nirvana. The Jataka
s—parables told by the Buddha in
nse to a question or problem posed

King Mahajanaka, in detail of Ajanta mural, tells queen and concubines that he is renouncing world. His hands are fixed in symbolic expression of his spirituality.

by a monk—are represented in continuous narrative. Within each story told by the Buddha resides a clue to a solution of the problem posed: the monk had to grasp the clue and the answer himself. Within this context, the murals depict a profusion of scenes of human love, compassion, happiness, yearning, death, suffering, and sacrifice.

The artists of Ajanta worked in the tradition of the projection of a personal, inner world. Emphasis on inner qualities and lofty religious ideals is perhaps symbolized by the placement of the Ajanta caves, which are numbered one to twenty-nine. There is a sharp contrast between the rocky desolation of the caves' outer setting and the rich life created inside by the paintings. Also, the lush corporeality of the figures in the murals merely represents the fascinations of this world, which are to be rejected. Words on the walls of Cave II make this perfectly clear: "Virtues brought to perfection are the proper ornaments of living beings."

None of these religious considerations

need prohibit the non-Buddhist from appreciating the beauty of the paintings, however. If the great Bodhisattva (a luminous warrior on the way to enlightenment) of Cave I were still totally preserved, it would be apparent that a pinnacle in art had been achieved. The women of Ajanta are rendered with special sensitivity. Large eyes, seeming exaggerated to the Western viewer, are intense and forceful. In one case, the compassionate eyes of a Buddha are all that is left of the portrait.

Every detail is invested with importance. There are no exclamation points in the paintings; they are a blended unity of detail. One sees an ant crawling on a tree trunk in a Jataka scene painted twelve hundred years ago and is tempted to reach out and brush the ant away. Renderings of hair are remarkably lifelike (hair was a symbol of health) and the hands, so often a vehicle for expression in Buddhist thought, are unexcelled in their precise execution.

The Buddhist conception of *arupa dhatu*, or "formless form," constituted one theoretical framework of graphic representation. For instance, in Cave I the artist makes use of *arupa dhatu* in an exquisite scene depicting a prince and princess in conversation. Surrounded by court attendants (including some of the loveliest of the Ajanta women), the prince has fixed his hands in a symbolic position (*mudra*), which in this case communicates the necessity for prayerful repetition of the moral doctrines of Buddhist law. The lines and shadings of the hands make them appear ethereal; this contrasts sharply with the clear detail of the rest of the figure. To see the hands in such a setting is like watching the blur of a hummingbird's wings.

At Ajanta, the artists have been as faithful and accurate in their representations of flowers, plants, and animals as they have been in portraying human figures. Some brilliant colors appear on the ceilings, which often are decorated with fruit and lotus blossoms. The animals, some in pairs, are quite vivid.

Both at Ajanta and Ellora, the visitor cannot help being aware of the twofold significance of what he views—works of art that, aesthetically, are outstanding examples of creativity, and that, as religious teachings, set forth admirable principles of moral and spiritual conduct.

Dr. McCully studied in Asia, and is Director of Clinical Psychology at the Payne Whitney Psychiatric Clinic of The New York Hospital.

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The Biological Collector

By Jack J. Rudloe

ERE does an Ohio medical school staff involved in cancer research nomalous fishes with tumors, or a ngton. D.C., zoologist, research- e distribution and identification of les, get specimens from some far- coast? How can a biochemist iso- nzymes from a shark's liver to the trigger mechanisms of nitro- etabolisms? In situations such as many researchers rely on the serv- f a biological collector to provide nens; even scientists working at laboratories often have speci- brought to them by professional ors in order to save time.

earch programs require a routine of experimental animals over a of months or even years. If the ch is being done in a university, rofessor conducting the experi- usually has a team of graduate ts and laboratory technicians, ssigned a specific phase of the re- . Each team may require a large er of animals. Should the supply mals fail to arrive, months of ex- entation could be disrupted.

Locating Specimens

ING specimens for research pre- ts varied problems. In the case of ne collector, the only way to learn here the organisms can be found becoming thoroughly familiar with ashore, and learning all the eco- l habitats, as well as the time of nonth, or year when collecting con- s are favorable. The collector must ncerned not only with the general phic distributions of animals, but locations where the animals are concentrated. It is often on the iso- rock pile that one will find clusters ertain species of sea anemone or te, or discover amphioxus on the and bar within a hundred miles. ggregations of marine animals are om understood.

the seashore nothing is constant. ent hurricane can alter ecological ts overnight causing some species ninish or resettle elsewhere, and ent animals to move in. And with ncreased dredging of harbors, the ng of rich coral reefs, and the ng exploitation of the sea's re- es, the old collecting places are ing drastically. Pesticides can wipe st numbers of fiddler crabs, and stroy the amphipod beach-hoppers ive in cast-up seaweed and are an important food source for other animals. A collector must constantly rediscover the animals on his beaches.

The seasons dictate the availability of the animals; in winter the bryozoan *Bugula* cluster around wharf pilings and disappear during the summer. Then they are replaced by the waving, feathery hydroids, *Obelia*. The collecting depends on how long the animals stay in the area. Many fishes, including sharks and rays, move out into the warmer waters, far too deep for gill nets.

Tide Changes Important

A collector carefully studies the tide tables to learn when the lowest tides occur. With strong favorable wind and a good low tide the waters recede far out from shore, and multitudes of marine animals are exposed. Walking along with buckets under these conditions I pick up sea pansies, giant cockles, sand dollars, blood clams, lugworms and sipunculoids, starfish, conchs, scallops, crabs, and sea cucumbers often covered with parasitic snails. While digging about through the eelgrass for brachiopods I find horse mussels, pen shells, and burrowing tubed sea anemones.

During high tide *Limulus polyphemus*, the "horseshoe crab," comes to the water's edge. It is important in studies because of the copper pigments in its blood, its large heart, and eyes with accessible optic nerves that lend themselves in the laboratory to demonstrations of light response. High tide will also cast up sea hares, whose giant nerve cells are useful in neurophysiological studies, as well as Scyphomedusae, live sponges, clumps of bryozoans, and tunicates that break off from their holdfasts and are washed up on the beach by the surging sea. On picking up a drab brown basket sponge, one may find commensal anemones living in its canals. The sponge is host to brittle stars, snails, polynoid and polyclad worms, snapping shrimps, amphipods, copepods, isopods, and hairy little crabs and peculiar sponge barnacles.

A flat that is most unproductive during the day may become rich and rewarding at night. Under the illumination of the moon, sea cucumbers can be seen thrusting out their floriated heads from the mud to feed on plankton, sea anemones emerge from the sand, green-eyed squid dart through the waters, shrimp leap and fall back with a splash, swimming crabs paddle along the surface, and schools of minnows are caught in

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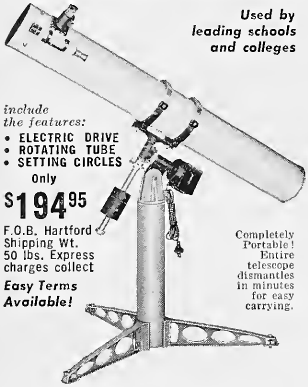

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the beam of the collector's glaring gasoline lantern. Slowly and gracefully sea hares, *Aplysia*, undulate their wings, speckled nudibranchs creep out from under rocks, and chitons emerge from the crevices. Shrimp trawlers pulling their nets at night get a great assortment of continental shelf fauna. The winches wind in an immense net packed with shrimp, squid, huge sponges, crabs, Mexican lobsters, and sometimes many octopuses. Sharks, rays, batfish, scorpion fish, and filefish are also caught with flounders, butterfish, and catfish.

I am kept busy aboard the trawlers saving animals or parts of animals that are considered worthless by fishermen, but that may be valuable in scientific research. Shrimp eyes, for example, are important because they contain hormones that regulate light adaptation. To preserve the eyes, one snips them off and immerses them in a subfreezing solution of alcohol and dry ice. Octopus, living batfish, and electric rays, studied for nerve innervations, are hurriedly culled and rushed into buckets of sea water. Parasitologists do research on living tapeworms and trematodes from sharks and bony fish. To extract the parasites, the hosts are instantly gutted and the intestines put in a solution of diluted sea water, which is isotonic to the parasites. Octopus kidney smears for mesozoans are made aboard the shrimp trawlers, and random samples of shrimp intestines and rectums are carefully placed in special fixatives to preserve gregarian parasites. The identity of these parasites is determined by their histological structures. Upon finding a bizarre, flame-streaked box crab, the collector removes the carapace and examines the gills for parasitic barnacles. Occasionally, the collector finds a new species and is rewarded by the feeling of exultation when a specialist informs him that he has contributed something new.

I make a quick check through the piles of fish for abnormalities: tumorous growths or malformations, for example, or wounded fish with regenerated tissues. All uncommon and rare fish are saved; some may be strays from the Bahamas and West Indies to the northern Gulf of Mexico, enthusiastically welcomed by ichthyologists because the specimens help document knowledge of fish migrations and distributions.

Problems of Shipping

Once a biological collector has gathered his specimens, there still remains the problem of getting them to their destination. A biologist may want his specimens live, frozen, or preserved, according to his research program. If he wants live animals, the collector determines how well they will survive shipment. Chances of survival vary when you take an animal from its environment—the

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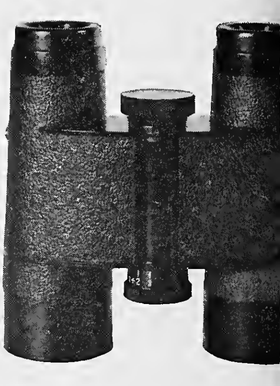

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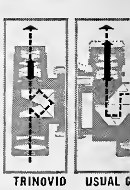

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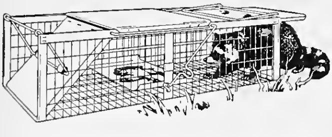
and confine it in a plastic con- ; then rush it to a specialist. Some iens will not survive shipment, so est not to commit oneself and dis- it the scientist. The constantly g eagle ray, for example, will die se confinement, as will squid, but opus will live for a short time.

chemists often require frozen spec- ; the validity of their research and gs may depend in some degree on areful and exacting the collector been. Researchers working with unstable enzymes require that specimens be frozen instantly. The e provides an example of why this essary; after the shock of being ed from its holdfast, the sponge's te chemical structures begin im- te deterioration while the animal l alive. The process can only be ed by instant freezing. The sponge d-packed in dry ice for shipping. there is a flight delay or the ship- is mislaid en route, the specimens out and are ruined.

hysiologist in New Jersey studying escence in marine life wishes to ment with ctenophores, delicate ls resembling jellyfish; how does nip live ctenophores for any dis- ? They are so fragile—made up of cent water—they are apt to break hat are the chances of their sur- ? There is no literature to guide llector, to tell him how or how not p these animals. Careful experi- tion is necessary to avoid failure. cking the ctenophores in plastic of oxygenated sea water and simu- conditions of 18-hours flight time, offer an educated guess as to what condition will be on arrival. If the nens die in the laboratory, another d will be tried—perhaps using a y-powered air pump, or packing ecimens in ice.

er luminous animals are no prob- ship. The interesting parchment that glows inside of its tube is ately exposed to icy weather and ense heat and dehydration on the dal flats, so we know it will endure ing. The midshipman, a tough little fish with rows of luminous photo- s, or light-producing organs, will e in a bucket of sea water over- and can be transported quite . Animals' powers of endurance considerably; dull, cumbersome shoe crabs can survive weeks in ent and are often sent to Europe. ne ghost crabs—*Ocypode*—must be ed in individual containers, and d air express even for short dis- s. If six are requested, I usually twelve to allow for a high percent- f fatalities. Among other consider- , it is important that the collector the airline schedules and the est shipping routes; the time of



Mr. Rudloe, a biological collector who took part in the International Indian Ocean Expedition, is active on both the Atlantic and Gulf coasts.

year has to be taken into account, since precautions must be taken to keep the animals from freezing or overheating. The recipient must be notified of a shipment well in advance so he can be at the airport to pick it up.

Preserving Is Vital Step

Preserving museum specimens properly for identification is another responsibility of the collector. Many soft-bodied invertebrates are identified by their internal structures, and care must be taken to see that the specimens are properly preserved. Unfortunately, this often is not the case. Inexperienced collectors frequently gather sea anemones, sea cucumbers, and tunicates and toss them indiscriminately into formaldehyde. Immediately the animals contract violently, preventing the preserving fluid from penetrating their internal cavities. Consequently, when a scientist carefully cuts through the preserved outer walls of the animals, a macerated ooze runs out and the specimens prove useless. In order to preserve the viscera, an experienced collector will inject formaldehyde into the internal cavity. Knowing the right preservative is essential. All too often sea cucumbers and soft corals arrive at museums packed in formaldehyde, the acid in which breaks down the calcareous spicules that are a key to the animal's identification. Sea anemones macerate in alcohol. and gastropods fixed in formaldehyde are impossible to dissect because the tissues will soon become too hardened.

Although the scientist is trained to classify museum specimens even in a contracted, poorly preserved state, he prefers the specimens to be thoroughly relaxed. Sea anemones suddenly whip in their petals when even slightly irritated and draw up into something that resembles a boiled onion. The waving frills and fronds of the nudibranchs—so important for identification—contract, and flatworms and comb jellies disintegrate into a slimy mass if carelessly preserved. The collector must know how to deal with such problems; certain marine invertebrates are narcotized if epsom salts or menthol crystals are slowly added to their dish of sea water until the animals are immobilized. Others, such as polychaete worms, become slowly relaxed when alcohol is added to the water until they succumb.

The preparation of museum specimens does not end with preservation. Unfortunately, color pigments of most fish and invertebrates cannot be maintained after death. In a short while all the beautiful colors fade. The collector takes ca notes and draws the animals to de strate the color pattern. Equally i tant to a scientist is the collec ecological field data, a great hel learning the zoogeography of the se

One of the biological collector's important contributions can be in field of behavior. A preserved speci floating in a jar of alcohol gives no c to how it escaped predators, what de it used to capture food, how it r duced. But among the rocky tidepoo the Pacific and the coral reefs of South Atlantic, as the collector g removes a cluster of delicate pink droids from a rock, he observes how animals behave, and he keeps recor that behavior. Perhaps the most rew ing aspect of being a professional logical collector is the awareness tha is making a contribution to man's kn edge of his environment and the b ficial applications that eventually result from this increased knowle

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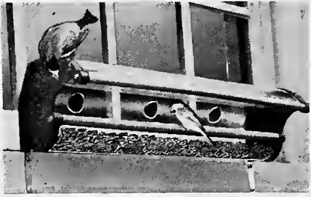

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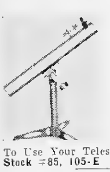

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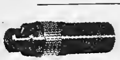

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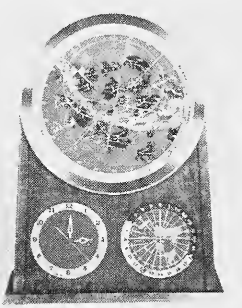

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SAME AS ABOVE—non-illuminated dials
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Stock No. 70,473-E .... **$4.95 Postpaid**

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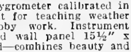

New "Weather Station" is highly sensitive to weather changes. Consistently accurate thermometer to ± 2%; barometer accurate to ± .25" and hygrometer to ± 5%. Foretells weather changes from 12 to 24 hours in advance. Hygrometer calibrated in percent relative humidity. Excellent for teaching weather phenomena and meterological hobby work. Instrument mounted on handsome wood-grained wall panel 15½" x 5¾". Meter cases heavily metalized—combines beauty and protection. Dials, in etched aluminum, of high precision. Full instructions.

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Useful to all outdoorsmen, especially s
shooters, fliers, golfers. Lightweight
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scales—low and high velocity. One from
MPH graduated in ½ MPH increments.
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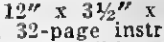

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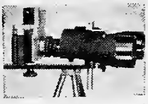

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Exciting outer space display and conversation piece. Exact replica. 30,000 formations—peaks, craters, Ocean of Storms, etc.—all in relief. Scaled to size. Accurate distance relationships. Proper lighting shows moon phase, "black light" produces startling effects. Tough, washable plastic. Three colors. Far side blank—can be used for space data. Excellent gift item. 12" dia. wt. ¾ lb.

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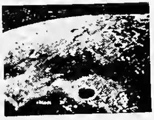
A SLIDE TRIP TO THE MOON—MOON TOPOGRAPHY STUDY AID



As the universe shrinks, interest in astronomy increases. This highly informative series of 29 black and white slides features such topography as the southwestern limb and Mare Imbrium—the "pearl" of the moon. Also, full moon taken with Mount Wilson 100-inch reflector and the crater Clavius through the 200-inch.

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Black and white photo reproduction of full moon with all named lunar formations clearly marked. Complete index to locations and other valuable information.

Stock No. 9297-E .... **.95¢ Ppd.**

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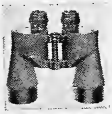

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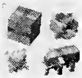

12 Different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals and geometric forms to take apart and reassemble, give a chance for all the family, young or old, to test skill, patience and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now.

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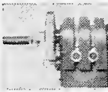

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Lifts 350 lbs. . . . . **533.60 FOB**

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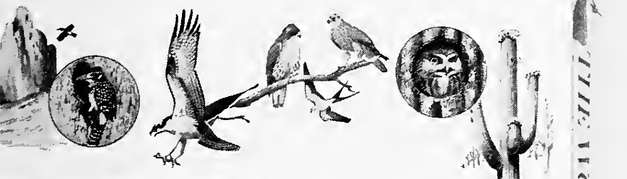

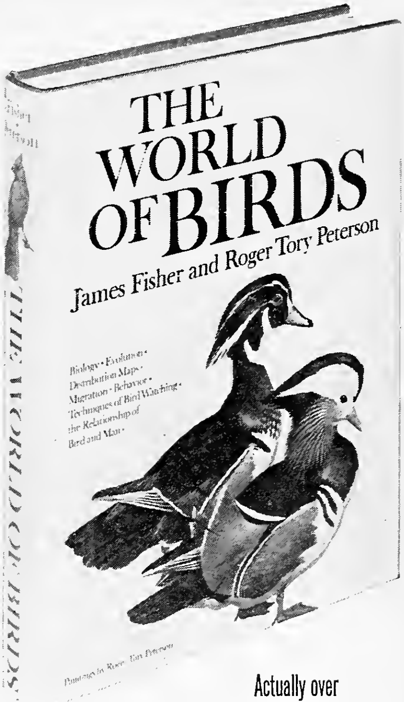

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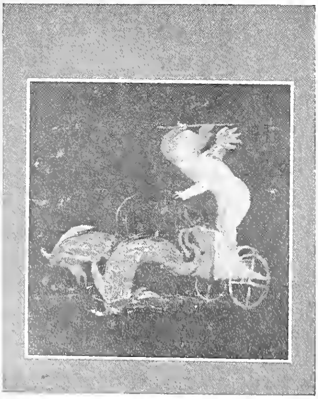
ARTICLES

DEPARTMENTS



COVER: When Mt. Vesuvius erupted and dropped ten to twenty feet of cinc
pumice, and ashes on Pompeii, an estimated 10 per cent of the population of
city perished. But the same ashes preserved the remarkable art that existed w
the tragedy struck in A.D. 79. For example, the dolphin-driving cupid was
the wall of the *Casa dei Vettii*, and is strikingly modern in its use of v
colors. For further information about the flora and fauna of Pompeii and
neighbor, Herculaneum, please turn to page 30, where Dr. Wilhelmina Jashen
gives a detailed discussion of the many animal paintings found on ancient w

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SILENCER

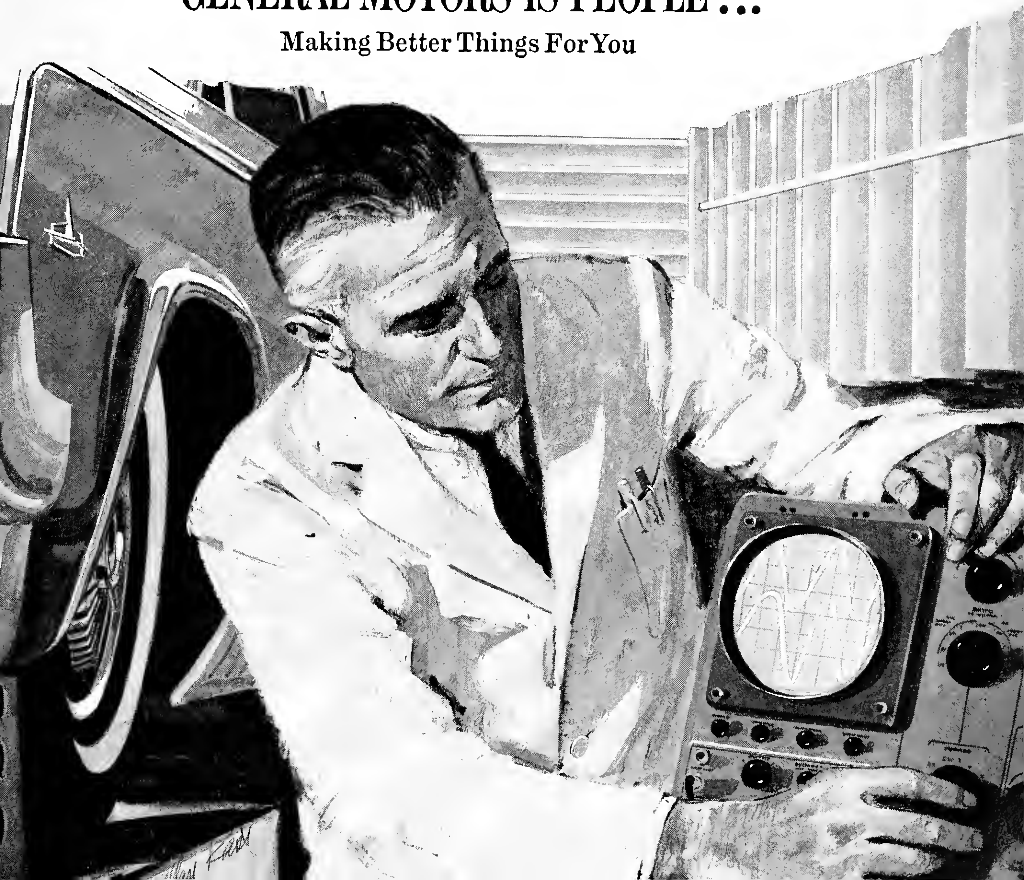
His business is *quiet.* He's a General Motors development engineer and his job is to help see to it that every GM car operates as smoothly and quietly as advanced technology and human skill can reasonably achieve. His work takes him into an anechoic chamber at the Milford Proving Ground where walls made of glass-fiber-wedges up to a yard deep absorb 99 percent of the sound made by a car in operation.

In this room GM cars are "road proved" on a chassis dynamometer under many driving conditions and at varying speeds. Every significant noise, no matter how slight, is studied, charted, evaluated. Object: quiet. This man and others like him never stop striving to reach that goal.

Highly refined laboratory setups like the Milford anechoic rooms contribute vitally to the constant improvement of General Motors cars. But they would be valueless without the knowledge and experience of the men who use them. People, after all, are the key to the continuing excellence of GM products. General Motors owes its position in industry to the dedication and ability of a great many exceptional people.

GENERAL MOTORS IS PEOPLE...

Making Better Things For You



BOOKS IN REVIEW

Wildlife under siege

By Joseph A. Davis, Jr.

Africa's Wildlife, by Eric Robins. *Taplinger Publishing, $5.95; 224 pp., illus.* Vanishing Wildlife, by Roy Pinney. *Dodd, Mead & Co., $5.00; 193 pp., illus.* I Walk With Lions, by Mervyn Cowie. *The Macmillan Co., $4.95: 245 pp., illus.* Between the Sunlight and the Thunder, by Noel Simon. *Houghton Mifflin Co., $6.00; 384 pp., illus.*

A single species, in a geological twinkling, has wrested dominion over its fellows. Although natural forces continue to act upon the fauna and flora of the world and must inevitably doom some species to extinction, the technology and sheer number of humans, increasing by a geometrical rate that needs no longer be measured in millenniums or centuries, but by the year, has in many ways precluded nature's long-term effects. Man (a wonderfully impersonal word for avoiding the incriminating "we") has in the past extirpated species in isolated instances—one here, another there, in widely scattered places and times throughout his history. Each loss has been a tragedy in itself, but the overall number of species lost forever has remained small enough to be listed conveniently. In the past few years, however, it has become clear that the foreseeable future holds the awful promise of certain doom on a wholesale scale for the plants and animals of entire regions. Worse, region after region will be added to the list, like pieces of a vast planet-wide jigsaw puzzle, and when at last the picture emerges it will be one of desolation, not alone for the plants and animals of the world, but for ourselves as well, for only recently have we begun to suspect the extent to which all living things are interdependent.

Public awareness appears to be the only hope today for averting the otherwise irreversible process. A few species of animals have been hauled from the brink of man-made extinction in the last century—it can be done. In large measure, these species were saved by the process of breeding captive animals, however, and the preservation of wild-living populations is still a precarious undertaking whose success only a future generation can judge. The task that lies ahead is staggering, and although scarcely anyone who reads newspapers and magazines today can be unaware that the natural world is under siege by humanity, a true understanding of the crisis that is upon us has yet to impress itself
upon more than the few ecologists
are working in the field. Fortunately
past few years have seen an increas
amount of publicity given to the sub
from various avenues of approach.
four books reviewed here are represe
tive of the growing number of popu
appeals for animal preservation.

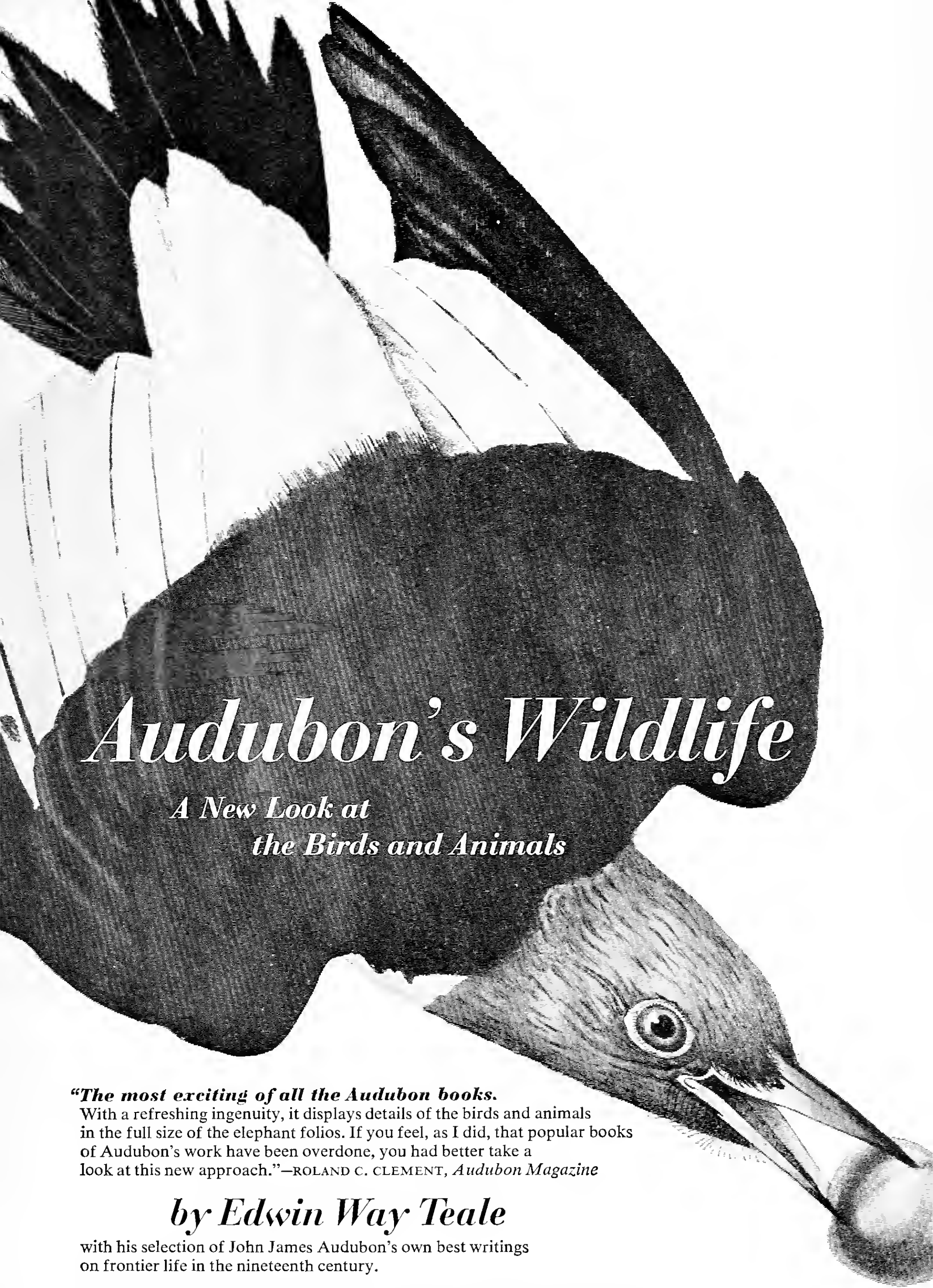
Eric Robins' approach is a subtle
In *Africa's Wildlife* he uses a serie
vignettes to recount visits with pe
involved in one way or another with
wildlife of a large area of southern
eastern Africa. Slowly he assemble
disquieting mosaic relieved by s
patches of heroism and hope that st
out the more by contrast to the b
ground. The occasional statistics in
narrative are unobtrusive, but telling

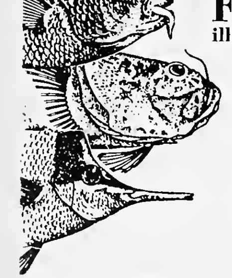
Vanishing Wildlife is another mat
We may grant that Roy Pinney's g
intentions are above question, but,
bluntly, he is not qualified to disco
on the subject and has done a slove
job. Some passages are accurate
forcefully written, but the instance
misstatement and carelessness are
too frequent to be forgiven. Pinney
photographer, and he has illustrated
book liberally with photos, many ta
by himself. This makes even more
prising the use of his pictures of
gemsbok and white rhino in hab
groups in the Akeley African Hal
The American Museum of Natural
tory over captions describing Ara
oryx and Indian rhino.

Carelessness in the text, too, is
pant. For example, the following oc
on a single page in the discussion of
Javan rhino: the animal, he says is "
lieved to exist now only in Sumatra,"
then below, "The only place where
species now survives is in Java."
status of the whooping crane is lost i
series of confusing data that will f
trate the attentive reader.

To dwell further on the shortcomi
of this book would serve no useful p
pose. Suffice it to say that it is to
recommended only to the zoologist
enjoys underlining other people's er
and has a serviceable pencil sharpe
close at hand.

In *I Walk with Lions*, Mervyn Co
has chosen to thread the story of
conservation problem in Kenya thro
an autobiography. His account cov
the diminishing of wildlife in the ye
since his childhood, but is devoted p
cipally to his efforts in connection w
the establishment of Kenya's Royal





tional Parks. The narrative is pepper
with amusing anecdotes, but the hea
emphasis upon individual animals ter
at times to obscure the author's conc
for the species, and Cowie's frequent
of the expression "my animal frien
becomes a bit cloying. Like Robi
book, *I Walk with Lions* is not ba
reading on the wildlife problem, but
interesting correlative material.

The reader who wants an excell
presentation of the over-all picture
conservation as it is to be found in Ker
will find Noel Simon's *Between the S*
light and the Thunder just what he
looking for. To begin with a seemin
trivial matter, he is the only one of
African writers who does not overe
mate the reader's familiarity with Afri
He provides maps (Robins does too,
not such meaningful ones) and expla
tions that the non-Kenyan reader
find invaluable if he is not to be bogg
down among the details necessary to
exposition of the problems there. Sim
has organized his presentation adm
ably, covering the historical setting
some detail, providing an incisive
count of the present situation, and, p
haps more important, offering propos
for action. A glossary of the scient
names of the species treated in the t
is a happy addition, and the tables a
appendixes further enhance an alrea
fine, carefully executed book.

Mr. Davis is Curator of Mammals at
New York Zoological Park (Bronx Zo
One of his duties is the development
breeding herds of endangered mamm

DOWNSTREAM, by John Bardach. *Har*
& Row, $5.95; 278 pp., illus.

IN this well-written and enlighten
volume, Dr. Bardach embraces wa
in its many forms—fog, clouds, rain, h
snow, and ice—and discusses the vari
phenomena that affect water, such
topography and aquifers. Man and
effects on waters are also included.

Beginning with the premise that p
cipitation in some form gives rise to
streams and that their ultimate desti
tion is the ocean, the author discus
brooks that originate from melting g
ciers, bogs, marshes, lakes, springs,
tesian wells, surface drainages, and
on. He follows the brooks as they beco
streams, join one another to beco
large rivers, finally form deltas, and
ter either the sea or an estuary, whe
their waters become brackish.

Most fresh waters are in motion as
waves in lakes and currents in strea
and the book includes much informati
concerning such water dynamics. Ra
erosive effects by high-gradient strea
are compared with the silting effects
static waters, and water as a modif

landscape is also interestingly dequately treated.

Bardach gives us a huge and varied it of excellent natural history. are concise life histories of many and animals, including such diaquatic and dry-land forms as mosses, buttercups, dragonflies, beetles, mollusks, oysters, annelid s, many fishes, amphibians, repbirds, and mammals. Even the min of musk ox along river courses is sed. The author points out a numf instances of highly specialized ıtions to extreme conditions, such rential currents, which result in e species with marked morphologinilarities inhabiting widely sepawaters of the world.

last three of the nine chapters ırgely with man's use and misuse aters. These thought-provoking ers are written in an objective r in which the increasing shortage er in the face of a rapidly expanduman population is evaluated. laws, detergents, insecticides, and energy wastes are discussed. is a bibliography and index.

ı the average reader and specialist rofit by reading this book.

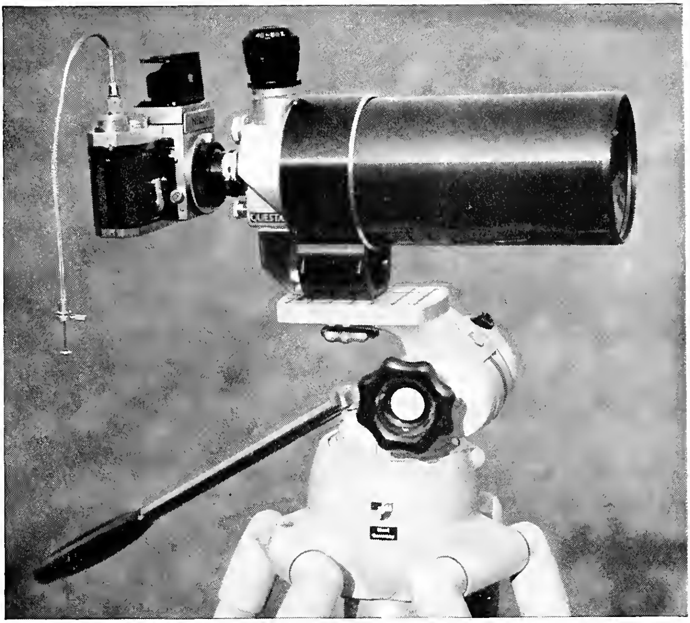
MILTON B. TRAUTMAN
The Ohio State Museum

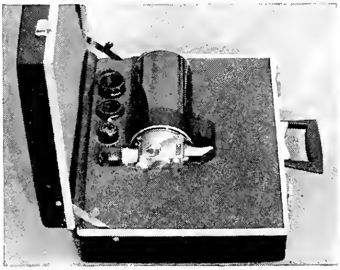
VIEW OF LIFE, by George Gaylord on. *Harcourt, Brace & World, 308 pp.*

RGE GAYLORD SIMPSON is not only e of the most outstanding investiof organic evolution; he is also a who has often gone before a wider to present the results of modern ts into the historical phenomena logy. In *This View of Life*, he has bled a number of his previously hed essays—edited to avoid repeand to embrace a larger concept—as added a few new articles. The is a volume that can be read as a or from which isolated chapters selected.

re are four principal divisions: oaches to Evolution"; "Evolution g the Sciences"; "The Problem of se"; and "Evolution in the Uni-" Each part consists of three or chapters. The scope of the book e outlined by mentioning a few of chapters.

title of Chapter 2, "One Hundred Without Darwin Are Enough," is wed from H. J. Muller's angry extion on the centenary of the publiof Darwin's *The Origin of Species*. on shows that there is justification ing indignant about the treatment ıffered by the teaching of evolution too-many high school curriculums. textbooks omit evolution comy, and others discuss it late in the





text where it may never be used as a term hastens to its close. Some teachers who do refer to evolution do not include human origins. Other books and teachers circumvent the term evolution by using "development" instead. And there are still other ways to avoid trouble from often ill-informed but powerful community opinion. Simpson minces no words in referring to "the higher superstitions celebrated weekly in every hamlet of the United States." This phrase is not applied to religious attitudes as such. On the contrary, the author is well aware of the separateness of the religious sphere, which lies beyond the rational considerations of the scientist. But because he recognizes and respects the borderline between science and religion, he justly demands that the same respect be shown by those on the other side. It seems strange that one of the central facts of nature and one that has the greatest impact on man's evaluation of his status in the material universe still divides our society into two cultures—one rational and one deliberately ignorant.

"The Historical Factor in Science" is the theme of another chapter. Here the distinction is made between the non-historical, *immanent*, unchanging properties of matter and the historical, constantly changing specific situations in the world, which represent a *configurational* conditioning of future changes. Evolution, while necessarily based on immanent processes, is unique because of its configurational dependence. Immanent properties imply what is possible; configurational limitations determine what actually happens. The historical factor excludes the possibility of evolution reversing itself, because history is inherently irreversible. Configurational limitations are responsible for the fact, stressed often in the book, that evolutionary lines usually do not lead to a continuous future. Most species die out without evolving into new ones.

A searching section of Simpson's book concerns the problem of purpose. There is no denial that adaptation is an all-pervading phenomenon in organisms—how could it be otherwise? There is, however, a great difference between the fact of adaptation and such supposedly causal concepts as teleology, finalism, and *élan vital*. The origin of adaptation is seen in natural selection in a refined sense that not only eliminates the less fit but also leads creatively to the occurrence as a usual phenomenon of what, a priori, is extremely improbable. Here one may have wished for a more extensive treatment of the genetic basis of evolution than Simpson, the paleontologist and taxonomist, offers the reader. Instead, there is a special chapter, "Evolutionary Theology," that critically analyzes the views of Lecomte du Noüy, E. W. Sinnott, and Teilhard de Chardin the heading "The New Mysticism." he chapter "The Nonprevalence of noids." Simpson applies some of olutionary thinking to the question ether it is likely that we can obtain edge concerning the existence out- ur own planet of organisms with an gence comparable to man's. The r's answer is a nearly absolute His reasoning is plausible, but its ssion is colored, unfortunately, by lmitted bias as an organismal, in ist to a molecular, biologist. As is ent, *This View of Life* gives its rs a many-faceted insight into aspects of life.

CURT STERN
University of California

ILE, by Eliot Elisofon. *The Viking $17.50; 292 pp., illus.*

photographs are the *raison d'être* this volume. There are 290 of -many magnificent—taken by Mr. on on five separate visits to Africa. trace the course of the Nile from uatorial sources until it flows into editerranean, 4,160 miles away. e the glaciers, plants and jungles, and swamps, birds, animals, and of its headwaters and of the far . Continuing downstream—the scenery constantly changing—we are shown more settled village life; we meet our first antiquities at Meroë, reminders of the Nubian dynasty that governed Egypt for a hundred years. Next we see Abu Simbel and Philae (the latter scarcely visible above the waters of the inundation), Elephantine and Aswan, and enter the Egypt of the dynastic period. From here on, as is to be expected, there are many views of ancient buildings, wall reliefs, paintings, statues, and scenes of modern life.

The plates are arranged in groups of fifteen, separated from each other by about three pages of text and a page of detailed captions written by Mr. Elisofon; at the head of each of these chapters is the appropriate section of the useful map with which the volume starts.

There are some other publications with more detailed accounts—both literary and pictorial—of, for instance, the Ruwenzories, the customs of the tribes of the Congo, or the history of the Sudan. The Egyptian antiquities pictured are all well known to the archeologist; and for his resumé of ancient Egyptian history and chronology Mr. Elisofon has unfortunately taken as his authority a book written sixty years ago. The beauty of the photographs is often obscured by the confusion caused by binding together two unrelated scenes with no margins to separate them; the color plates are poor; and one suspects that some shadow detail was lost in reproduction.

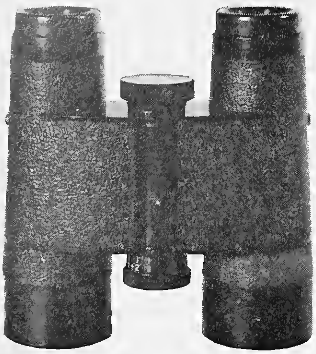
Nevertheless, this would be a very pleasant book to give or to receive: it falls into the category of "gift" or "art" books. With the photographs themselves Mr. Elisofon has achieved his aim—to capture for us, arrestingly, the Nile and the lands through which it flows.

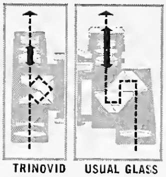
NORA SCOTT
The Metropolitan Museum of Art

THE SENSES OF ANIMALS, by L. Harrison Matthews and Maxwell Knight. *Philosophical Library, $7.50; 240 pp., illus.*

THIS volume is actually two books in one. The first half, by Maxwell Knight, is entitled "Animals in the Field," and the second half, by L. Harrison Matthews, is "How Senses Work."

The section by Knight begins with some general remarks on sensory equipment. Unfortunately, no general definitions or classification of the senses is given, other than the classic concept of the five senses. The writing is simple and, for the most part, on an elementary level. Each "sense" has its separate chapters on general aspects and on "field work and experiments." The treat-





ment of the latter consists in the main of anecdotes—often related in the first person—and shows little understanding of experimental techniques.

Matthews begins his section by describing the sensory apparatus and function of some of the most primitive animals, such as flatworms and sea anemones. He states that the difference between these primitive types and the higher animals is one of degree, not of kind. Such a statement ignores the qualitative morphological, physiological, and psychological evolutionary advances that have taken place at the various phyletic levels. The difference between a simple flatworm eye and the eye of an insect is not simply the latter's additional sensory units and more complex organization. At each phyletic level there is the addition of new structures that operate on different physiological principles. The concept of levels is of fundamental importance in animal behavior, as well as in other biological fields, and this could have been clearly demonstrated in the study of sensory modalities.

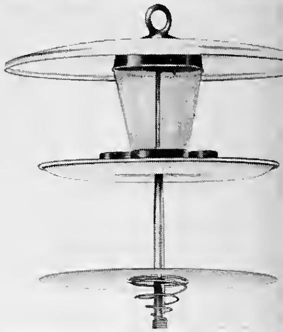
It is difficult for me to recommend this book to any particular circle of readers, as it is not evident for whom the book was intended. Since experimental evidence and documentation are given little attention, it is not a good general reference on animal senses, nor would it be useful to the serious student. The style and coverage vary from juvenile to pedantic, so it is neither a children's nor a college level book. It is too technical and yet too narrow in its approach to be valuable to the person outside the ken of natural history. Perhaps its main value might be to stimulate some thought about the sensory aspects of animal behavior.

William N. Tavolga
The American Museum

Familiar Reptiles and Amphibians of America, by Will Barker. *Harper & Row, $5.95; 220 pp., illus.*

The illustrations by John C. Yrizarry make up the best part of this book. Showing some appreciation of typical positions and attitudes as well as meticulous attention to morphology, Mr. Yrizarry provides some excellent renditions of native amphibians and reptiles.

The text, mainly compiled from previous compilers, is made up of a repetitious and naïvely conceived series of accounts that is unrelieved by either knowledge or clarity. While easily checkable items such as scientific names and geographic ranges are relatively accurate, a lack of basic understanding of the subject is visible throughout. Neither field guide nor handbook, and without any unifying conceptual design to tie it together, the book rambles over body sizes, geographic ranges, and individual life histories without illuminating



of them. Both herptiles (explained
ie glossary) and herpetologists de-
: a better reporter.

H. G. Dowling
New York Zoological Park

IN THE SEA, by Gösta Jägersten and
ıart Nilsson. *Basic Books, Inc.,*
)0; 184 pp., illus.

.THOUGH many popular books pic-
turing the creatures of the sea have
:ared in recent years, *Life in the Sea*
book with particular appeal for
ers of NATURAL HISTORY magazine.
ke most books on the subject, this
has devoted much of its space to
ıring the diversity of the marine
oworld. With skillful use of the
e microscope, Lennart Nilsson has
ured the beauty of many unusual
unfamiliar organisms. The book is
ogenetically organized into chap-
The authors have made no pretenses
ıt the accompanying text. It is dis-
.ed and discusses each of the photo-
hs in simple terms. Occasionally
ing the text, for the trained scien-
are misstatements or oversimplifica-
. This, however, does not diminish
vide appeal of the pictures.

John J. Lee
The American Museum

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ie following books are listed for
ial interest readers.

MON TREES OF PUERTO RICO, by
bert L. Little, Jr., and Frank H.
adsworth. U. S. Department of Agri-
lture Handbook 249, $4.25; 548 pp.,
us.

)LIFE MANAGEMENT AND CONSERVA-
)N, by James B. Trefethen. D.C.
eath and Co., $1.32; 120 pp., illus.

SALT-WATER AQUARIUM IN THE
)ME (revised), by Robert P. L.
raughan. A.S. Barnes & Co., $8.50;
4 pp., illus.

To KNOW THE CACTI, by E. Yale
ıwson. Wm. C. Brown Co., $2.25;
8 pp., illus.

ERS OF AUSTRALIA, by Barbara York
ain. The Jacaranda Press (Bris-
ne); 124 pp., illus.

VE FRESHWATER FISHES OF AUSTRA-
ı, by Gilbert P. Whitley. The Jac-
anda Press; 127 pp., illus.

S, MINERALS, CRYSTALS, AND ORES,
Richard M. Pearl. The Odyssey
ess, $6.95; 320 pp., illus.

SECRET LIFE OF THE FLOWERS, by
ıne Ophelia Dowden; BUTTERFLIES
D MOTHS, by Walter Robert Corti;
IE CORAL REEF, by Alfred Butter-
ld; THE SUN, by Walter Robert
ırti. All from The Odyssey Press,
¢; 45 pp., illus.

SOUTHERN FERN GUIDE, by Edgar
Wherry. Doubleday & Co., $4.95;
9 pp., illus.

Fire Ecology of the Giant Sequoias

Controlled fires may be one solution to survival of the species

Thick bark of sequoia trunk usually protects it from serious fire damage.

Richard J. Hartesveldt

FIVE-YEAR STUDY of the effects of
_ heavy human impact upon the
ra Nevada's giant sequoias has
ealed a fascinating story of this
ies' virtual dependence upon re-
ent fire for survival. The story is
no means singular, nor is it new.
re are many plant species through-
the world for which fire plays an
ortant role in preparing suitable
lbed conditions and in eliminating
more shade-tolerant plants that
npete with them and impair their
early growth. Parts of the story of *Sequoia gigantea* have already been told by John Muir, George Sudworth, Willis Jepson, Woody Metcalf, Harold Biswell, and others. It is being supplemented annually through a research program encouraged and financed by the National Park Service.

The story concerns a process known as plant succession, the continual change of the plant communities. As groups of plants change the soil's nature by the addition of their remains, other species respond to the new conditions, invade the area, and gradually crowd out the earlier plants. Each invading species of plant is usually better adapted for growth in reduced sunlight and soil moisture than were the plants of each previous group. In turn, as these plants change the environment, still others invade and crowd them out. Changes continue until a long-enduring community of shade-tolerant plant species is established that can reseed successfully in full competition with itself. This stage, in which the soil depth becomes static, is known as the climax stage of plant succession. Soil depth increases very little at this point because additions of organic material at the surface are balanced by decay at the bottom. The climax is reached only through the absence of disturbance factors, such as fire, blowdowns, insect and fungus epidemics, logging, or other interference by man. The presence of any one of these factors arrests normal progression and usually returns plant communities to an earlier stage. Then plant invasion begins again and proceeds once more toward the climax. In temperate climates, where soil moisture is adequate throughout the growing season, later stages of succession are generally typified by trees. The sequoia story is one of repeated disturbances that have set back the succession of other plants and have favored the reproduction of the sequoia, a tree of intermediate position in plant succession. Fire is the most important disturbance factor in this story.

In light of our long-ingrained abhorrence of fire in the forest, it may seem incongruous that our highly successful and costly programs of fire prevention and suppression have produced, however inadvertently, conditions that have led to the decline of populations of certain desirable plants. To offset such trends, man has employed prescription burning rather widely in the United States on both range and forest lands. If it seems contrary to current feelings that fire should be used as a management tool in our renowned sequoia groves, let the reader first consider that the giant sequoia is well equipped for fire survival, and that wildfire has been a natural environmental factor throughout the evolution of the species. In fact, it could not have evolved or survived as it has without frequent fires.

FOSSIL sequoias from Nevada date back to the Miocene and Pliocene Epochs (from about 12 to 25 million years ago). These remains are of *Sequoia chaneyi*, a predecessor similar to *S. gigantea*. One theory is that the earlier form migrated over the Sierra Nevada before that range rose to its present height of 12,000 to 14,000 feet. Abundant evidence reveals that fires were frequent in the sequoia groves before the advent of Western civilization. Sequoias five feet or more in diameter without large fire scars on the trunks are scarce, if not nonexistent, so it is inferred that the species indeed developed with fire as an accomplice. This inference is valid, I believe, because the wood chars so slowly that many fires are required to produce a large scar. Many of the trees bear multiple fire scars, probably the result of repeated fires against the bases of the trees. Some are cavernous or extend high up the trunk. When total scars represent severance of as little as 15 per cent of effective connections between the roots and the crown, the crown's topmost part often dies for lack of moisture and produces the familiar snagtop sequoia. Yet, 85 to 95 per cent of the tree can be burned without resulting in the tree's death. When one does die through total destruction of the crown, the wood rots very slowly. One burned remnant of a stump, tested by radiocarbon dating methods, was found to be 2,100 years old on its outer edge, and it had only begun to decay! It is also significant that while fire scars are universal, there is scant evidence that there were many intense crown fires.

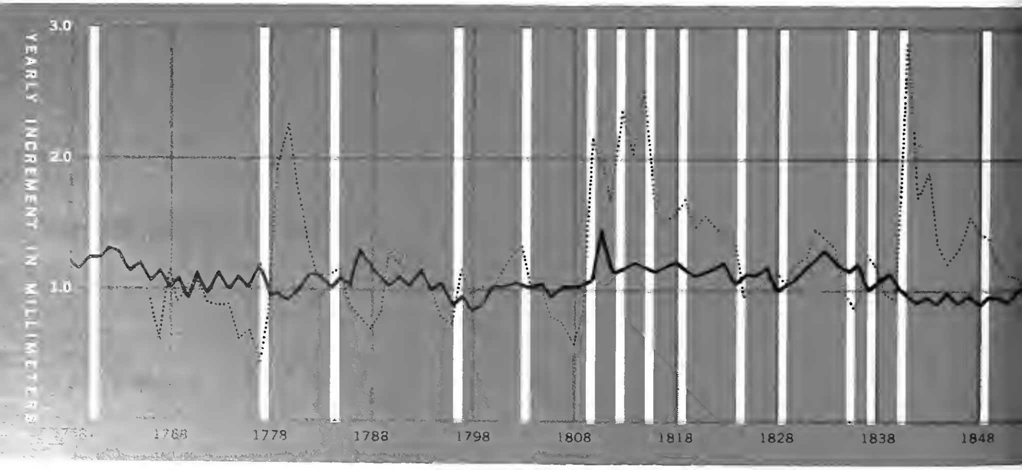
To gain some knowledge of prehistoric fire frequency, I made growth patterns from increment borings of approximately 100 sequoias in Yosem-

Snagtop results when fire severs the connection between roots and crown.

ite's Mariposa Grove and analyzed them for growth variations. A few sequoias have grown consistently within 15 to 25 per cent of their average growth rates during the past two centuries, while the growth of others has fluctuated, showing sudden increases of as much as 200 to 400 per cent. Climatic changes were quickly dismissed as the cause of the increases because the years were not consistent for all the sequoias cored (*graph, below*). And then there were trees that showed few, if any, striking departures from the average growth rate for as much as two centuries. It may be that the topographic location of these trees was not favorable to fires.

Records show that the last major forest fire in the Mariposa Grove occurred in 1862, and that another fire burned into the perimeter of the grove in 1889. More than one-half of the cored trees showed a marked growth increase in the middle 1860's, and several showed an increase immediately after the fire of 1889. In addition, the ages of some of the younger sequoias indicate that they germinated shortly after these fires. The stimulus to growth is explained simply—fires provided a release from competition. The fire-resistant sequoia, with its thick, fibrous bark, may only have been injured, while its less resistant associates were either killed or greatly impaired. This left more soil moisture for the remaining sequoias. The slowing of the sequoias' annual growth rates after their increases probably represents the re-establish-

Sequoias killed by crown fire are rarely found in groups of more than



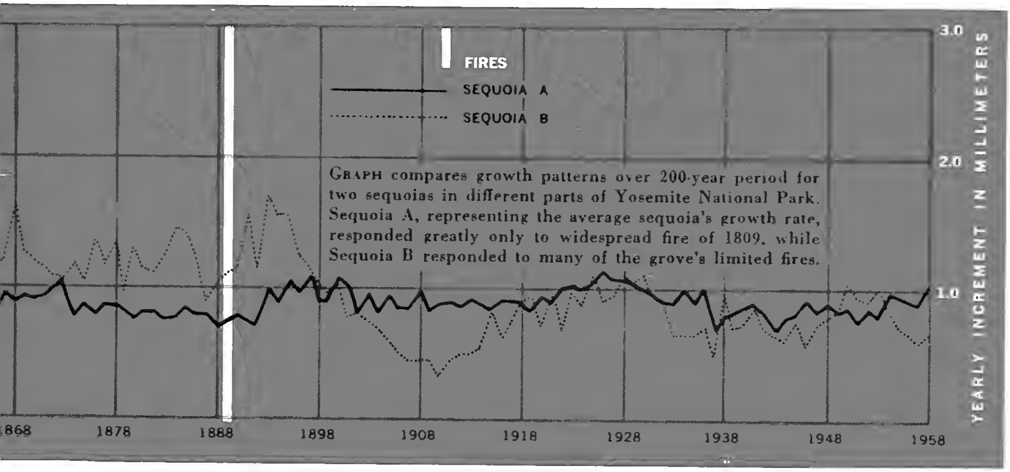
or three. Scarcity of clusters
icates few fires of any intensity.

ment of competing plants. The only striking departures of growth after 1889 are generally correlated with activities of man, such as vista clearing and the removal of shrubs.

Clifford Presnall, a National Park Service naturalist in the 1930's, made a study of forest fires based on fire scars and ring counts, and in conjunction with his studies it has been found that between 1760 and 1900 there were at least 18 fairly extensive fires within the 250 acres of the Mariposa Grove. This is an average of one fire every seven or eight years. In an area of similar elevation in Stanislaus County, Harold Biswell of the University of California found an even greater fire frequency. It is likely that more fires burned during this 140-year period, but were of such small areal extent as to be recorded on only one or two trees. This number is too small for any assurance that fire was truly the cause for the release of growth. There is evidence that lightning ignited the tops of some sequoia trees early in the spring when debris on the ground was too wet for burning. Firebrands from the treetops dropped to the ground, burning the area immediately around the trees, but not spreading farther.

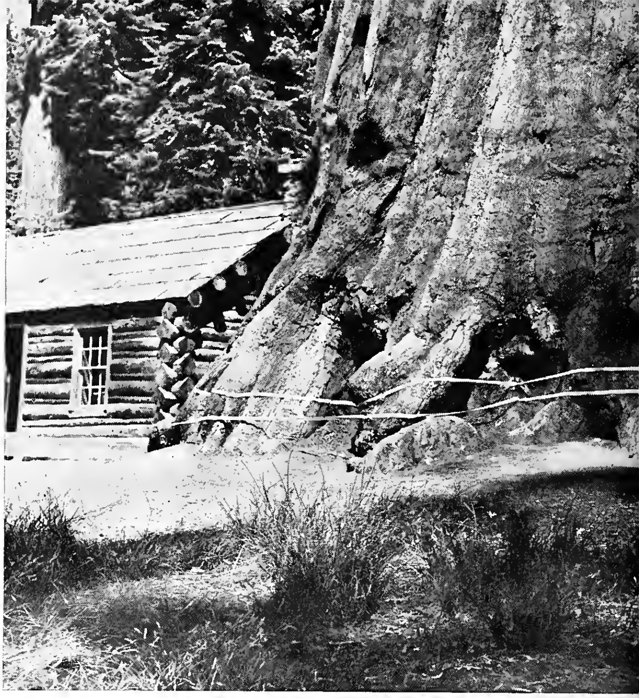
The period since 1889 represents, in all likelihood, the most prolonged fire-free period in the history of the Mariposa Grove, or perhaps in any sequoia community. Although since 1864 and 1889 both lightning and man have ignited many fires in the Mariposa Grove, fire-suppression activities

Lightning-struck sequoia lost its top, and lateral limb became crown.



Graph compares growth patterns over 200-year period for two sequoias in different parts of Yosemite National Park. Sequoia A, representing the average sequoia's growth rate, responded greatly only to widespread fire of 1809, while Sequoia B responded to many of the grove's limited fires.

Embryo is in center of sequoia seed. Winglike outer part aids in dispersal.



have held each to minimal areas. The absence of fire has permitted uninterrupted plant succession and has altered the species composition of the groves in favor of sugar pine and white fir. Of the two, fir is more tolerant of shade and root competition and becomes the dominant vegetation under climax conditions at these elevations. In some places, stands of fir are so dense that their deep shade renders conditions intolerable for young sequoia seedlings, which thrive best in sunlight and eventually die in shade. These dense growths and the unprecedented accumulations of dead, combustible debris in the absence of fires occasion the highest degree of fire hazard ever observed in sequoia communities.

The conditions under which these successional changes have occurred are not uncommon to those plants whose ecological position is intermediate, like that of the sequoia. Sequoias respond well to disturbed conditions and do not reproduce significantly as the climax stage approaches. This is contrary to earlier published works in which the giant sequoia was, by virtue of its great size and longevity, regarded by some as a climax species.

The tiny seeds of the giant sequoia (91,000 per pound) can bridge the gap of life only where there exists a rather exacting set of conditions. In seeds so small, the amount of stored food material is also small and permits but a short growth of the seed roots. As a result, the chance of germination is slight in places where even a minimum of leaf litter accumulations have built up. Dr. Nellie Stark recently showed that even though moisture conditions may appear adequate in the spring or early summer, the sequoia litter layer is especially resistant to wetting, and that sequoia seeds rarely germinate there. Even if they could germinate, it is doubtful whether the short, emerging seed roots could reach down into mineral soil. Litter removal, then, is requisite to successful regeneration.

The means of litter disturbance for this purpose appears immaterial. Sequoias have seeded in burned areas, on flood plains or stream banks from which water has carried away the litter, in avalanche chutes, in root pits and skid trails of fallen sequoias, and in areas disturbed by man—logging sites, road and trail sides, and building sites. Although the scouring and transporting action of flowing water has been important locally, wildfire probably has been the major infl encing factor. John Muir was im pressed with the potentialities o species survival on the basis of seed lings growing in the root pits of falle trees. Recent examination of twenty five groves of sequoias has shown thi means of regeneration to be meage at best, and avalanche chutes are no common in the groves.

Once germination has occurred, th young sequoia requires much sunligh and continuous soil moisture through out the growing season. In the uppe section of the Mariposa Grove, th mortality of young sequoias during twenty-five-year period was 86 pe cent because of competition for ligh and moisture. Numbers of dead se quoia seedlings beneath the dens canopies of white fir attest to this in tolerance. Dr. Stark's recent field in vestigations also show that seedlin sequoias grow best in full sunlight i the stems are protected against sun scald, such as by low shrubs. Of th natural disturbance factors, fire an snow avalanches are the only commo ones capable of producing both requi sites for sequoia regeneration. O these two, avalanches are of mino importance at most altitudes amen able to sequoia growth.

Soil compaction by visitors is shown at left by top tape, the 1862 soil level.

Increased tourism to sequoia groves led to study of human impact on trees.

THOUGH older sequoias are relatively resistant to fire because of thick, fibrous bark of low flamlity, young trees lack this pron. Of those few surviving over enturies, many have undergone ted burnings. In areas of red fires, there has been little opnity for great accumulations of , so that most fires were probably atively low intensity. As a result, succession was more or less ted, and sequoia communities ined relatively free of the dense fir growths that are so common now. Other species of trees, such e incense cedar, ponderosa pine, black oak, were also more pret then, for the recurrent fires uced favorable conditions for early-to-intermediate-stage spe- Occasional fires of high intensity inly destroyed many or most of ounger sequoias in given areas, h may well explain the noticeable roup gaps in many sequoia es today. A new gap is now deing because of the reduced rerative success of sequoias in the of advancing plant succession. e upper Mariposa Grove, for ine, not more than thirty sequoias survived germination since 1934. Each of these is in an area disturbed by man, and most of them are so densely packed in small groups that only a few will survive to become mature giants. Recent National Park Service-financed examinations of thirty-one groves in Sequoia and Kings Canyon National Parks show that seedling and sapling sequoias are scarce in all but a few groves. White fir, on the other hand, is abundant.

The unintentional results of successful fire prevention and suppression have thus brought about problems that must be solved if the sequoia is to replace itself. Because plant succession creates excessive fire hazards, the situation requires immediate attention. On the other hand, the establishment of conditions for sequoia regeneration must be approached with careful deliberation. Assuming that protection from uncontrolled wildfire will continue as an absolute necessity, it must further be assumed that the problems of thick litter and heavy shade will become more severe unless a program of sequoia management is implemented. The National Park Service, committed by law to maintain sequoia groves in a natural condition for all generations, is faced with a precedent-breaking decision in order to attain this goal. The act that created the National Park Service in 1916 implies a continuum of the sequoia community in national park groves. Yet the present sequoia situation suggests a trend toward the elimination of certain sequoia populations. As older sequoias die and are replaced by other species, the percentage of sequoias in the community is reduced. While this is a long-term malignancy, it must be faced sooner or later by a management program.

A big problem that must be solved by interpretations of the legal mandate is how to achieve desired goals without impairing other park values. The National Park Service has held its active forest management to a minimum in the past, so that either prescription burning or physical removal of plants and litter will very likely be repugnant to some citizens. Yet, without employing either method or a combination, the situation will become more serious.

Fire by prescription is widely used in the United States today in vegetation control, and its effects are generally far more desirable than detrimental. Because of differences in fuel concentrations, there is a great

Seed from which this lone tree grew may have been transported by floods.

difference in the heat intensity of prescribed fires under control and wildfires. Prescription burning more nearly duplicates the effects of repeated wildfires of the past, even though it does not generate as intensely hot flames. Further, man prescribes the conditions under which burning is done and chooses the weather conditions best suited to his needs. He thus reduces the danger of fire escaping and damaging the plants he is attempting to manage. In the parks where non-commercial aesthetic and scientific values are primary, extreme care will have to be exercised to minimize charred remains by reducing fuel concentrations—primarily tangles of fallen dead limbs and thick growths of young trees, such as white firs, which have a high content of pitch. Of course, growth and leaf fall obliterate lightly charred areas in a comparatively short time.

THE physical removal of competing trees and shrubs and the raking and removal of thick layers of leaf litter would possibly prove as successful as fire in aiding sequoia regeneration. Although many persons have expressed a strong preference for this method of management, the implied frequency of natural wildfires before the advent of man suggests that fire creates conditions more natural than cutting. Perhaps cost is the most serious objection to raking and removal. To prevent exposing unsightly stumps, all woody vegetation would have to be cut at or below the soil surface and the remains hauled away, or they would create an even more serious fire hazard. The magnitude of raking and disposing of hundreds of acres of leaf litter is nearly beyond comprehension. Each acre of litter two inches thick, if packed firmly, would fill a 28-foot cube-shaped box. In many areas of advanced plant succession, the litter exceeds three inches in depth. Transportation of the raked material from areas not adjacent to roads would be grossly impractical, and it could not be piled and left without being burned.

One additional possibility is the scarification of the soil surface by power machinery. Great care would have to be exercised in the use of this method because of the shallow roots of the sequoias—both the small feeder roots and the main laterals, which occasionally extend 150 to 200 feet from the trunk's base. Also, remote parts of the park, where roads would detract from aesthetic values, are virtually inaccessible to machinery.

In the face of extreme fire hazards that exist in many of the groves, it is evident that widespread burning alone would prove as impractical as physical removal of materials, despite the beneficial long-term value to the sequoias. Small local fires, which I hope will succeed in establishing sequoia regeneration, will be of little benefit in the reduction of grove-wide fire hazards. All in all, under present conditions, there does not appear to be a simple solution.

There is understandable apprehension at this time about the use of fire as a silvicultural tool in our national parks. However, the precedent has been set. In Everglades National Park, Florida, burning has been used for several years under the direction of Park Biologist William Robertson to prevent the further disappearance of the pine forests and prairie marsh communities resulting from advanced plant succession. Just recently the National Park Service granted its approval to the burning of four small plots and physical removal of plants and litter from other plots to determine the feasibility of securing sequoia regeneration. Although details of the experiment are not yet complete, the area tentatively selected is the Redwood Mountain Grove in Kings Canyon National Park. It presents variety of soil moisture and plan density conditions, and is accessible b a park fire road.

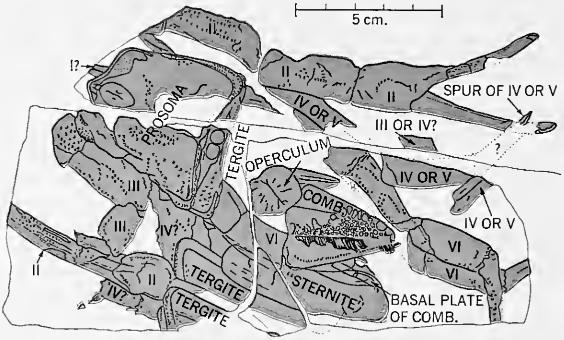
THE areas to be burned, seldo visited by the public, will be plot of approximately two acres each an will be mapped and studied intensivel before and after burning. Actual burning will be under the direction of fir control personnel of Sequoia an Kings Canyon National Parks. Othe plots nearby will be treated by phys cal removal of the litter, dead fue and competing trees, and by mechanical scarification of the soil. A comparison of the results may well suppl some much-needed answers.

The preceding story was the unanticipated result of a study designe to identify and measure the effect of heavy human impact upon the gian sequoias. Curiously, the problem described here emerged as mor serious than the expected ones of so compaction and foot erosion abou the bases of certain large trees. A though both have occurred, there i nothing apparent in the growth patterns of these sequoias to indicate tha intensely compacted or eroded soil have impaired them. Shrubs and herbaceous vegetation have been literall trampled out of existence in a fe areas, but fears of workers in 1926-2 that such traffic spelled doom to the sequoias now seem exaggerated. Man' tenure in the sequoia groves, howeve has been comparatively short, and it i possible that cumulative effects no now evident may occur in the future This eventuality is recognized and wil be watched for. Moreover, muc physical damage to the environmen can be prevented by rather simpl techniques and an increasing comprehension of the physiology and ecolog of the giant sequoia. The species is no now seriously threatened with extinction, nor is it apt to be, especially wit the implementation of sequoia management. And there is little doubt tha careful use of fire and cutting constitute a much more realistic approac than does a policy of "hands off." A someone once said, "Conservation i intelligent co-operation with Nature.'

Density of white fir under sequoi indicates advanced plant succession

Anatomy of Decay as Preserved in Shale

Fossil scorpion remains, incomplete and distorted, were found in shale in Scotland. The numerals refer to six appendages.



Reconstruction sho
two views: dorsal (black
ventral (white). Rest
probable form of the bo
is seen in the dotted line

Analysis shows biochemical degradation in fossilized scorpio

By Leif Størmer

The principal task of paleontologists is to discover and describe fossil forms and to find out where they belong in the natural system of plants and animals. The relations between the fossil form and the environment in which it existed also must be determined to find out how the organism lived and in what medium it could survive. Such studies have been based chiefly only on the hard parts that were fossilized—those portions that were left after the soft parts had rotted away.

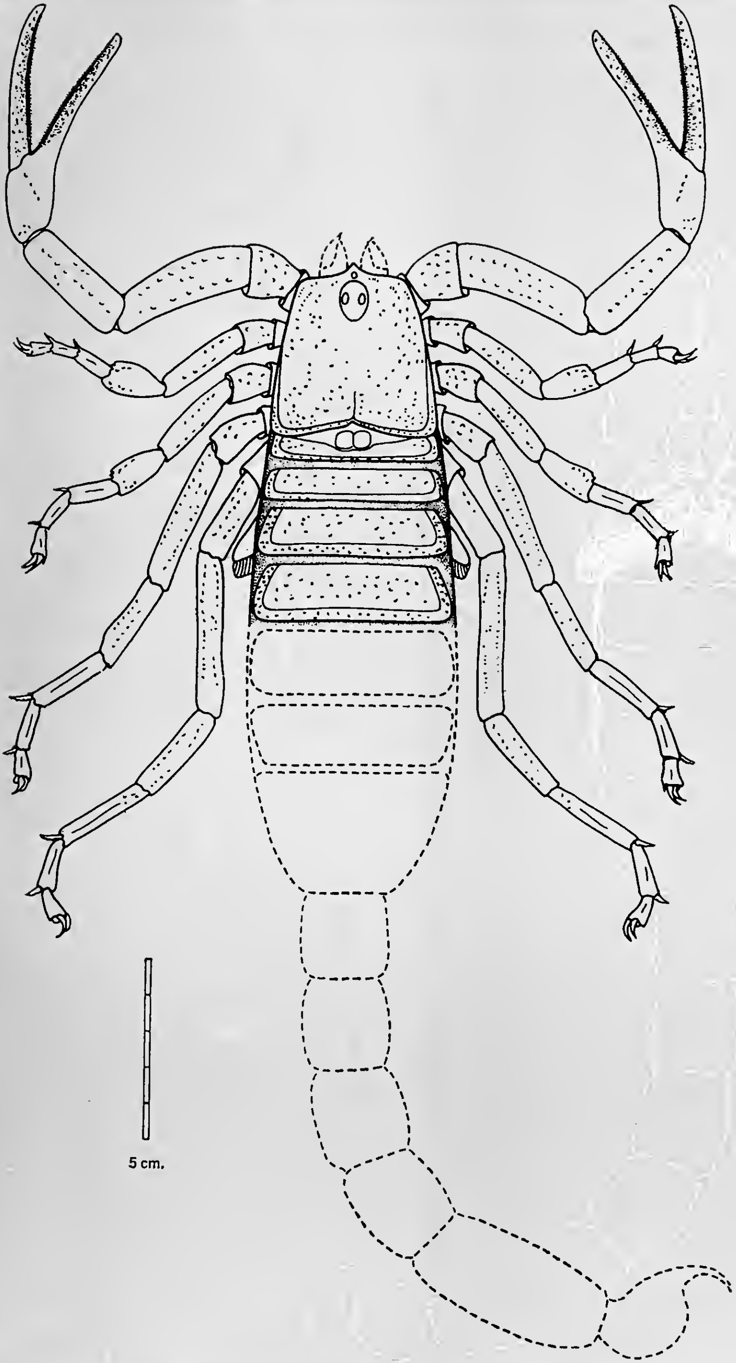
Little has been known of what happened to a now-fossilized animal immediately after it died and became buried in sediment of one kind or another. A single find of one fossil scorpion from the Lower Carboniferous of Scotland—about 300 to 350 million years ago—has, in a unique way, been able to shed light on this problem.

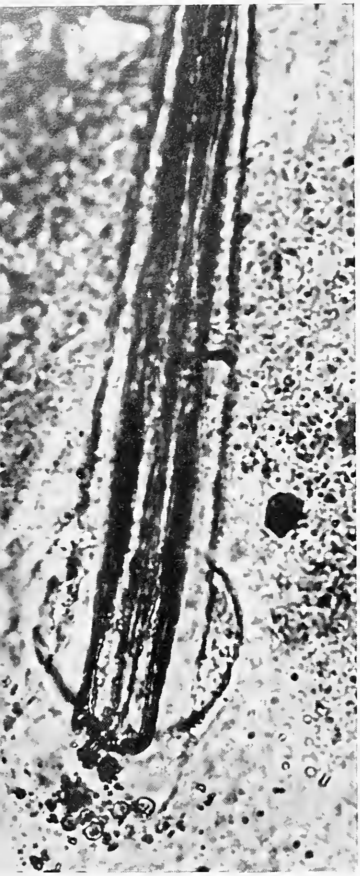
In the rich fossil collection of the British Museum (Natural History) are two pieces of a large arthropod. These fossil remains were found in a dark shale, the so-called oil shales, in southern Scotland. In 1959 the fossil was examined by Dr. L. J. Wills, Professor Emeritus of the University of Birmingham, England. He concluded that the remains were those of a true scorpion of an unusual size. In the same year, the fossil specimen was sent to me for further study—a study that extended to about three years instead of the few weeks I had expected.

At first sight, the two pieces did not look very promising. The crushed body was distorted and flattened to such a degree that the skins, or exocuticles, of the upper and lower surfaces were pressed tightly against each other, leaving no space that could have defined the internal organs that once were present. However, after minute preparation and study of the remains, it eventually became possible to disentangle the broken bits and to make a reconstruction of the main part of the body. The tail and hind part of the preabdomen ("thorax") are missing, but were probably similar to those of other Carboniferous and Recent forms. The scorpion has proved to belong to a new
genus, and I have called it *Gigant*
scorpius willsi because of its extrac
dinary size. The scorpion measur
about 30-35 cm. in length, and th
was considerably larger than a
known fossil or Recent species (t
largest one known is 18-20 cm. long

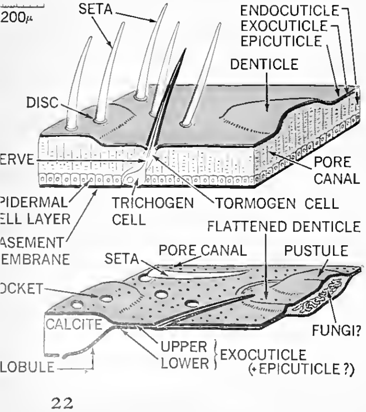
Of particular interest is the uniq
preservation of the exocuticle, whi
has remained virtually unaltered sin
Lower Carboniferous time. This sk
consists of dark amber-colored chiti
and it is so well preserved that even t
minute tactile setae, or hairs, are pre
ent. The chitin is still so tough that t
thin setae did not break off when t
surface of the skin was cleaned of t
embedding matrix.

For microscopic study, pieces of t
exocuticle were peeled off and embe
ded in Canada balsam. In transmitte
light, the basal portion of a tactile se
was seen to be pushed into its sock
in the exocuticle. A string, preserve
in the internal cavity of the seta, ev
dently represents the nerve (or ce
lular extension of a trichogen cell
group of cells). Such a preservation


5 cm.



TACTILE SETA, *above*, magnified X660, is partly pushed into its socket in the exocuticle. In lumen at center there is apparently a nerve or extension of trichogen cell. Reconstruction of the cuticle is below. Original layers are at top; bottom sketch shows how the two surfaces became pressed together.



probably unique in Paleozoic arthropods. Other ornamental structures, such as scales, tubercles, and pustules, also are present in all details.

However, some of the sculptural features are evidently secondary, and were formed after the carcass was buried in the sediment. Typical of such secondary structures are the semispheric "bubbles" on the surface of the exocuticle. The drawing below left presents a reconstruction of the cuticle compared with its fossil condition.

A peculiar, striated ornamentation occurs on the femur and tibia of the last pair of legs. It consists of small, narrow ridges not unlike the characteristic striae, or terrace lines, on the shells of trilobites. However, mounted pieces showed that the ridges actually are caused by enclosed, rodlike bodies. Microtome sections were prepared from the exocuticle to determine whether the rods originally occurred as canals within the exocuticles that are now pressed against each other.

In transmitted light the pale, rod-shaped bodies were seen to be beautifully preserved between the two amber-colored exocuticles. In several cases, these bodies showed a distinct parallel orientation *(photograph, bottom right)*, and it was apparent that they were not part of the scorpion's structure. Under stronger magnification, it could be seen that they were actually wormlike, and they revealed morphological structures that are characteristic of certain worms of the phylum Nemathelminthes (=Aschelminthes). For instance, the cylindrical bodies, about 250 microns long, terminate in a blunt head ending in a slight constriction, or neck. The rest of the body is nearly straight and has a blunt distal end, which, however, is not well preserved in most cases. The head has a frontal opening—apparently a mouth—from which a dark-colored tube, some three microns wide, leads backward into the body. The tube probably represents a chitinized buccal capsule between the mouth and pharynx. A very similar structure is found among the Gastrotricha and Nematoda of the Nemathelminthes. The Nematoda have cylindrical bodies without lateral lines of setae, so it is probable that the fossil worms are nematodes.

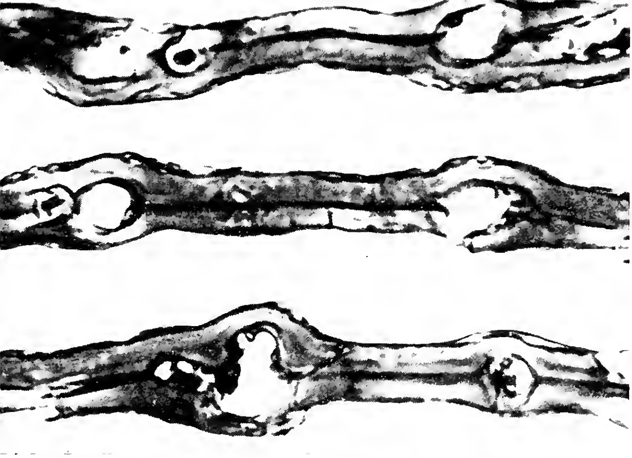
Dr. H. E. Welch, of the Research Institute, Belleville, Ontario, Canada, agrees that the observed structures (with the exception of the septa-like structures) suggest nematode-like ani-

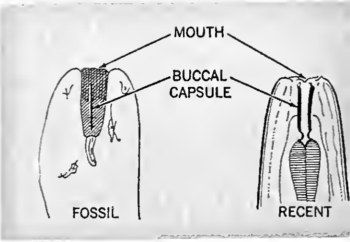
mals. He also suggests that if the
mals are nematodes, their simil
in size indicates they might be in
tures belonging to the same broo
have given the new Carbonife
nematodes the name *Scorpioph*
baculiformis, to indicate that
were scavengers that fed on the
body of the scorpion.

In Recent faunas, nematodes
very abundant. They occur in salt
fresh water and in soil, and are
pable of enduring considerable v
tion in the acidity and alkalinity o
environment (the *p*H). Micros
nematodes take part in the decay
esses of all plants and animals, in
ing insects. But until now, fossil n
todes have been known only from r
younger Tertiary and Quaternar
posits—up to 60 million years old

The nematodes of *Gigantosco*
willsi are plastically preserved bet
the two exocuticles. This is puzz
one would expect the presumably
worms to have been squeezed fla
tween the chitinous and normally
exocuticles. The explanation mu
that the two exocuticles were sof
flexible when the worms were enc
between them, and soft chitin sug
an alkaline, rather than an acid
vironment. This agrees with the
ion of Professor L. R. Moore, Un
sity of Sheffield, England, accordi
whom the sediments were accumu
under anaerobic (without oxy
conditions. When the nematodes
trapped and died between the e
ticles they were, so to speak, wra
up between softened chitinous
kets. Afterward, the worms be
more or less hermetically sealed
the exocuticles again hardened in
nection with the change to a n
*p*H. The preservation is not dissi
to that of insects in amber or o
embedded by man in plastics.

BUT the nematode bodies are r
tact in their chitinous encl
The photomicrographs on pag
show how the worms are them
penetrated and partly destroye
smaller microorganisms. The
branching rods, sometimes be
probably are hyphae of fungi. Be
the fungal remains occur coccoi
bacilliform bodies with a diame
about one micron. Some of these
ute bodies closely resemble Recen
teria. However, at least some o
bacteria-like forms appear to
from the disintegration of larger





Buccal capsules of fossil and Recent nematodes, *above*, show chitinization. Below is a photomicrograph (X310) of fossil nematodes trapped in scorpion. In the microtome sections, *left*, what appear to be holes are cross sections of nematodes that have been enclosed between the two skins of the animal.

a feature that has led Professor Moore to the assumption that these microorganisms belong to the actinomycetes. The new form has been named *Polymorphyces major* Moore *(photographs E and F bottom right).*

Obviously, one must be sure that the supposed fossil forms are not Recent bacteria introduced at a much later date than that of the scorpion's fossilization. However, Dr. Moore has found forms identical to those in the scorpion in many thin sections of rocks from contemporaneous beds of the same area, and is convinced that at least most of the scorpion's microorganisms were indigenous and took part in the actual degradation of the scorpion in Carboniferous times. Another factor supporting the thesis of the indigenous origin of the organisms is that they occur within the cavity of the setae and on the nerve at the base of one seta. To be sure that the microorganisms are not of Recent contamination, a piece of the exocuticle was cultured. Recent bacteria are present, among them the common soil bacteria *Bacillus subtilis*, which is able to form long-living spores; it deviates, however, by being considerably smaller than those present in the fossil.

In several places the inside of the exocuticle is corroded, probably by the activity of bacteria or bacteria-like organisms. The inner surface may occasionally bear impressions of small (25 microns wide) tetrahedric (or pseudotetrahedric) crystals. Tetrahedric crystals are not common; the impressions might possibly belong to the organic compound barium calcium propionate, which has tetrahedric and octahedric crystals. X-ray analysis of the matrix between the exocuticles has shown traces of barium. The possible presence of barium calcium propionate is interesting, because propionic acid is an end product in bacterial activity.

The biochemical activity in connection with the degradation of the scorpion evidently resulted in the release of various gases (NH_3, CO_2, and CH_4). The bubbles (globules) and pustules visible on the surface of the cuticles now filled with calcite were probably formed by such gases. A secondary character of the bubbles is evident for the following reason: a semicircular pustule on the upper exocuticle is accompanied by a similar one covering the same area on the lower exocuticle. This would not have been the case if the two exocuticles had not first been pressed together. In two cases, imprints of nematodes were found on the inside of the exocuticles of the bubbles. As mentioned above, however, such imprints were formed when the two cuticles were pressed together. When they occur on the inside of the inflated bubbles, it is evident that the bubbles were formed at a later stage.

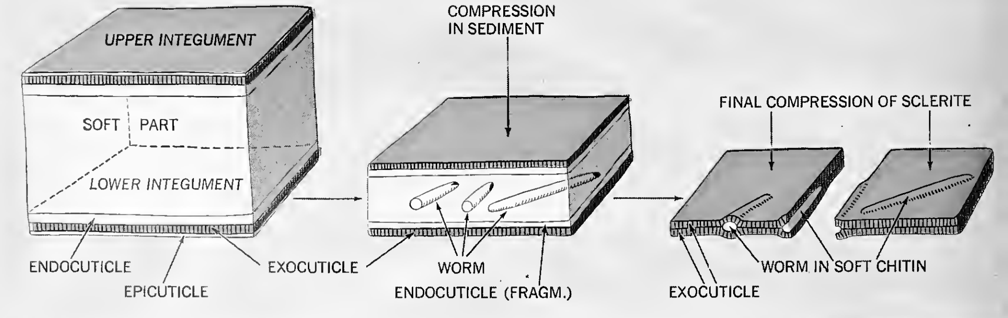
The observed structures permit us to draw certain conclusions as to what happened to the scorpion after it died. Its body, subject to waves and currents and the attacks of scavengers, became distorted and was gradually covered by muddy sediment. Putrefaction began and the soft parts inside the exoskeleton disintegrated. Various scavengers took part in that degradation and in the removal of the products of decay. The weight of the accumulating sediment above and the removal of the soft part inside the body caused the scorpion to become more and more flattened. At last the chitinous exoc ticle of the upper side of the body m and was pressed against the exocuticl of the lower surface, as suggested i the diagram below.

At this stage of the degradatio some of the scavenging nematode were trapped and enclosed betwee the two now soft and flexible exoc ticles. In one case, perforations of thin part of the exocuticle, correspon ing in width to the diameter of th nematodes, suggest that some of th worms may have succeeded in escapin before being trapped.

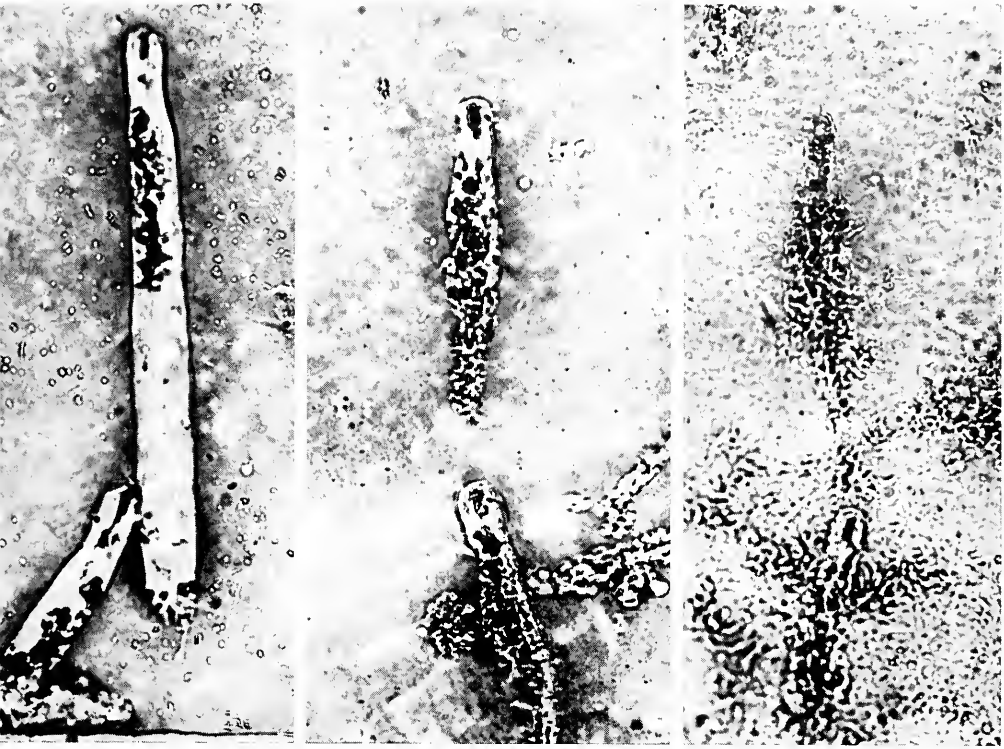
The dead nematodes, in turn, we attacked by microscopic fungi, actin mycetes, and various bacteria. Gra ually the scorpion's body was fille with minute hyphae and bacteria-lik organisms. To some extent, the latt also attacked the chitinous skin. Pro ably various organic compounds pr duced by bacterial activity crystallize on the inside of the exocuticles.

At a late stage in the degradatio putrefying gases caused the forma tion of bubbles between the cuticle The skin, or exocuticle, of the sem spheric pustules formed by the bubbl is often ruptured, suggesting that this stage it was not so soft and flexib as when the nematodes were enclose —a feature that suggests a change t ward a more normal *p*H.

The unusually well-preserved Ca boniferous scorpion has thus throw some light on the little-known fir phase whereby a dead animal is tran formed into a fossil. Observations su gest that the incidents and processes millions of years ago were more or le the same as those that take place toda in an environment that is simila

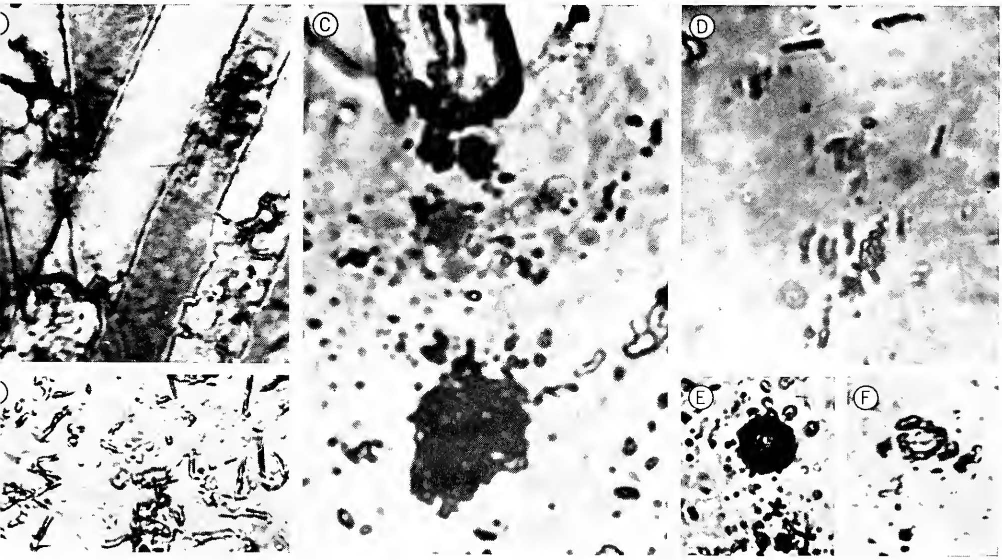


BLOCK DIAGRAMS illustrate the preservation of nematodes between exocuticles. The soft parts gradually decomposed, and eventually the weight of overlying sediments caused th two skins to compress, trapping the nematodes between the



ADUAL DEGRADATION of nematodes is seen above (X525). left, very few hyphae are present. Large portions of the bodies are decomposed, *center*, by hyphae and bacteria-like microorganisms. Only shadows of nematodes remain at right.

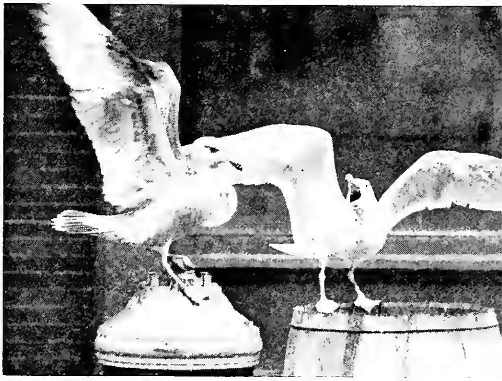
GNIFICATION of 1100 shows: A, nematodes with hyphae of gi; B, beaded filaments of the same fungi; C, base of seta with bacteria-like forms; D, organisms of exocuticle; E and F, colony of microorganism *Polymorphyces major* Moore.

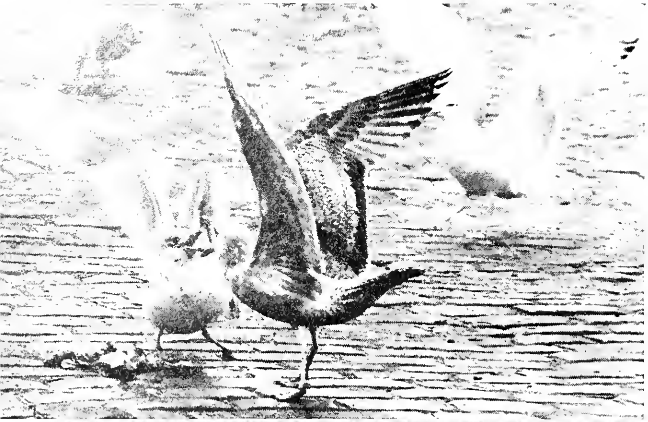


EASY AVAILABILITY OF FOOD DRAWS GULLS TO THE Fulton Fish Market

photographs by LOU BERNSTEI

THE WELL-KNOWN Fulton Fish Market, at Fulton Street and the East River in lower Manhattan, is the Atlantic coast's largest wholesale commercial fish exchange and a favorite visiting place for the gulls of New York Harbor. The pictures on this and following pages were made after the hurried early morning activity of the market place had subsided and the gulls were doing battle among themselves for the scraps that lay about on wharves, barrels, streets, and in the water. In the course of any one day, some 120 different varieties of sea food are received and sent from the Fulton Fish Market, so the gulls can find in the waste a diversified fare that no natural feeding ground offers. Today, boats still dock at the piers, but the majority of the fish arrive in refrigerated trucks with catches from ports up and down the eastern coast.





SEA GULLS seem at least as commo in lower Manhattan as pigeons, an they are the aggressive conquerors, s far as the avian world is concerned, c the Fulton Fish Market area. Mos business is ended by 9:00 or 9:3 A.M., and as the men and trucks disappear from the streets, and the boat slip out from quays, sea gulls arriv in increasing numbers. On these tw pages, the squabbling contest for wast and leavings is in progress. At lef beak-to-beak combat is under way while at the right a struggle in th East River involves five gulls. Below victor makes off with the spoils.

Prosperous or humble, a ma

P O

Resting bear is detail on garden wall in the House of Lucretius Fronto.

Painting in House of Romulus and Remus survived World War II bombings.

uld enjoy his own paradeisos

MPEII

Pompeii, because of its sudden and tragic destruction by Vesuvius, is a unique archeological site; only at Pompeii can the visitor walk up and down miles of streets and see the homes, temples, and places of business of thousands of former inhabitants. For this reason Pompeii is still an unexhausted source of information for students who would know more about how people lived, worked, worshiped, and played in the Roman Empire. Household shrines reveal the owner's religion. Shops attached to his home indicate his business interests. Election notices painted on the outside of his house record his participation in politics and the candidates he endorsed. The pictures on his walls tell something of his taste. Among these pictures are almost life-size paintings of wild animals, startling if come upon unaware.

But wild animals were not unfamiliar to the ancient Pompeians, for animal hunts, or *venationes*, as they were called, were often a part of the entertainment of the amphitheater. The huge signs painted on the walls at Pompeii, which announce the shows (*munera*), frequently mention a *venatio* as one of the attractions. Paintings found on the amphitheater furnish evidence regarding the nature of those entertainments. At the time of excavation, a six-and-one-half-foot wall enclosing the arena was discovered. It was decorated with pictures

by WILHELMINA JASHEMSKI

of animal hunts, as well as of gladiators. It is not surprising that the oldest Roman amphitheater yet found is in Pompeii, for the Campanians had been fond of gladiatorial combats long before Pompeii was besieged by the Roman general Sulla in 89 B.C. and made a Roman colony in 80 B.C. The amphitheater at Pompeii had a seating capacity of about 20,000—enough to seat every man, woman, and child in Pompeii itself, with room left for visitors from the neighboring towns of Nuceria, Nola, Abella, Stabiae, Surrentum, Herculaneum, and Neapolis who thronged into the city for entertainments.

The question naturally arises as to what animals were used in the *venationes* at Pompeii, but there is little written evidence. Specific animals are mentioned in a graffito found on the interior wall of a house near the Forum. Here some unknown Pompeian had scribbled the reminder: "there will be a *venatio* on August 28, and Felix will fight the bears." Animals are also mentioned on the tombstone of A. Clodius Flaccus, *duovir* (or magistrate) for the third time in A.D. 3. His epitaph records the various spectacles that he gave during his three magistracies. Among these was a *venatio,* with bulls, bullfighters, wild boars, and bears. We know from the ancient writers that these animals were all available in Italy.

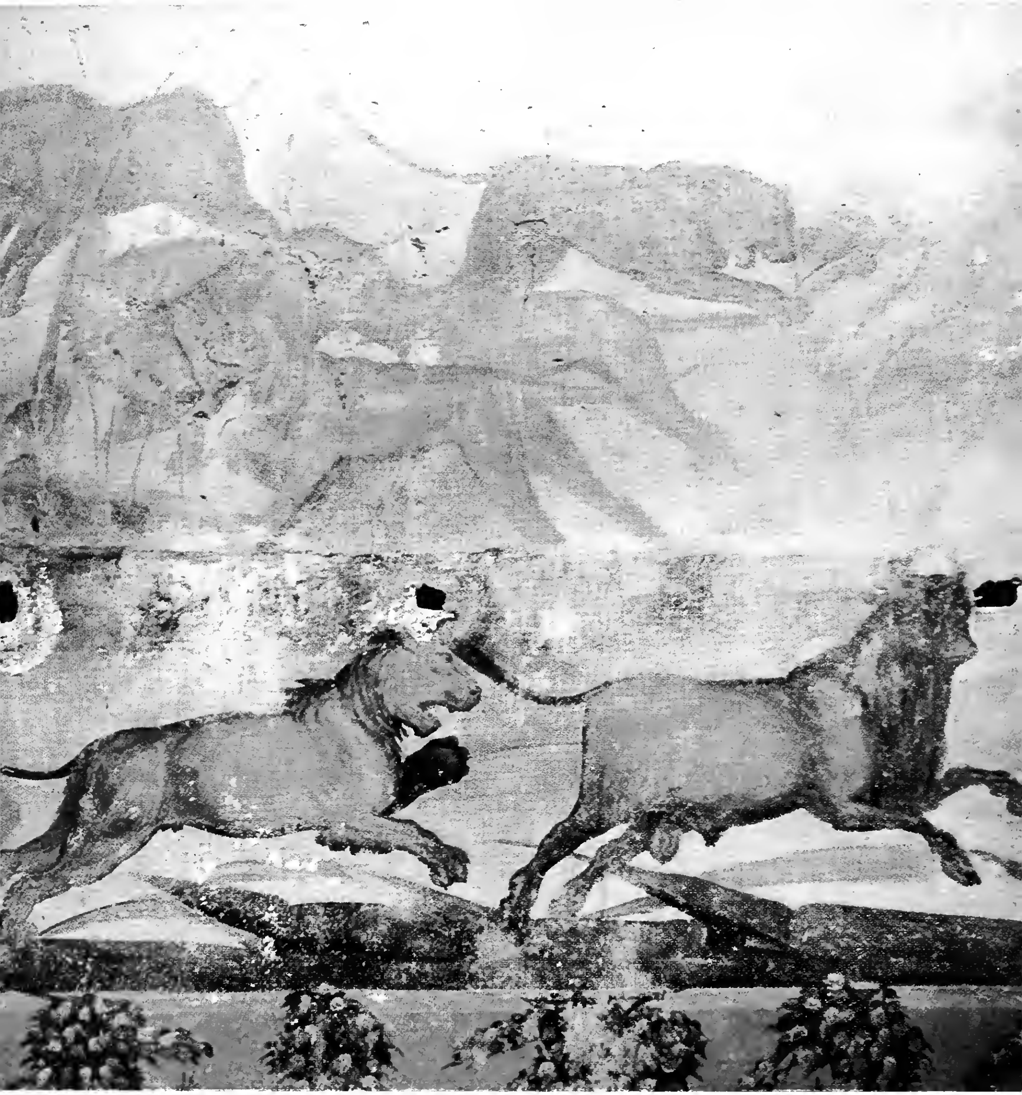
Pictorial evidence should be considered alongside the epigraphical evidence. Detailed representations of both *venationes* and gladiatorial combats were depicted in the stucco reliefs that decorated the tomb of A. Umbricius Scaurus, son of A. Umbricius Scaurus. This family had made a fortune manufacturing the fish sauce for which Pompeii was famous. The tomb was excavated in the days before photography, and today the reliefs are mostly gone, but fortunately drawings were published by the French scholar M. Mazois between 1824 and 1838. In some cases the animals are difficult to identify from these drawings, so we have only Mazois' description. In the largest panel dogs pursue a wild boar; a *bestiarius*—a man trained to fight with wild animals—runs a lance through a bear; another *bestiarius* boasts of the bull that he has transfixed with a lance; in the background are rabbits, dogs, and a deer. In the other panels the animals identified by Mazois include a lion, a tiger, and a leopard. If the tombstone of Umbricius Scaurus pictures a *venatio* at Pompeii it would indicate that expensive imported animals were sometimes exhibited at Pompeii alongside the wild animals available in Italy. A wealthy manufacturer with an important export business might well have imported, for a *venatio* in his home town, a few animals such as those he had seen in the great shows in Rome. Paintings of lions and tigers found on the podium of the amphitheater likewise indicate that at times the more exotic animals were seen at Pompeii.

The word *venatio* occurs at least thirty times in inscriptions and graffiti found at Pompeii, but in spite of the popularity of the animal hunts, they provided only a secondary attraction; the gladiators were the chief feature in the *munera.* It is the gladiators who are featured in the signs announcing the shows. The *venatio* is mentioned briefly at the end, along with other extras such as *athletae,* the prizefighters or wrestlers who performed between more spectacular events; *vela,* the awnings stretched to protect the spectators from the sun; and *sparsiones,* the sprinklings of perfume, which may have helped to dissipate the stench caused by sweat and carnage. (Pliny, in his *Natural History,* says that the fragrance of powdered saffron mixed with sweet wine is most efficacious for such a purpose.) The amphitheater at Pompeii had no provisions for elaborate animal hunts, and it had no underground chambers from which wild beasts could be lifted up to the arena to replace those that had been killed.

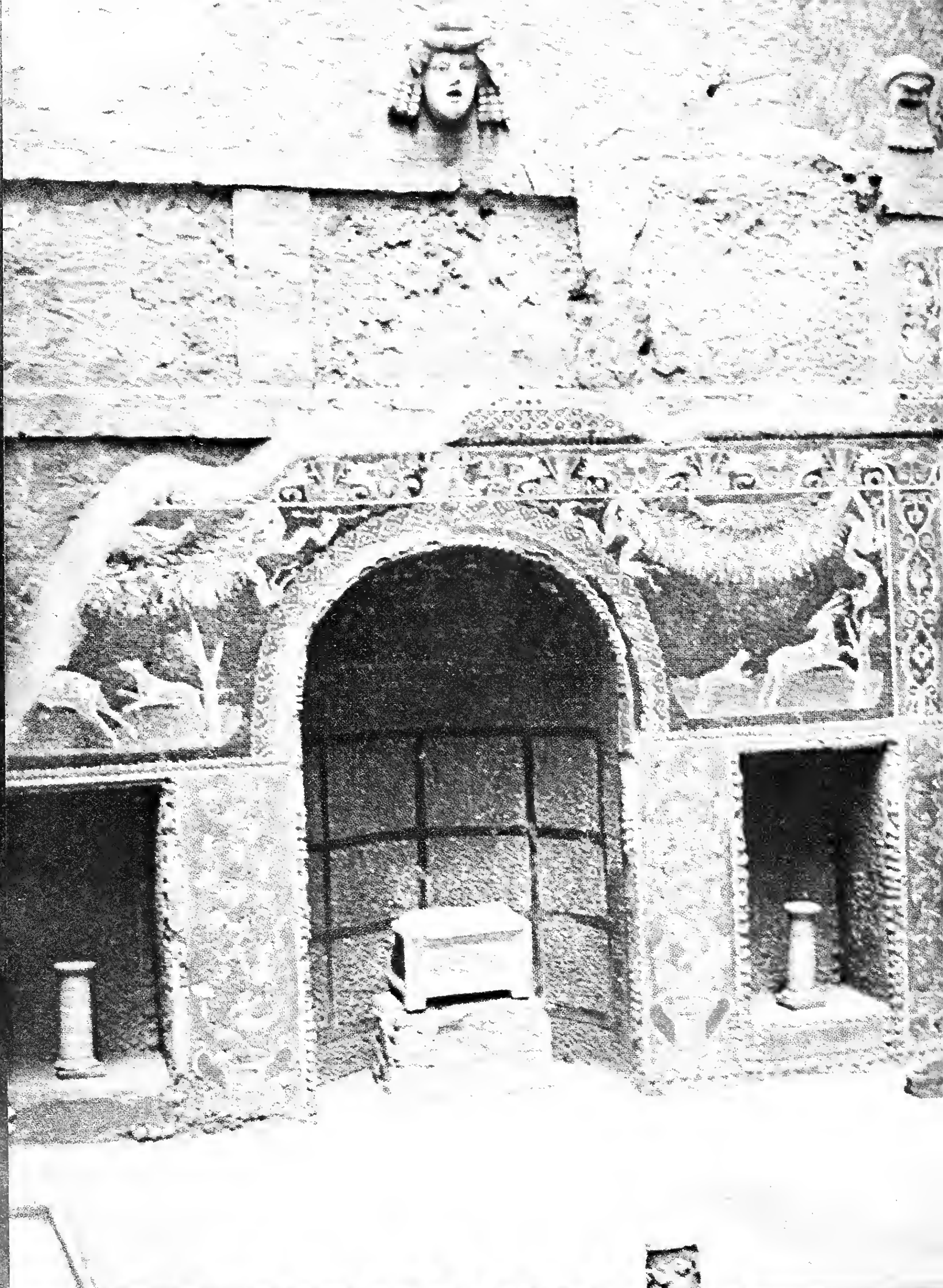
Pompeians witnessed nothing comparable to the spectacle put on by Titus in A.D. 80, when the Emperor celebrated the opening of the great Flavian Amphitheater (later known as the Colosseum) with games lasting one hundred days, and on a single day delighted the populace with five thousand wild animals. The historian Ludwig Friedländer comments that "the animals consumed at Rome for one great festival, would amply stock all the Zoological Gardens of modern Europe." A Pompeian visiting in the capital might have seen hippopotamuses and crocodiles from the Nile, lions from Thessaly or Mesopotamia, tigers from Hyrcania or India, elephants from North Africa or India, rhinoceroses from Egypt, ostriches from the African deserts, or even camels and giraffes. The insistent letters from M. Caelius, aedile in 51 B.C., begging Cicero to send him leopards from Cilicia, are indicative of the kind of pressure that was put on provincial governors to supply animals for the hunts at Rome. During the empire, exotic animals were welcome gifts from heads of foreign states. The feverish activity of rounding up quantities of wild animals for the *venationes* at home was not without some peripherally positive aspects.

Strabo, a contemporary of the Emperor Augustus, remarked that great areas of Nubia had been rendered suitable for agriculture because the wild animals had been trapped and shipped to Rome for the spectacles.

A careful examination of the large animal paintings at Pompeii shows that most of them are unlike those of animal hunts found in the amphitheater, or the stucco reliefs of a *venatio* on the tomb of Umbricius Scaurus. They are found on the walls of private homes, and usually on an outdoor garden wall. The ancient Pompeians frequently decorated the walls of their enclosed gardens with paintings designed to make the area appear larger. In these paintings, behind a low fence, trees and taller flowering shrubs appeared to grow in profusion. Statuary and fountains, frequently too large to be used in the actual garden, could be enjoyed in the painted version. One might ask what



Best preserved of Pompeian animal paintings is on garden wall in House of L. Ceius Secundus.



Courtyard "garden" in Herculaneum displays mosaics of garlands, peacocks, and hunt scenes (left), and Neptune and Amphitrite (right).

prompted some owners to include huge animal pictures in their gardens. To answer this question we shall examine some of these paintings and study the way in which they are used.

The best-preserved animal painting in Pompeii is on the back wall of the garden in the house of L. Ceius Secundus. On either side of the picture is a painted fountain. At the bottom of the wall a realistic, painted border of plants, amid which birds fly, continues the actual plantings of the true garden. Above the plant border is a grandiose mountain scene filled with wild animals. In the lower foreground on the rocky edge of a lake, a lion pursues a bull. On the opposite shore, in the middle of the picture, are wolves and wild boars. To the right a leopard is gaining on two mountain rams; to the left are a graceful stag and a gazelle. The mountainous terrain, with its trees and other vegetation, and the body of water in the foreground shows that the artist was not picturing a *venatio,* even though such hunts were sometimes made more realistic by the addition of greenery. On the west wall of a little storeroom is a garden scene in which a nymph holds a fountain surrounded by plants, flowers, and birds. Everything suggests that the ancient owner felt that his animal painting was a perfectly appropriate decoration.

The House of Romulus and Remus, near the Porta Marina, contained a beautiful painting on the garden's west wall. Beyond a low wall is a scene of trees and shrubs. An umbrella pine dominates the garden and shades a reclining silenus. Ivy and other plants grow in front of the wall. In the center a bird sits on the rim of a crater fountain, on each side of the crater a nymph holds a fountain, and a peacock struts in the foreground. The adjoining peristyle wall is decorated with an animal picture. A snake is coiled around a tree, and an elephant, bull, mule, chamois, lion, fox, and bear appear to live peacefully together.

Other interesting animal pictures are found in the modest but elegant home of Lucretius Fronto. The garden opens off a peristyle on the south. The animal paintings cover part of the west wall, all of the long north wall, and the east wall of the garden. On the west wall a tiger pursues a deer. On the adjacent north wall is a peaceful scene in which a resting lion appears to be watching a graceful deer as it quenches its thirst in a rocky stream or lake.

ted fountain and low fence with birds are
of Herculaneum "garden" in preceding picture.

Garden sculpture of hounds attacking deer
was also discovered in the ruins of Herculaneum.

In the foreground a bear calmly rests in the shade of a tree and devours fallen fruit. In the next picture a lion pursues a bull, which is confronted by a tiger. A stag and a fleeing deer can be seen between the huge trees in the background. There is again water in the foreground. In the third scene a huge deer looks back as a tiger hurls itself at a horse, which nips the tiger's hind paws. A lion runs from the background toward the unfortunate horse. At the right a wild boar prowls through a thicket of plants. Again the rocky shore of a lake (or mountain stream) appears in the foreground. Painted statues of nymphs holding fountains separate these pictures, and underneath, the border is decorated with exotic plants.

The paintings in houses that were excavated many years ago have almost completely disappeared, but a few should be mentioned. The House of the Hunt takes its name from the impressive animal picture on the south wall of the garden. Although this house was excavated in 1834, before the days of photography, a drawing made at the time gives a good idea of the painting. Small pictures of cupids hunting wild animals also decorate one room. It is not unusual at Pompeii to find such charming scenes, in which cupids are pictured engaged in the occupations and pastimes of men.

Another large animal painting, now completely disappeared, was found in 1875 when

Painting of birds and flowers is in garden of a recently excavated house at Pompeii.

the luxurious home of the banker, L. Caecilius Jucundus, was uncovered. This wealthy businessman, whose father apparently had been a freedman, had amassed a fortune that enabled him to own a home as elegant as those of the local aristocrats. The preservation of his business documents on 153 wax tablets found in his home, and his realistic bronze portrait bust, dedicated to him by one of his devoted freedmen, make Jucundus today one of the best-known citizens of Pompeii. According to the excavation reports there were a lion, a stag, and a tiger in his garden painting. On each side of that painting was a garden scene that featured a nymph fountain.

Animal paintings have also been found at nearby Herculaneum, which was also destroyed by Vesuvius. At this site the volcanic debris poured down, swept along by heavy rains that made it into a torrent of mud that penetrated into every crevice of the ancient town. Through the centuries this material has hardened into a rocklike substance that is exceedingly difficult to excavate. For this reason, only a small part of Herculaneum has been uncovered, but the buildings are better preserved than are those at Pompeii. The house of one prosperous merchant is especially interesting. It has a food and wine shop—the most complete shop of any kind yet found in the ancient world—and the beautifully decorated home shows an owner of unusual taste. The house was too small to have a garden, but the walls of the little courtyard in the back were painted to suggest one. The best-preserved portion, on the right of the back wall, shows a delightful garden scene. Oleanders and trees grow behind a low fence. Birds fly through the trees, two perch on the edge of the fountain, and two are on top of the fence itself. Traces of similar paintings are preserved elsewhere on the walls. In the center of the back wall, visible from the entrance of his house, this prosperous merchant had placed an elegant mosaic of Neptune and Amphitrite.

It is quite possible that his considerable wealth was derived from trade by sea, and that he had good reason to worship Neptune, the sea god. The nymphaeum on the end wall is richly decorated with two exquisite mosaic garlands, on which peacocks are resting. Gardens, homes, altars, and temples were frequently decorated with actual garlands; wealthy owners took pride in the peacocks that strutted in their gardens. Here in this tiny courtyard there was no space for large birds, but the owner could enjoy mosaic birds and flowers that did not fade. Beneath the peacocks are scenes in which dogs pursue fleeing deer. One of the merchant's neighbors had placed in his garden two beautiful sculptures of dogs attacking a deer.

The dignified dwelling of a middle-class family in Herculaneum is illuminating. There was no room for a garden, but at the rear was a small courtyard that served as a lightwell and also carried rain water to the cistern. There was, in addition, room for a few plants. The plaster on the back wall is for the most part missing, but above and to the right of the temple-shaped household shrine I found fragments of a wall painting of graceful wild animals in flight; adjacent are remnants of a garden painting. As the owner looked out from his large window, the trees and shrubs in his courtyard might become a great landscaped garden, and the wild animals in the background might remind him of those that roamed on great estates, such as the one which the Emperor Nero had built within the walls of Rome.

The Swedish scholar Axel Boëthius has pointed out that the remarkable thing about Nero's famous Golden House in Rome was not the luxury of the palace and the other buildings, but the way in which the Emperor had built a huge villa, with landscaped gardens, groves, pastures, even wild animals, within the city—a *rus in urbe*. Great estates with large enclosures filled with wild animals were owned by many wealthy Romans both in Italy and in the provinces at the time of the eruption of Vesuvius. Such estates were first introduced to the Western world by the Greek writer Xenophon, who described the great parks of the Persian kings and nobles that he had seen on his march. Xenophon uses the Greek word of Persian origin, *paradeisos,* to describe these royal gardens, which were vast enclosures that included fruit and ornamental trees, flowers, birds, and mammals. In much the same way the Latin *paradisus* is the word used in the Vulgate (Genesis 2:8) to describe the Garden of Eden, and the word "paradise" has come to mean a place of bliss or happiness—even the heavenly paradise of the New Testament.

The hunting ground was an essential part of the oriental *paradeisos.* Xenophon, in his description of the education of Cyrus, describes the animals that the young prince was taught to hunt: bears, boars, lions, leopards, deer, gazelles, wild sheep, and wild asses. According to Quintus Curtius, writing in his life of Alexander, "There are no greater indications of the wealth of the barbarians in those regions than their herds of noble wild beasts, confined in great woods and parks." When Alexander the Great conquered the Persians, he took possession of their *paradeisoi.* His successors also acquired such parks. When the Romans conquered the Hellenistic world they, in turn, acquired a taste for *paradeisoi.*

Cupid hunts a lion on wall of House of the Hunt. Cupids were often shown in human pastimes.

In Varro's handbook, *On Agriculture,* written during the last years of the Republic, he describes the large hunting preserves found on great estates in Italy. He says that "nowadays people enclose many acres within walls, so as to keep numbers of wild boars and roes" for hunting. He also describes the hare warren, and the

Imported and local animals both are seen in this detail from House of Lucretius Fronto.

aviaries, where thrushes and peacocks are raised, and, of course, the fishpond. Varro reports a conversation, in which his friend Appius describes how wild boars frequently become tame. On one of Varro's country estates "wild boars and roes gathered for food at the blowing of a horn at a regular time. . . . 'Why,' said Appius, 'I saw it carried out more in the Thracian fashion at Quintus Hortensius' place near Laurentum when I was there. . . . We were dining at a table spread out in the game preserve, to which he bade Orpheus be called. When Orpheus appeared with his robe and harp, and was bidden to sing, he blew a horn; whereupon there poured around us such a crowd of stags, boars, and other animals that it seemed to me to be no less attractive a sight than when the hunts of the aediles take place in the Circus Maximus without the African beasts (panthers).' "

This description calls to mind an unusual animal painting in the house of the well-to-do aristocrat M. Vesonius Primus, who owned a large fullery (a shop to treat cloth) at Pompeii. The painting takes as its theme the Thracian Orpheus, who is described by both the Greek and Latin poets as being able to charm the wild beasts with his music. A huge painting of Orpheus playing his cithara to the wild animals dominates the back wall of the garden, and is visible even from the street. On either side of the huge, T-shaped Orpheus painting is a typical garden painting. The garden of Vesonius Primus was too small to re-enact the Orpheus tableau that took place in the garden of Varro's friend, but the picture of Orpheus in a garden setting could suggest a great hunting preserve.

What the resources of empire permitted an emperor to create in reality in Rome, or vast personal wealth made possible for a citizen in the Italian countryside or in the provinces, the modest inhabitant of a town such as Pompeii or Herculaneum could suggest through the illusion of the painter's brush. It seems very natural and charming to see the apparent size of a modest garden extended through a garden painting. But if the owner had greater aspirations, he might suggest that the painter include in his garden decorations not only fountains, trees, birds, and flowers, but lakes or streams, set in a mountainous landscape, through which wild animals roamed in profusion. An examination of the animal paintings at Pompeii shows that some of the fauna are in almost identical poses. For example, the picture of a leopard attacking a bull in the House of the Hunt is almost a mirror image of a similar leopard and bull in the animal painting in the House of T. D. Panthera at Pompeii. The stag in the latter painting is the same as the stag in the House of Lucretius Fronto. Other duplicates could be pointed out. Painters at Pompeii apparently had samples, and painted pictures to order. A modest inhabitant of a small town could order as elaborate a painting as he desired. He might include all the animals of a king's preserve, such as the young Prince Cyrus was taught to hunt. He might even include an elephant, which no man save the emperor could own. The *nouveau riche* banker, L. Caecilius Jucundus, the prosperous aristocrat-fuller, M. Vesonius Primus, or a humble freedman could recline in his garden adorned with paintings and enjoy his own *paradeisos.*

Impressive animal painting, no longer in existen is said to be from House of T. D. Panthera.

GRAY SQUIRREL, after introduction to the British Isles, moved rapidly along timbered network formed of hedgerows and woods of oak, ash, and hazel. Typical of such routes is that provided by Herefordshire country, *below*.

ntroduced Menace

nerican gray squirrel poses threat to British woodlands

MONICA SHORTEN

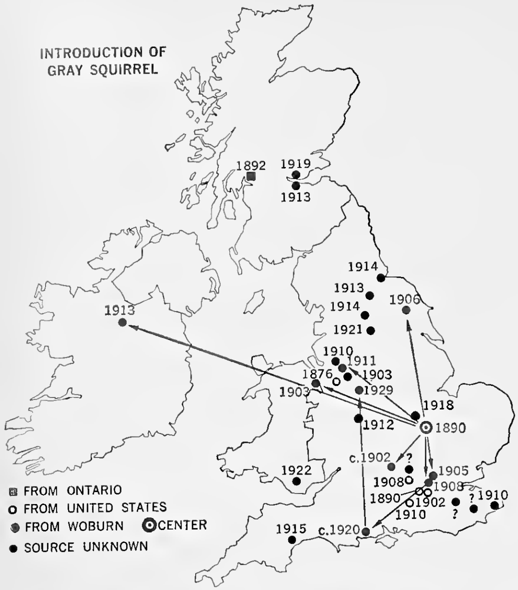
RAY SQUIRRELS are popular small game animals in the eastern s of North America. Management tices aimed at conservation of the ies include deliberate sparing of rees in which squirrels have dens, iding artificial den boxes, and at- pting to increase supplies of foods inter. The squirrels are protected nst overhunting by restricted open ons and by limits on the number a hunter may kill: in 1949 a er in Virginia was fined twenty- dollars for shooting two gray rrels during the closed season.

ich protective legislation can be d to the late nineteenth century in Jnited States. Before that, in the of the early settlements, squirrels ued the farming pioneers. We read hite settlers in Ohio required to nt a hundred squirrel scalps a or to pay a three-dollar fine. The s of Massachusetts and Pennsyl- a offered bounties for squirrel uction in 1740 and in 1749, hop- o reduce damage to crops. It is urprising that some protests were raised when the squirrel became a protected game animal, or that fears were expressed that the crops would be ravaged, birds destroyed, and forest trees damaged. The main reason protests went unheeded was that clearing of the old hardwood forests had sent squirrel populations tumbling to a point where hunting pressures might have begun to have a real effect on numbers.

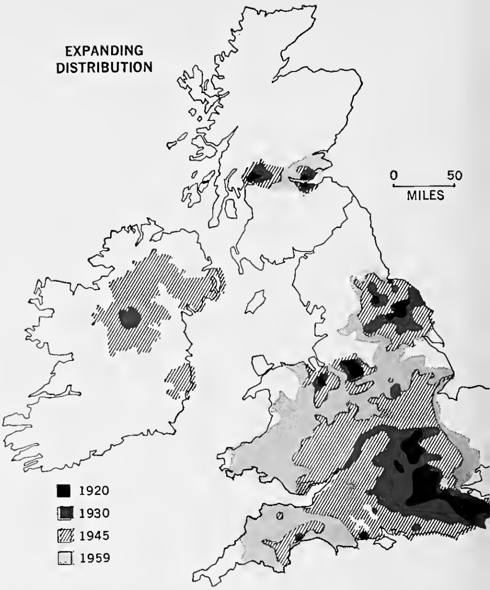
Perhaps it was anxiety about the future of the gray squirrel in some eastern states that led enthusiasts to seek a new refuge for it in Britain between 1876 and 1910. At that time, it was apparently still possible to look upon the countryside as a painted backdrop to be enlivened by the gambols of exotic actors placed before it. Few managements knew that it might prove impossible to clear the stage or to repair the scenery when the performance had lost its charm. From the mammalian troupe, Europe was dispatching hares, rabbits, and wild boar to play their roles in North America: red and fallow deer were contributed to the South American scene; the relatively bare stage in New Zealand was fast filling up with foreign acts — the English weasel. stoat, and ferret joining in about this time to play alongside an earlier star performer. the rabbit. Perhaps there the scenery was just beginning to show signs of wear! Having received most of their immigrant squirrels by 1910, the British continued for another twenty years to transplant the newcomers from one district to another within their country. Of thirty-three known introductions. only three failed. After a time, twentieth-century Britain was viewing the gray squirrel with the same dismay that had been exhibited by eighteenth-century America: bounty payments were made, free cartridges were offered to hunters, squirrel destruction was urged at all seasons, and another lesson had been learned about the folly of introducing foreign species. Since 1937 the importation of gray squirrels has been prohibited, as has also the keeping of one as a pet, a zoological exhibit, or an object of scientific study, unless a special license has been secured.

In his book, *The Ecology of Invasions by Animals and Plants*, Charles Elton writes about ecological explosions—the enormous increase in numbers of some kinds of living organisms that burst out of control when freed from a previous restraint. He considers that of all Nearctic mammals introduced to other countries, the gray squirrel and the muskrat have been. perhaps, the most explosive. The early stages of the squirrel invasion have been well mapped and documented in the published work of A. D. Middleton. and its progress between 1937 and 1957 was surveyed at intervals and reported on by the present author. The latest account by H. G. Lloyd describes the distribution in 1959, and shows it to be still increasing. From these accounts we can examine the speed and extent of the "explosion." We can now recognize some factors that encouraged the gray squirrel's spread in Britain, and some of the difficulties it met and overcame. During adaptation to new conditions, *Sciurus carolinensis* earned itself the status of forest pest.

THE whole lamentable exercise could not have been timed and planned better had the intention really been to insure a permanent. thriving addition to the fauna of England, Wales, Scotland, and Ireland. A glance at the map on page 44 will show the scatter of introduction points. at each of which two or more gray squirrels were liberated. However, it does not show the wooded country estates with their mature oaks. sweet chestnuts, and beech trees, which were often the actual sites chosen, nor does it show the pheasant-feeders so conveniently placed in the winter woods. On such a map there is no indication that certain woods are closed to public hunting, of the scarcity of winged or arboreal predators capable of harassing the gray squirrel, nor of the fat and vacant living waiting for it once the only native squirrel had been struck low by



American gray squirrels were introduced to Britain from 1876 on. Later, they were transplanted inside the country.



Expansion was rapid despite bounties and free cartridg
offered to encourage year-round control of the squirrel

disease. In this land there was no interest in squirrels as game or as food.

The most important of the immigrants appear to have been squirrels brought to Britain by a Mr. G. S. Page of New Jersey. In 1890 the Duke of Bedford accepted ten for his estate at Woburn. This colony later provided animals for at least eight new centers, quite apart from those overflowing into neighboring counties and populating some 1,350 square miles around Woburn within thirty years. This was a more rapid spread than that from the three Scottish centers: three squirrels were released in 1892 near Loch Long, and gave rise to a population that in forty years had spread over 300 square miles. Mountain and moorland in Scotland enclosed the squirrels, confining their spread along the hardwood areas on lower ground. In such northern English counties as Yorkshire, gray squirrels also first advanced along river valleys and lower wooded levels, and in parts of southern England they at first bypassed the hill country, even where it was wooded with beeches.

It now became clear that individual squirrels or small groups were advancing briskly from established centers in which numbers were still low. The initial spread would often leave pockets of promising habitat uncolonized, while five to ten miles farther on the pioneers were settling in. The appearance of the first squirrel, perhaps miles beyond the known distribution frontier, would be a warning that some favorable route existed and would be used again, even though the first comers had been killed. There were places where a different pattern developed; colonies remained largely confined to one area and built up densities of about three squirrels per acre.

Writing of this in 1930, Middleton commented: "Extensive migrations of grey squirrels in vast hordes have frequently been witnessed in America, but no mass migrations have so far been recorded in this country. There does, however, appear to be a strong migratory instinct among individuals rather than masses, as evidenced by the rapid extension of range carried out in thinly populated areas such as Wharfedale. It is possible that in this country the migratory instinct may be stronger in some individuals or families than in others, in which case the ones less inclined for migration would, by breeding, establish concentrated colonies, while the migratory ones were engaged in extending the range of the species. In the circumstances under which the spread of the
grey squirrel has occurred in this cou
try, where the population of large are
must in many cases have resulted fro
the progeny of isolated pairs, tl
genetical character of the ancestral i
dividuals must have a pronounced i
fluence on the character of the descen
ants, so that there is a much great
chance of certain variant characte
becoming established in these circun
stances than in the normal conditio
of a constant population." This wi
be returned to in another context.

By 1930, populations arising fro
many centers were already overla
ping. The total range in Englan
Wales, and Scotland was then judge
to cover some 13,000 square miles. I
five years this increased to 19,00
square miles, and in the following tw
years to 21,000. At this late stage, th
Grey Squirrels. Prohibition of Impo
tation and Keeping Order, 1937, wa
published; but soon the war year
brought a neglect of gamekeeping, an
the squirrels' range was over 29,00
square miles at the next survey mad
in 1945. Ten years later distributio
had spread to almost 39,000—roughl
44 per cent of the total land surface c
England, Scotland, and Wales. Gra
squirrels had also been introduced t
Ireland at one place in County Lon
ford, from whence they are reported

: spread to five counties in Eire and our in Northern Ireland; but no iled survey has been made there. he Ordnance Survey maps of Brit- ire overprinted with National Grid .res, the smallest being those that sure one kilometer across; these ear on maps scaled at one inch to nile. Localities can be defined by National Grid map reference, and of this system allows transfer of ibution records to maps of smaller : with speed and precision.

HE most recent survey results, published by H. G. Lloyd in 1962, r only England and Wales. They that in 1959 gray squirrels could ound in 1,072 of the 1,638 10-kilo- r grid squares of this area. There been little dramatic advance since , but rather a number of small ex- ons and some filling-in of small nes of unoccupied territory. If the of spread shown over the past ten s were to be maintained, the squir- ight celebrate the centenary of its al by colonizing the entire land ice of England and Wales.

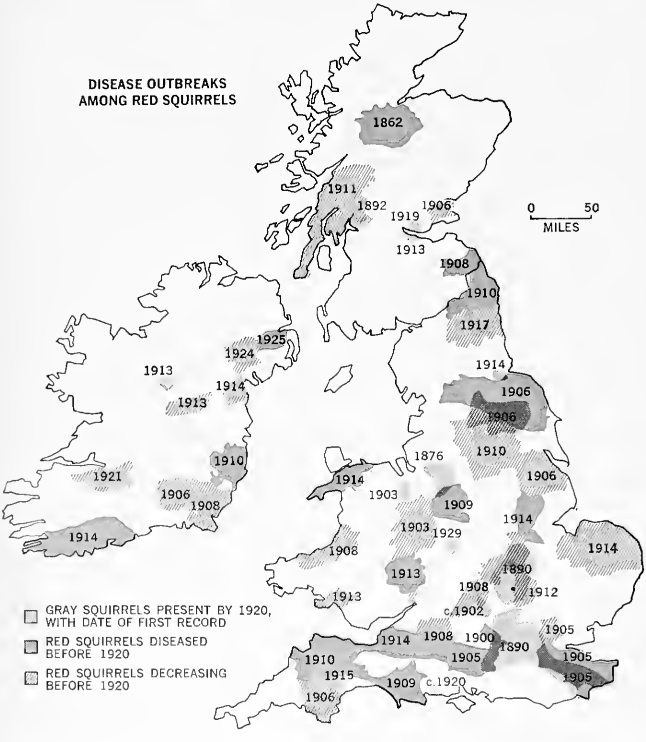
is scarcely necessary to caution he total ranges calculated by such eys give an inflated area. Records rst mapped on a parish basis, and hen transferred to the small-scale using a grid system. In Britain, a ish" in this sense is an adminis- 'e subdivision of a county, often erritory served by a church. There 12,780 parishes in England and s. Until 1945, the grid squares covered 64 square miles: if one h in such a square had gray squir- the whole square was counted as ive. From 1945 onward, the 10- neter National Grid was used, and ange comparisons, all earlier rec- were also replotted on this sys- One wood containing squirrels t still add 100 square kilometers : total range, however. A transient rel might have the same effect. rally, squirrels can only be resi- where there is suitable habitat for , which means food and cover at asons of the year.

art from more obvious obstacles read, such as treeless moors, fen- heavily industrialized areas, and l rivers with few bridges (squir- wim well, but tend to follow the e of a river rather than to strike s), a rather mysterious barrier s to inhibit the eastward expan- of range in England. The eastern

BARK STRIPPING by the American gray squirrel is abundantly evident on the sycamore tree, *above*. This particular tree once grew at Betchworth, Surrey.

CAMBIUM at base of this beech tree has been gnawed by the gray squirrel. Such hardwood damage is particularly noticeable from late April until July.

British red squirrels have been twice threatened—in the 18th century from agricultural expansion, and in the 20th century from virulent disease.



Epidemic disease among red squirrels was suspected in 1862. Then outbreaks occurred throughout British Isles, and animal was nearly exterminated.

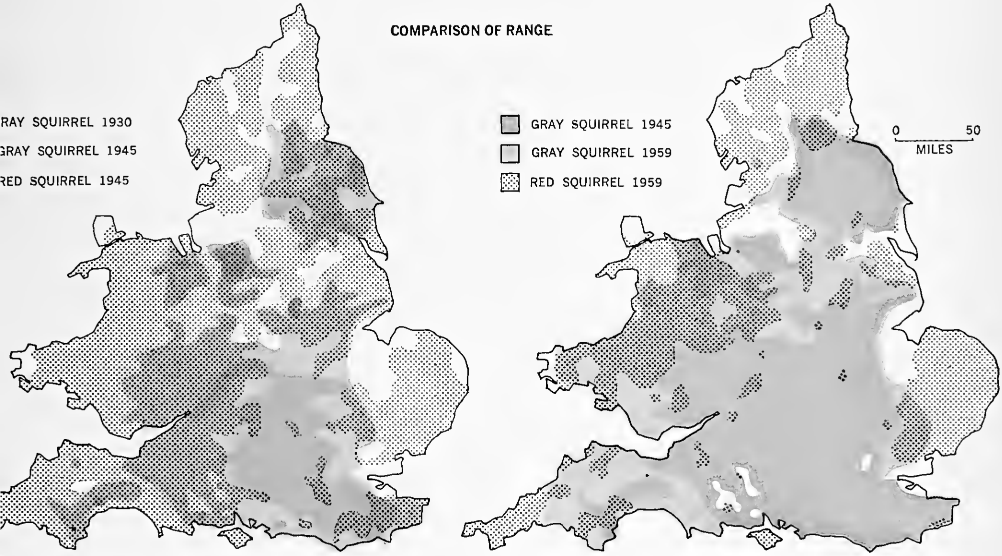
frontier has moved very slowly, an sometimes the ground gained one yea has been lost subsequently. Fenlan blocks part of the front, but no appa ent obstacle prevents the gray squi rel from skirting this and reaching th wooded country beyond. In man cases, the records show that movemer from the original centers was more t the west than to the east.

Compared with the eastern states America, Britain is relatively tin berless; the total extent of woodlanc larger than five acres accounts fc about 7 per cent of the total land su face—about four million acres. Th includes very young and coniferou woodland (newly planted areas which trees are under 25 years old) i addition to any suitable for gray squi rels to live in. Oak is the most impo tant tree for gray squirrels, and the are only two species (both of which b long to the white oak group) co monly found in Britain, in contrast the 36 species of white oaks and blac oaks that grow in the squirrel's nati range. Although the acorns from whi oak are preferred by squirrels becau they contain more sugar and mo water, the trees are not reliable cro pers, and may fail to produce abo once in five years. It is hard to imagi that such a limitation in the variety acorn-producing trees in Britain is n a disadvantage for squirrels, partic larly as there are no hickory tre either, and the remainder of the woo land nut crops—beech, sweet chestnu and hazel—crop irregularly and, mo often than not, poorly. A saving fact for the squirrel may be the pattern land-use in Britain—the presence smaller, scattered woods and plenty "edge" habitat, which places a varie of food within cruising range. High densities of squirrels have been fou in 40- to 80-acre woods with a mixtu of coniferous and hardwood speci including well-grown oaks. Here up five squirrels per acre can be found favorable years.

Today, as in their early years, t introduced squirrels wander; isolat woods in which all squirrels are kill soon become reinvaded. The timber hedgerows, which link wood to thick and the tree-lined watercourses enco age mobility, and mobility makes sen if food supplies are unstable. By th means, when bumper mast crops le to crowded populations the squirr disperse to explore fresh woods a escape the stress syndrome. When is scarce because the acorn crop ailed, widespread foraging may ver alternative supplies. It is noble that in Britain gray squirrels af nests rather than dens for shelnd for rearing their young: this, must aid mobility. The prevalence f nests may be a reflection of the l absence of airborne and arbopredators that attack squirrels in nests. On the ground, man is the predator, but for a number of ns he is less effective than he be. The highest estimate of the l kill of squirrels in England and was less than 400,000 at a time fourteen cents was offered for gray squirrel's tail handed in. tate of North Carolina, which is square miles smaller, claims up 00,000 squirrels a year. There e more woodland in North Carobut there are ten times fewer to hunt squirrels. In other , presumably a much greater rtion of North Carolinians hunt, ey kill a greater number of squirer gun. However, the American probably less damaging to the el population, thousand for thouthan is the British kill. American rs take squirrels when numbers the annual peak and breeding is or the year, while the British aim ducing the population, and concentrate most shooting, trapping, and nest destruction to coincide with the spring breeding season. The gray squirrel is classified as vermin; there is no tradition of squirrel hunting for sport or for the pot. Before a licensed hunter can fire a shot outside land he owns or occupies, he must secure verbal or written authorization from the owner or authorized tenant, and if there is game in the area, a stranger may find such permission refused. Differences in customs like these have helped the squirrel to prosper.

The success of an introduced species will depend upon the competition it encounters in its chosen ecological niche. There is only one squirrel of any kind native to Britain. *Sciurus vulgaris leucourus* Kerr is also a diurnal tree squirrel, a subspecies of the Eurasian red squirrel developed from ancestors adapted for life in dense coniferous forest. In the British Isles, largely deciduous forests covered the country before the onslaughts of agriculture and industry destroyed them and reduced the wildlife they sheltered. The red squirrel suffered the expected fate of a species whose habitat was reduced in extent and altered in nature long before the first gray squirrel appeared. It came to the verge of extinction in Scotland at the end of the eighteenth century, when replanting and the introduction of conifer species from overseas were only beginning to have an effect. A series of reintroductions between 1772 and 1872 were successful, however. It is probable that all red squirrels in Eire and Northern Ireland are descended from introductions there between 1815 and 1880. Newly formed plantations of conifers and the growth of hardwood areas allowed a rapid increase in red squirrel populations, until at the end of the nineteenth century they were abundant. Epidemic disease was first suspected in Scotland in 1862; then scattered outbreaks in all parts of the British Isles caused a violent reduction in numbers, amounting to disaster for the red squirrel in some areas. Gray squirrels, however, continued to spread, themselves unaffected by the disease—which, indeed, must have made their conquest easier.

At first sight, the arrivals of imported gray squirrels between 1876 and 1929 and the main outbreaks of disease among red squirrels from 1900 to 1925 suggest a direct connection. It is tempting to conclude that the American squirrels were immune carriers of some agent that proved lethal when transmitted to the British red squirrels. The detailed pattern and timing of the gray squirrel invasion does not, however, fit the pattern and timing of the epidemic outbreaks. Even if highly mobile carriers, such as birds,



es of native and introduced squirrels in England and s are seen above. In 1945, red squirrels were absent from 66 per cent of areas occupied by grays since 1930; in 1959 they were absent from 81 per cent of the gray's area.

are imagined and full allowance is made for temporary, unrecorded introductions of gray squirrels, there is no positive evidence to prove that the disease agent came in with them. Had it done so, one would expect to find that sickness among the red population radiated first from some of the major centers where grays had been introduced. No such picture emerges from the data collected by Middleton, to whom we owe virtually all our knowledge of this period.

THE squirrel that might have been a competitor of the gray in the deciduous and mixed woodlands of Britain was thus struggling for survival on another count during vital years. When the distribution of each species was compared in 1945, the red squirrel was found to be absent from 66 per cent of those grid squares in which gray squirrels had been present for at least 15 years. This looked like replacement, but no previous survey had been made of red squirrel distribution in the area, and it might always have been thinly populated by them. Of the total area positive for gray squirrels, only 43 per cent of the squares were without red squirrels in 1945. There were more reports of red squirrels where grays had only recently appeared. Fourteen years later, 81 per cent of the same area was without red squirrels. While grays had spread from 708 to 1,072 squares, reds had retreated from 1,011 to 571 squares out of a total of 1,638 squares available.

This replacement of the native by the introduced squirrel cannot be explained by the popular idea that there was mass slaughter of one by the other. It is easy to see how the idea arose, for the European red squirrel, unlike the American red squirrel, would be no match for the gray in direct combat. It is smaller, half as heavy as the gray, and very unlike the American red squirrel in character. It lacks the chickaree's noisy, pugnacious nature, and is not a close relative. Red squirrel populations, struggling to recover from the disastrous decline of 1900 to 1925, have done best in districts where gray squirrels have never penetrated and where coniferous habitat is plentiful. Since grays largely avoid purely coniferous forest, this may prove a final refuge for the red. We do not know which factors are proving decisive in affecting the change-over—"superior adaptability" is a useful blanket term—but, however unjustly, the gray squirrel is commonly blamed for the scarcity of the British red squirrel.

The main outcry against *Sciurus carolinensis* is for another reason. It has developed into a pest of broadleaved forests, stripping bark and gnawing cambium from living stems of young hardwood trees. The habit was noticed soon after the squirrel's arrival, but became serious as young stands of the slow-growing, valuable trees developed in acreage. It was the chief reason for the five-year bounty scheme to encourage gray squirrel destruction. The damage is confined to a definite season from late April to early July, and the trees most usually attacked are the European sycamore (which is a maple, *Acer pseudoplatanus*), and a beech, *Fagus sylvatica*. At least a dozen other species are less frequently damaged, but very rarely do gray squirrels strip conifer stems. Beech trees may be attacked on exposed roots, the main stem, or the branches, but the most typical damage is stripping at the base of the main stem or where a branch leaves it. Butts are often completely girdled, killing the tree. In sycamores, damage often occurs in the crown of the tree, but the lower main stem is also attacked. Outer bark is torn upward in strips, and the cambium layer is damaged. Attacks can be distinguished from those of rabbits when near ground level, as the outer bark is uneaten.

The two trees most often damaged are not native to North America, but it is interesting that fox squirrels in Michigan have been known to girdle and kill maples and beech in June and July. Winter damage to hard maples, involving the stripping of living bark from stems and branches in January and February, is also recorded for both fox and gray squirrels. In 1958 Longley reported that gray squirrels near Lake Minnetonka in Minnesota had been stripping bark from sugar maples during summer months, although winter damage was more usual. J. M. Allen recorded damage to soft maple by squirrels in June. It can be seen that this habit was not learned by the gray squirrel for the first time after its arrival in Britain, but three new factors have arisen: new species of trees have been encountered, damage is more regular and extensive, and more attention is paid to such damage in a country where home-grown timber is scarce (90 per cent of the nation's timber requirements are imported

Some foresters believe that ba
stripping is more frequent in dry su
mers, and that thirsty squirrels li
sap, but damage is often found
trees that border streams and lak
Others believe that the cambium lay
with its sugary sap, is a valuable fo
for squirrels in the lean period betwe
April and July, when one mast crop
exhausted and the next is not
formed. There is a possibility that su
behavior is confined to young of t
spring litters, their family ties brok
by the imminent arrival of summer l
ters, or that it is a release for so
sociological stress. Not enough dir
observations have been made of squ
rels actually stripping bark, and we
not know the sex or age of anim
responsible, but not all individuals c
indulge in this activity, or matt
would be much worse. The British r
squirrel behaves in the same way at t
same time of year, but restricts its
tack to young *Pinus sylvestris* (t
Scotch pine) and a few other conife
There have been similar attacks
conifers by other races of red squ
rels in central Europe, and forest
in Finland have described recent o
breaks of damage to pine that nea
parallel the British experience. Th
is some evidence that red squirrels
Alaska damage conifers, and the Ab
squirrel may also do so. Probably,
we knew enough, we should find t
all tree squirrels have this habit, l
when even-age stands of young tr
are grown as a crop, the habit becom
more obvious and more annoying.

EARLIER, a suggestion by Middlet
was quoted that referred to ge
tic differences developing in g
squirrel populations arising fr
progeny of isolated pairs. The Finn
authors Pulliainen and Salonen s
gest that bark stripping is behav
governed by a recessive gene, whi
becomes obvious when isolated po
lations inbreed to produce individu
homozygous in this character. Diffic
as this may be to prove or disprove
does raise a disquieting thought—w
those gray squirrels shipped to Brit
nuisance squirrels, trapped and
moved from areas where the map
and the beeches had been stripp

PHOTOGENIC qualities notwithstandi
***Sciurus carolinensis* poses real haz**
to deciduous trees in the British Is

Crab Nebula photographed from Mount Wilson Observator

SKY REPORTER

The remarkable Crab Nebula evolved from an exploding sta

By Thomas D. Nicholson

In last month's "Sky Reporter," we saw that the constellation Orion is a region from which much has been learned about the *birth* of stars. This month we describe the Fourth Wonder of the Universe, the Crab Nebula, which has resulted from the *death* of a star.

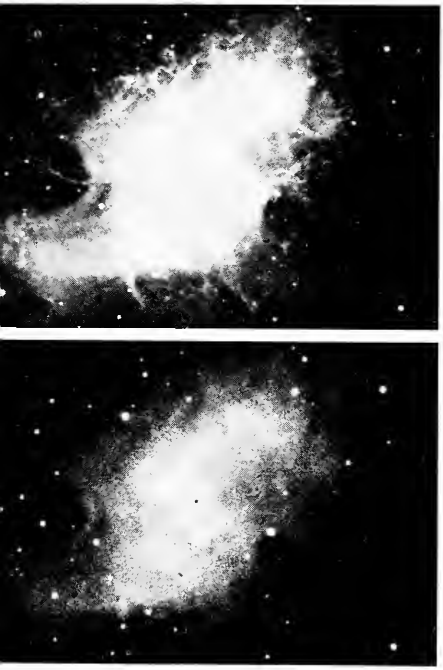
The Crab Nebula is a compact, bright region, roughly oval in shape, which measures about six minutes of arc by four minutes of arc on the sky. It is located in the constellation Taurus, the Bull, and is prominent in December skies. It is about one degree to the north and slightly west of the third-magnitude star Zeta Tauri, often represented as the tip of the Bull's left horn. Although too faint to be visible with the unaided eye, the nebula can be seen easily in a small telescope and looks pearly-white in color. The striking appearance of the Crab Nebula is most apparent, however, in photographs taken with large telescopes. There is no object similar to it in the entire heavens. The photographs reveal a complex system of bright filaments surrounding a diffuse, almost featureless central brightness.

In 1844 the Irish astronomer Lord Rosse discovered these tentacle-like streamers of brightness woven through the nebula, and it was he who contributed its name. The earliest records of the appearance of the nebula are the sketches left by Lord Rosse. Interest in the Crab Nebula
something other than a curiously shaped cloud of glowi
gas arose during the 1920's. The astronomer K. Lundmar
of the Mount Wilson Observatory, noted that it was locat
in the approximate position of a star that had first be
reported by Chinese and Japanese astronomers in A.
1054. According to their account, this new "guest sta
appeared suddenly near the star Zeta Tauri, becan
brighter than the planet Jupiter, and remained visible f
approximately two years.

Such a star is recognized today as an exploding sta
either a nova or a supernova, depending on the magnitu
and characteristics of the explosion. Ordinary novae a
supernovae may be distinguished by, among other thing
the maximum brightness they achieve during their ou
burst. A nova may attain an absolute magnitude of abo
—7 or —8, some 50,000 times the luminosity of the su
A supernova may attain an absolute magnitude of —1
or —16, about 350 million times more luminous than t
sun. Novae and supernovae represent very different event
although both may be described as stellar explosions.
nova is a relatively minor outburst, involving only supe
ficial changes in the characteristics of the star that remain

supernova probably involves the basic structure of ar. The outburst of a supernova results in the loss re than one-tenth of the star's material, a mass loss n some stars may equal or exceed the mass of the sun. vae and supernovae also differ a great deal in the ency with which they are observed. Novae are rela- common; probably 25 to 30 occur annually, although remain undetected. Supernovae, on the other hand, re in our stellar system; only three are definitely n to have occurred in the Milky Way in the past nd years. Perhaps a dozen other supernovae are ob- l annually in other galaxies, all at great distances earth, of course. Supernovae probably occur at a rate ut one each three hundred years per galaxy.

lay, astronomers are of the opinion that nova-type rsts represent a stage in the evolution of certain types rs toward what is known as the white dwarf or de- ate state. The few white dwarf stars that are known r to be of low mass, and it may be that many stars somehow lose a good deal of their mass in order to this last stage in their evolution. Nova-type bursts e one way in which the loss occurs. The outburst probably results from an instability that develops in r as it approaches white dwarf stage. Little is known the causes or effects of a supernova, since so few are ed. None has been observed in our Galaxy since the ion of the telescope. The great amount of energy ed and the mass lost to the star are so great, however, t must be quite a different kind of event from that is observed in an ordinary nova.



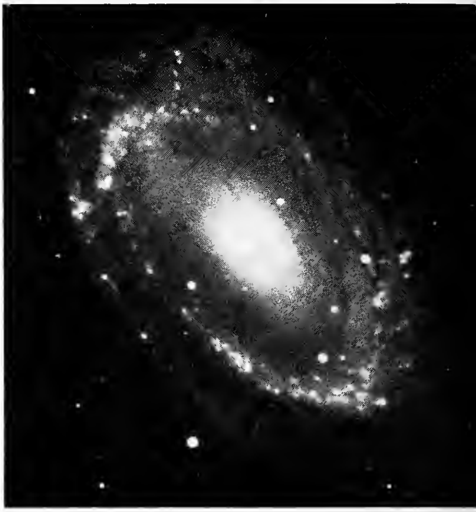
ENTARY STRUCTURE appears relatively weak in the top , taken in the blue area of nebula's spectrum. In lower e, taken in infrared area, filaments cannot be seen.

That the new star witnessed in A.D. 1054 was a supernova is clear from what we now know of its apparent brightness and the distance from earth of the cloud it produced. The absolute magnitude of the star at the peak of the outburst has been estimated at about −16.5, indicating that it was one of the most brilliant supernovae known in relation to ones observed in other galaxies. The agreement of its position with that of the guest star and the observed expansion of its gaseous clouds leave little doubt that the Crab Nebula is the visible remains of the supernova of 1054. Two faint white stars near the center of the cloud have been investigated from time to time on the possibility that one or the other may have produced the outburst, but this is unlikely. They are probably background stars, moving—but not in the same direction—as the nebula.

THE source of the light coming from the Crab Nebula was not established until about ten years ago. The spectrum of the cloud showed strong, bright emission lines superimposed over a very bright continuum. The bright lines suggested that it was an emission nebula—that its light was produced by emission of its tenuous gases, stimulated by radiation from a nearby hot star. But there was no type of star in or near the cloud that could supply the required radiation. The bright continuum in the background of the spectrum suggested that it was a reflection nebula—that is, its light was starlight scattered and reflected by dust particles in the cloud. But the strength of the continuum was far greater than could be produced by reflected light from any of the nearby stars.

PHOTOGRAPHS of nebula's polarized light, *above*, were taken through 200-inch telescope at Mount Palomar. Polarization plane is turned ninety degrees from top to bottom picture.

Distant galaxy in Coma Berenices is viewed during the occurrence of a supernova, *arrow lower right.* The brighter region in center of the galaxy is the large stellar nucleus.



Galaxy after the supernova has faded. Each year about dozen are observed in galaxies other than our own, and th probably occur at a rate of one each 300 years per galax

A remarkable series of photographs, published in 1942 by W. Baade of the Mount Wilson Observatory, showed that the Crab Nebula actually consists of two distinct parts, and that each part is responsible for a different feature of the nebula's spectrum. Baade used a combination of filters and photographic plates to take pictures of the nebula in selected regions of the spectrum. Photographs in the area of the spectrum that included bright emission lines showed a considerable enhancement of the filamentary structure of the nebula. Other photographs, taken in wavelengths that were free from strong emission lines—such as the infrared—showed no filamentary structure, but only a bright S-shaped cloud (*photographs, page 51*).

These photographs by Baade showed that the strong continuous spectrum, accounting for about 80 per cent of the total brightness of the nebula, was produced by the nebula's relatively featureless inner region. The striking bright filaments, on the other hand, were responsible for the emission features. There was still no satisfactory explanation, however, as to what might be the source of the strong, continuous radiation.

In 1948 and 1949, several Australian radio astronomers discovered and investigated a strong source of cosmic radio waves in the constellation Taurus. The source was quickly identified with the position of the Crab Nebula, which then gained the distinction of being the first optical object definitely identified with a cosmic radio source. The radio radiation coming from the nebula was peculiar in many ways; it strongly covered a broad range of radio frequencies, and was also strong in relation to the optical radiation produced by the nebula.

The Russian astronomer I. S. Shklovsky suggested in 1953 that radio waves from the Crab Nebula were produced by electrons moving at near the speed of light in a strong magnetic field. This is known as synchrotron radiation. Shklovsky further theorized that the optical radiation from the inner mass of the nebula could also be explain in the same way. This suggestion, connecting radiation a peculiar nature in two widely separated regions of t spectrum, was bold and imaginative.

Two other Russian astronomers, V. L. Ginsburg a I. M. Gordon, pointed out that if the theory were corre the light from the Crab Nebula should be strongly pola ized. Evidence of the polarization was found by Russi astronomers in 1954 and was clearly confirmed by a seri of pictures taken in polarized light by Baade with the 20 inch telescope at Mount Palomar in 1956 (*see photograp page 51, right*). In that same year, 1956, J. H. Oort a Th. Walraven, of the Observatory at Leiden, The Neth lands, published a paper that confirmed Shklovsky's the that the nature and strength of the radiation from t Crab Nebula is attributable to synchrotron radiation. Th also suggested that the strong and complex magnetic fie present in the nebula is probably connected with the e panding shell of bright filaments. They suggested furth that the conditions within the Crab Nebula could make i source of cosmic rays—mysterious, high-energy particl emanating from space—and that supernovae might be important source of these particles.

Thus the Fourth Wonder—the Crab Nebula—has prov to be a remarkable object in many ways. It shows us the r sult, after nine centuries, of the death of a star, and m yet help to explain the processes that produce or res from supernova events. More than that, the investigati of this peculiar object has led to a new understanding the sources of the optical and radio radiation we obser in the universe, an understanding that should have an app cation in the interpretation of other celestial phenomen

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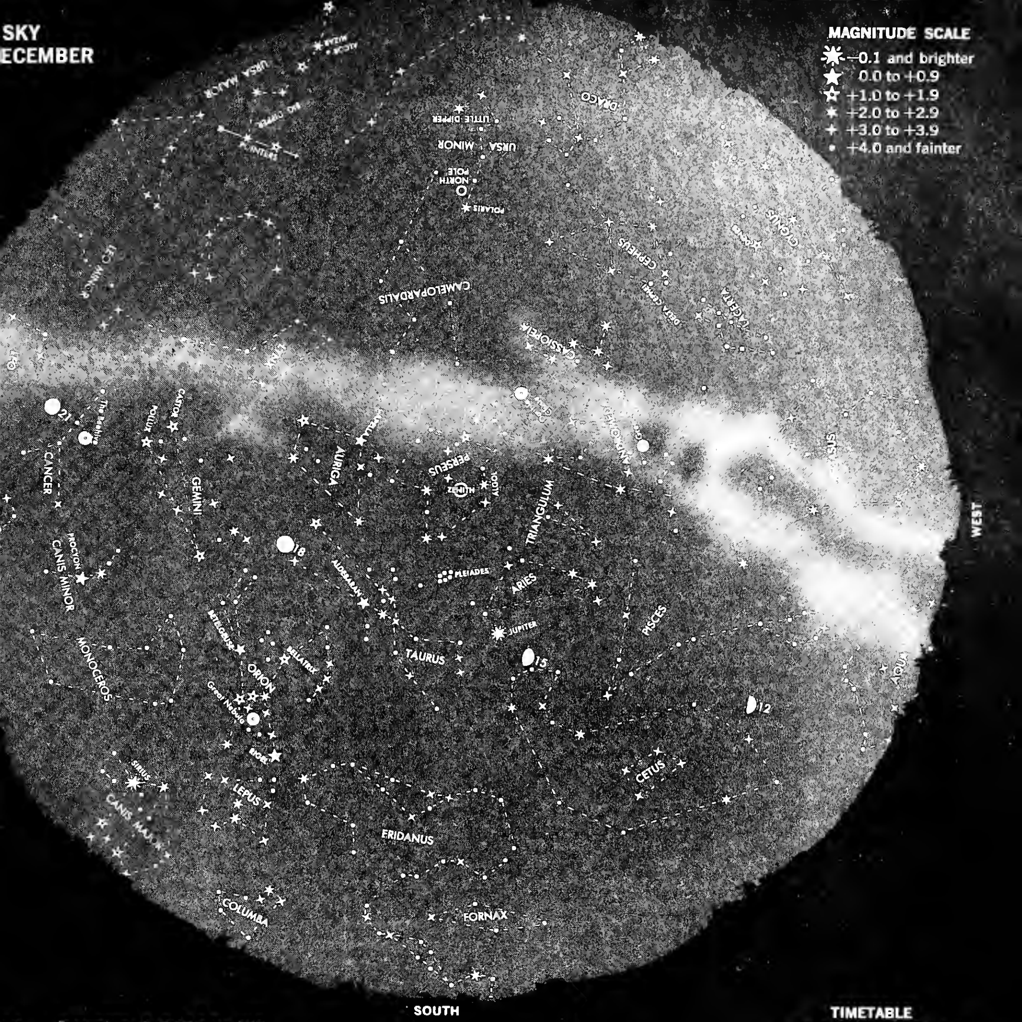
Dr. Nicholson, the regular author of this column, is als Chairman of **The American Museum-Hayden Planetarium**

SKY
ECEMBER



oon	December 3, 8:18 P.M., EST
uarter	December 12, 1:01 A.M., EST
on	December 18, 9:41 P.M., EST
arter	December 25, 2:27 P.M., EST

TIMETABLE

December 1 11:00 P.M.
December 15 10:00 P.M.
December 31 9:00 P.M.
(Local Mean Time)

ember 3: A partial eclipse of the sun occurs over the rn Pacific Ocean. It will be visible from Hawaii and estern Alaska just before sunset.

ember 5: Mercury may be seen close to the two-day-scent moon just after sunset in the southwestern sky. y (magnitude +0.1) is slightly south (below and to the the moon.

ember 5: Mars and Uranus are in conjunction at 3:00 ST. Mars is a reddish object (magnitude +1.0) in Leo, y between Regulus and Denebola, toward the southeast midnight. Uranus is a 6th-magnitude object located 1½ degrees south of Mars.

ember 10: Saturn and the nearly first-quarter moon are unction at 7:00 A.M., EST. Saturn is to the east (left) moon in the evening sky of the 9th; to the west (right) moon on the evening of the 10th.

ember 11-15: Meteors from the Geminid shower radiate he proximity of Castor, in Gemini. The moon will not re with observations after midnight. Expected hourly ear maximum on the 13th, is about 50.

December 16: Jupiter is in conjunction with the moon at 4:00 A.M., EST. On the evening of the 15th, Jupiter is east (left) of the nearly full moon.

December 18: A total lunar eclipse is visible throughout North America. The moon enters the umbra (dark shadow of earth) at 7:59 P.M., EST; total eclipse begins at 9:07 P.M., EST; total eclipse ends at 10:07 P.M., EST; and the moon leaves the umbra at 11:15 P.M., EST. For times in other parts of the United States, subtract one hour for each time zone west of Eastern Standard Time.

December 21: The sun arrives at the winter solstice at 2:50 P.M., EST. Winter then commences in the Northern Hemisphere; summer in the Southern Hemisphere.

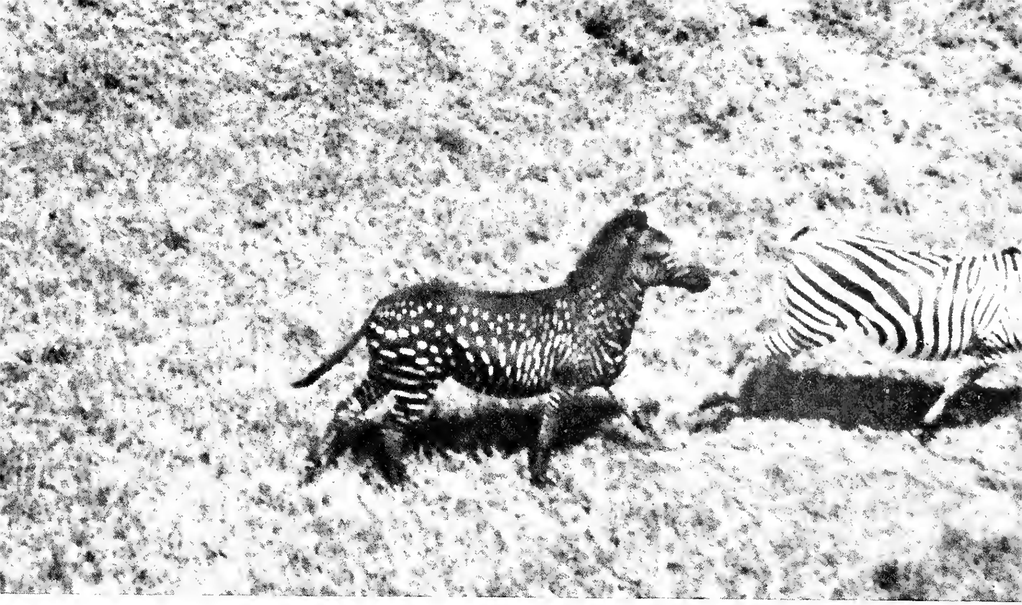
December 31: Venus, rapidly disappearing from the morning sky, may be seen very close to the thin crescent moon, low in the southeastern sky about dawn.

Venus, Mercury, and Mars are morning stars this month, but only Mars is well placed for observing. It rises before midnight and is in the southwest about dawn. Jupiter and Saturn are both easily seen as evening stars all month long.

Anomalies in Africa

Photographs by L. D. VESEY-FITZGERALD

The Rukwa Valley, in southwestern Tanganyika, is one of the world's greatest natural animal reserves, although it is not officially designated as a national park. Some four hundred species of birds have been identified, in addition to the thousands of mammals that roam the area. But among them all, the most extraordinary animals may be the two seen in these aerial photographs, taken from a plane flown by an International Red Locust Control pilot. There have been reports of albino giraffe over the years, but this record of a spotted zebra may be a first. Since these pictures were taken, a game officer reported the zebra had foaled, and the colt, too, was spotted.



Spotted zebra runs with the normally marked members of the herd. Color variation in single animals is not too unusual; recurrence in the offspring is rather striking.

Sightings of albino giraffes have taken place in many parts of East Africa, but so far this Rukwa specimen, like spotted zebra, has been viewed solely from a plane.

About the Authors

Dr. Richard J. Hartesveldt, author of "Fire Ecology of the Giant Sequoias," is Associate Professor of Conservation at San Jose State College in San Jose, California. He attended Grand Rapids Junior College and received his bachelor's degree, master's degree, and doctorate in conservation from the University of Michigan. Dr. Hartesveldt has worked for the National Park Service as a ranger in Hawaii National Park, as a naturalist in Yosemite National Park, Death Valley National Monument, and Devils Postpile National Monument, and as a research scientist in Sequoia and Kings Canyon National Parks. He began teaching at San Jose State in 1953.

"Anatomy of Decay as Preserved in Shale," the article on fossil nematodes, was written by Dr. Leif Størmer of the Department of Paleontology-Stratigraphy at the Institute of Geology, University of Oslo, Norway. Dr. Størmer received his doctorate from that University, and since 1945 he has been Curator of the University's Paleontological Museum and Professor of Historical Geology. His special fields of research are fossil trilobites, mesotomes, arachnids, and Ordovician stratigraphy. He is president of the International Commission on Stratigraphy.

Dr. Wilhelmina Jashemski, author of the article on Pompeii, is Associate Professor of Ancient History at the University of Maryland. She is author of *The Origins and History of the Proconsular and the Propraetorian Imperium to 27 B.C.*, and is currently engaged in research for a book on the gardens of Pompeii and Herculaneum. Her studies have been supported by grants from the General Research Board of the University of Maryland and the American Philosophical Society, and were carried on in Pompeii with the help of Professor Alfonso De Franciscis, Superintendent of the Antiquities of Campania. Dr. Jashemski received her Ph.D. from the University of Chicago.

"Introduced Menace," concerning the gray squirrel, was written by Monica Shorten, who lives and works in England. She was an Oxford honors graduate in zoology, did five years of postgraduate research at the Bureau of Animal Population there, and then made further studies on the gray squirrel for the Ministry of Agriculture. Two visits to the eastern United States have enabled her to see the gray squirrel in its native environment. Miss Shorten is currently interested in virus diseases of squirrels, and acts as field assistant to her husband, Dr. A. D. Vizoso, who is with the Research Council's Virus Research Unit located at Carshalton, Surrey, England.

Listening under water

By William A. Watkins

KNOWLEDGE that there are myriad nds under water came with the of wartime listening for subma- Biologists have learned that most e sounds are made by creatures e in the water: porpoises, fishes, nd even shrimps. All of the sea was discovered, do not make but those that do appear to have ly different "voices." The sound rimp can readily be recognized at of a toadfish; whales "say" dif- things than do seals. In fact, made by one species of porpoise fish differ slightly from those of pecies. Thus it often becomes pos- distinguish one from another sim- istening to their underwater calls.

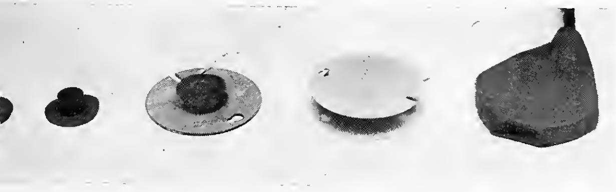
tists have been excitedly and con- ly discovering new animals or hat use underwater sounds, and nteresting experiments have been ed to try to discover what use the makes of these sounds. The click- ses of some porpoises, it has been are used for echolocation, and their squeals are for communi- The "boat-whistle" of the toadfish to be related to the establish- nd defense of its territory. The l quality of some fish sounds ap- y coincides with mating behavior. seem to snap noisily no matter ey are doing!

est in underwater sounds—by sci- and amateurs—has been increas- d with this interest has come a in the development of underwater g gear. For the most part, how- ich gear has been too expensive complicated for the general use ents and amateurs. In addition, few authors have discussed the ues of listening to underwater in a way that can prove to be to the interested amateur.

minimum listening system (for ater sound) is composed of a hone, an amplifier, and a set of earphones or a loud-speaker. The hydrophone picks up the water-borne sounds and translates them into electrical impulses. These are fed to an amplifier. The amplifier raises the level of these minute signals so that they may be converted to audible sounds by the earphones or by a loud-speaker. The hydrophone is the only distinctive component of a simple listening system. The type most generally used by scientists today is the piezoelectric hydrophone, utilizing crystals and ceramics as their active elements. They respond well to high frequencies and below their resonant frequency they give good uniform response. Hydrophones for amateur use have also been designed. The crystal unit from a microphone may be adapted to underwater listening by first immersing it in vegetable oil held in a suitable container (such as a plastic bag) so that good coupling to the water is achieved. For low-frequency listening a crystal hydrophone may be a disappointment, however, because with decreasing frequency its impedance rises, and consequently very high-impedance input circuits must be used in accompanying amplifiers.

The variable reluctance hydrophone fits most of the requirements of an ideal hydrophone for use by amateurs. The principle is that of inducing a changing electrical current-flow in a coil of wire by varying the reluctance of the magnetic circuit that intersects this coil. It utilizes a fixed magnet and a fixed coil with a separate moving ferrous diaphragm or plate within the magnetic field, and it has been used in many types of vibration pickups (magnetic phonograph cartridges, velocity-ribbon microphones, guitar pickups, etc.). Five factors make this a particularly good piece of amateur equipment:

1. Sensitivity—easily available amplifiers may be used for listening, i.e., ordinary phonograph or tape recorder amplifiers.



for assembling hydrophone shows, ft: fish paper flange, flange with magnet added, coiling of wire, iron plates attached, and the whole incased in balloon.

2. Good low-frequency response—most amateurs are interested in marine life sounds and these are nearly all relatively low in frequency, that is, below 500 c.p.s.
3. Easy construction—there is no need for special tools or close tolerances.
4. Simple parts—the bits and pieces are those than can easily be obtained. perhaps even from hobby or junk boxes.
5. Cost—the total cost of parts is less than one dollar.

Principle of Low Impedance

A permanent magnet with a coil of insulated wire wound on it is placed between two iron plates (diaphragms). Magnetic attraction holds these in place and the entire unit is slipped into a rubber balloon. A two-conductor cable leads out of the neck of the balloon, and plastic tape provides a watertight seal.

Sound waves traveling through the water strike the iron plates and move them a tiny amount. This motion, although very small, is sufficient to change the position of the plates relative to the magnet, and therefore to change the reluctance of the magnetic circuit. This varies the flux lines that cut the turns in the coil. A potential that changes with the sound variations is thus generated across the coil and may be fed to any appropriate amplifier.

This is a low-impedance hydrophone and requires a low-impedance input to the amplifier—a 50-ohms microphone input is best. A 50-ohms to 100,000-ohms transformer will adequately match the hydrophone to most of the high-impedance amplifiers.

A low-impedance hydrophone has advantages in underwater listening in that the cable does not pick up electrical interference and power line hum; also, minor motion of either the cable or the hydrophone is not transmitted as noise. This means that long hydrophone cables become practical, and it is unnecessary to use elaborate suspension systems to avoid the effects of shock and motion on the hydrophone and its cable.

The sensitivity of the hydrophone, using a given magnet, depends both on the size of the plates and the number of turns in the coil. The amplification necessary (which depends on the unit's sensitivity) will probably range from 40 to 65 decibels. The amplifiers of most tape recorders and phonographs should be adequate.

The output from this hydrophone will be greatest at 10 to 20 c.p.s.. and will fall off increasingly until at 500 c.p.s. its response is down 10 to 12 decibels. By using thin plates and by separating the magnet from the plates with a small air space, the high-frequency response may be increased to a maximum of about 5.000 c.p.s. (but only with the loss of over-all sensitivity).

Materials Needed

Magnet—short, round bar-type is preferable for more ease in winding and positioning;

Fish paper—or other durable, stiff sheeting that can be cut and folded to make coil flanges;

Cement—rubber is recommended, quick drying and contact setting;

Magnet wire—either No. 36 or No. 38, enameled;

Cable—two-wire, round insulation;

Iron plates—covers for electrical junction boxes used in house wiring, or tops from tin cans;

Balloon—natural rubber, large enough to hold plates up to 4 inches in diamete and tough enough so that the nec opening can be stretched by th amount (and to keep water out wit normal use). The thick "Jumbo"-typ available at most 10-cent stores for dime will serve the purpose;

Plastic tape—Scotch No. 88 works bes but any good. waterproof, pressu sensitive tape will do.

Hydrophone Construction

Flanges of heavy paper should be c mented onto the magnet flush wit the pole faces. (The permanent magn usually found in a castoff loud-speake is the right type, and ranges in size fro ½" by ⅝" in a small speaker to ¾" b 1" in a larger one. Usually they are onl cemented in place, and can be remove easily with a sharp rap of a hammer. These flanges serve to hold the coil c wire in place around the magnet. The should be disks cut about one inch large in diameter than the diameter of th magnet. If the center of these disks i then cut with 4 or 5 crisscrossing inc sions, the tabs formed can be folded bac and the magnet pushed through the r sultant hole. The tabs may then be c mented onto the sides of the magnet. On flange should be cemented in place a each end of the magnet *(see photograp on page 57)*.

The coil, of enameled magnet wir may now be wound directly onto th magnet. No. 36 or No. 38 wire will b fine enough to put many turns in a sma space, yet is strong enough to be handle without breakage. The number of turn will vary according to the sensitivit needed, and may be anywhere fro 1,000 to 5,000 turns. A coil ¼" by ½" i cross section made of No. 36 wire wi about 3,000 turns. So many turns be wound more conveniently by a vinder or lathe or drill. If this od is used, a spindle may tempor- be cemented (with rubber cement) e magnet face so that it can be held :urned by one of these machines.

e cable from the hydrophone serves as signal conductor and handle. It .d be soldered to coil ends and then l and tied around the coil so that veight of the unit is supported by able and not by the coil wires. The should have two (No. 16 or No. wires between 15 and 25 feet long ed with round insulation. A water- seal can be made more easily with on a round cable. This cable need e shielded, since it is a low-imped- device; most noise pickup will oc- t the hydrophone, not in the cable.

e diaphragm plates 2 to 4 inches in eter can be made of any ferrous rial such as 3-inch electrical junc- box covers or even tin can tops. The must either be rounded off or ed with tape to avoid cutting the on. They should be allowed to be in (or nearly in) contact with the of the magnet. The magnetic at- on will normally be strong enough ep the plates firmly in place. For ivity, these plates should be as as the balloon will hold. A rigid, thick plate is more sensitive, but a thin diaphragm will respond better to higher frequencies. The high-frequency response may also be helped (at the expense of sensitivity) by keeping a small (1/64 inch or less) air gap between the faces of the magnet and the plates. (In air the device will appear to be much more sensitive with a thin diaphragm held a little away from the end of the magnet, but for underwater sound reception a rigid diaphragm in contact with the magnet is most sensitive.)

A good grade of natural rubber balloon makes an easy waterproof housing for the hydrophone. It is thin enough to allow close contact between the water and the surface of the plates, which results in good acoustic coupling. It also permits a certain amount of pressure equalization—maintenance of a pressure inside the unit that is equal to the outside pressure. This prevents physical distortion of the hydrophone components as its depth is varied. The balloon pushes up between the plates and confines the bubble of air to a smaller and smaller space with depth.

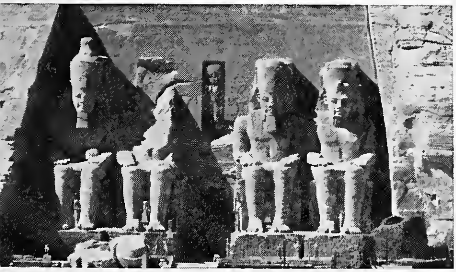
Insertion of the unit into the balloon can most easily be accomplished by first stretching the neck of the balloon with a finger of each hand. The two plates may then be slipped in first and the coil assembly can be put between the plates. The coil and magnet should be placed toward the bottom of the plates (as it is held by the cable) so that the pressure differential, as the hydrophone is introduced into the water, will not squeeze the plates together and partially pull them away from the magnet faces.

Exhaust enough air from the balloon to prevent it from floating and seal the neck to the cable with plastic tape. Starting at the base of the balloon neck, wrap the tape tightly around the neck and then up three or four inches beyond the end of the balloon (to keep water from seeping between tape and cable).

Unless the listening system is entirely battery-powered, careful grounding of the amplifier to the water will be necessary to reduce power line noise. A bare wire fastened to the amplifier case and trailing a few inches under the water will probably be adequate.

The variable-reluctance hydrophone is a departure from the traditional types, but because of its simplicity, frequency range, and ease of construction it lends itself to a variety of projects in recording, listening, and learning about a great many water-borne biological sounds.

Mr. Watkins, Research Associate at Woods Hole Oceanographic Institution, is currently in Antarctica, where he is studying calls of the Weddell seal.



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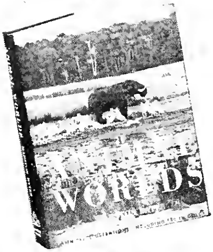

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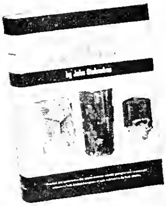

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Washington newsletter

By Paul Mason Tilden

HE 88th Congress, widely heralded
in some circles as the "conservation
ngress," passed into American history
ing the early days of October. Slo-
ns, of course, seldom tell whole truths;
s the sobriquet allows a minimum of
dit to previous Congresses that had
ested weeks and months of arduous
committee and full-committee spade-
k in the foundations of the conserva-
n legislation eventually passed by the
h. The above is not written in deroga-
n of the accomplishments of the 88th
ngress, which did, in truth, pass a
nber of measures of intense interest
he conservation world. It would seem
ropriate at this time to canvass sev-
l of the most important. In doing this,
attempt will be made to link prece-
ce with importance.

The Wilderness Act

ROBABLY there are few readers of
NATURAL HISTORY who are not aware
he passage, late in the second session
he 88th Congress, of a Wilderness
, which, with the signature of the
sident in early September, became
Wilderness Act of 1964. Formally
wn as Public Law 88-577, the act sets
a National Wilderness Preservation
em under which statutory protection
fforded qualified lands of the Forest
vice, Park Service, and Fish and
dlife Service; that is, lands in the
onal forests, national parks and mon-
nts, and national wildlife refuges
game ranges. The act itself defines
erness in rather graceful language:
wilderness, in contrast to those areas
re man and his own works dominate
andscape, is hereby recognized as an
where the earth and its community
ife are untrammeled by man, and
re man himself is a visitor who does
remain."

requirement that a wilderness area,
the purposes of the act, contain at
5,000 acres of land unimpaired by
nanent roads or other of man's works
qualified at the last moment before
age by addition of the words "or is
ufficient size as to make practical
reservation. . . ." This language was
rted so that worthy areas—roadless
ds of less than 5,000 acres, for ex-
le—might qualify for inclusion in the
erness system.

ne mechanisms for establishing wil-
esses on lands administered by the
artment of Agriculture (Forest Serv-
ands) and those under jurisdiction
of the Interior Department (parks, monuments, wildlife refuges, and game ranges) differed somewhat. All national forest tracts presently classified as wilderness, wild, or canoe (the Boundary Waters Canoe Area in northern Minnesota's Superior National Forest is presently the only unit in the third category) were incorporated into the wilderness system on passage of the act. All Forest Service areas presently classified as "primitive" will be reviewed by the Secretary of Agriculture within ten years for their suitability as a wilderness area; it is safe to assume that these reviews actually will be the responsibility of the Chief of the Forest Service, rather than of the Secretary. It might be added here that the Forest Service has, over the past few years, been making boundary adjustments and reclassifying primitive areas under a program of its own. The somewhat nebulous category of "primitive area" had been marked for elimination and reclassification as either "wilderness" or "wild." After review of the primitive areas—an operation that must be fully accomplished by 1974—the Secretary of Agriculture must make his recommendations to the President for or against wilderness classification. The President will then advise with Congress, and the Congress will pass or reject acts for each proposed wilderness.

With respect to lands administered by the Department of the Interior, the Wilderness Act calls for the Interior Secretary to review park and monument lands, wildlife refuges, and game ranges within ten years; in practice, this will mean that the Directors of the National Park and the Fish and Wildlife Services will do the basic studies. Each roadless area of more than 5,000 acres in the parks and monuments, and each similar area (plus roadless islands of any size) in the refuges and game ranges will be scrutinized for wilderness criteria; as with Forest Service lands, final classification will depend on acts of Congress.

Conservationists were well pleased with the Wilderness Act insofar as it touched on Forest Service lands; it afforded statutory protection to wilderness areas already existing, the size of which hitherto could be adjusted by mere departmental decision. Indeed, prior to passage of the act, wilderness areas of national forests theoretically could be wholly declassified to ordinary, multiple-use national forestland by executive decision. In regard to the effect of the act

on lands in the national parks and monuments, however, there were those in the preservation facet of conservation who were not unreservedly enthusiastic.

The great national parks and monuments, as all units of the park system, are administered under the National Parks Act of 1916, which provides, as far as possible, for the continuance of existing wilderness qualities. If the parks and monuments were "zoned," so to speak, on the basis of wilderness tracts of 5,000 acres or more, would they not be opened to pressures for development of sections that were not legally wilderness? Preservationist apprehensions were not lessened by the Park Service's immediately announced plans for just such zoning in two of the great national parks—Yellowstone, in Wyoming, and Great Smoky Mountains, in North Carolina and Tennessee. Further, some preservationists felt that mandatory new legislation for each of the great parks and monuments might bring to life the many predatory interests that are ever on the alert for cracks in the protective armor of the wilderness parks.

A New Conservation Fund

One of the recommendations submitted to the President by the Outdoor Recreation Resources Review Commission in January, 1962, called for prompt establishment of a federal program of grants-in-aid to the states, on a matching basis, "to stimulate recreation planning and to assist in acquiring lands and developing facilities for public outdoor recreation." Less than three years later the suggestion had been translated by the Congress into one of the basic purposes of the significant Land and Water Conservation Fund Act of 1965. The other purposes of the act are to provide money for federal acquisition of inholdings, or parcels, of private land lying within the boundaries of national park and forest system lands, and to acquire land and water refuges for threatened species of native animals.

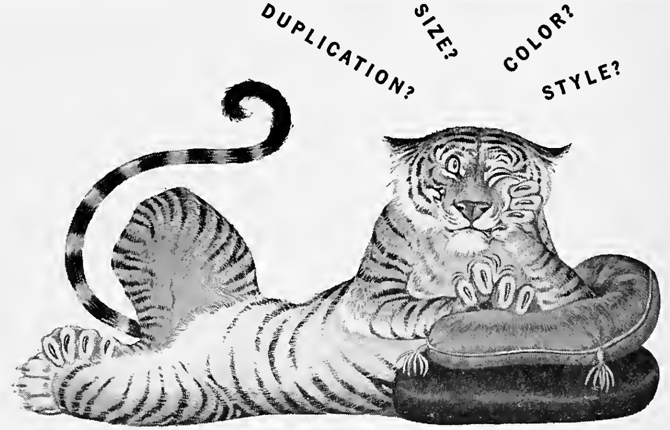
The fund, which most conservationists believe will lead to greatly expanded state and federal outdoor recreation and preservation programs, will be financed by money from three sources. First, the act provides for a system of admission and user fees in the national parks, forests, wildlife refuges, land management areas, and other federal property administered primarily for outdoor recreational, historical, or scientific purposes. Then, the fund will receive proceeds from sale of the surplus federal real and personal property. Finally, money will be derived from the existing tax on motorboat—and other special—fuels. Since the fund will commence operations in a relatively fundless condition, the statute provides for advances from the U.S. Treasury of not more than

)00,000 yearly for eight years, the nces to be repaid to the Treasury ɔut interest after the fund has been ɔeration ten years. As recommended '62, 60 per cent of the fund's annual opriations will be available to the s as grants-in-aid, to be matched equal amounts by the states. Forty :ent will go to federal agencies for and water purchases.

New Preservations

EN before passage, the land and water fund bill had an effect on : pending conservation legislation. oon as passage seemed reasonably :in, Congress took a more generous ıde toward addition of two new s to the national park system—the k National Scenic Riverways and ce Age National Scientific Reserve ce acquisition costs could be de- ed from future state shares of con- tion fund revenues.

e Ozark National Scenic Riverways, ,000-acre preserve stretching some niles along both banks of the Cur- and Jacks Fork rivers in south- al Missouri, was authorized by Con- in late August. Through agreement Missouri, the riverways could also de four state parks: Montauk, d Spring, and Big Spring on the ent, and Alley Spring on the Jacks ; were all four parks added by state tion, the area would be increased by 22,000 acres. Before passage of nabling act, some congressmen ex- ed doubts about committing the nal Park Service to the protection administration of a strip of land niles long and in many places little than a mile wide. This was an issue some conservationists had pondered, Congress also wondered about the ant proliferation of park system ories. In any event, a brand-new ory of preservation had been cre- to save portions of the two rivers in free-flowing condition, and most ervationists felt that the beautiful s and their valleys, which support nusually rich assortment of plants animals and exhibit many interest- eological features, were worth sav- or public enjoyment and education. t long after Congress had ques- d the wisdom of adding more cate- s of lands to the park system, it rized yet another—an Ice Age Na- l Scientific Reserve in Wisconsin— lp preserve and interpret for the ic some of the best of that state's anding relics of continental glacia- Scattered over the northern third e nation there are many superb nples of glacial sculpture and ice- ed topographic features, but prob- nowhere are so many of these ped together in such a relatively l and accessible area as in the au-



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reticle intensity. Reticle also has vertical and ho
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-ized Wisconsin preserve. Within
: or perhaps five nucleus areas al-
ly partly in state ownership, the
lic will be able to see and study such
nomena as drumlins, kames, kettle
aines, eskers, glacial bogs and ponds,
lder trains, and the high-and-dry
nds of former Glacial Lake Wiscon-
Most of these features are scattered
ıg the terminal moraine and the
en Bay–Lake Michigan interlobate
aine of the most recent, or Wiscon-
ice sheet. The act creating the re-
e authorizes additions to the state
sts and parks that contain the relics,
vell as acquisition of several other
s now in private ownership. The leg-
ion also provides a $50,000 federal
ropriation for a comprehensive plan
the reserve, but land acquisition
ey (some $750,000) will be deducted
ı Wisconsin's future share of land
water conservation fund revenues.

Pacific Botanical Garden

TH scientists and conservationists
were pleased by passage during the
mer of 1964 of an act providing con-
sional charter for a Pacific Tropical
nical Garden—perhaps more than
eventually. Business of the garden
be conducted by a corporation ini-
y consisting of five prominent con-
tionists: Henry F. duPont, Deane
lo Malott, Horace M. Albright,
ert Allerton, and Paul B. Sears.
le the enabling act mentioned no
ific site for the botanical garden or
ens, it is known that the first will
cated on the island of Oahu in the
of Hawaii. Prime purposes of the
en, which, it is believed, will be
ly if not wholly financed by private
tion, are: basic research into
cal botany; dissemination of the
ired knowledge; preservation of
tened species of tropical plant life;
more generally, the education, in-
tion, and recreation of Americans.

Fire Island

ME ten years ago the National Park
Service identified and studied those
ining strips of shoreline on the na-
; East and Gulf coasts which, from
tandpoint of scenic, scientific, and
ational values, might qualify as
nal seashores. From this study came
ort: of the 3,700-odd miles of gen-
shoreline stretching from Maine to
s, there appeared to be but 54 such
ents. (Two of these have become
nal seashores since the survey—
Cod, in Massachusetts, and Padre
d, in Texas.) Fire Island, off the
coast of New York's Long Island,
ne of the remaining 52. The prosaic,
raphed pages of the report noted
Fire Island, relatively unspoiled and
ly roadless, was "of extreme im-
nce because of its natural features

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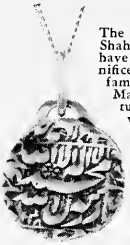

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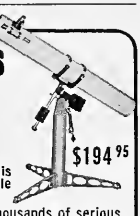

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MR. TILDEN, a writer and editor in the nation's capital, often contributes columns pertaining to government activities and the natural sciences.

and its close proximity to large centers of population." However, said the report, Fire Island "would be very difficult and expensive to acquire." But as it has turned out, Fire Island was acquired by the Park Service during the second session of the 88th Congress, and its acquisition will long stand as a monument to the persistence of the island's inhabitants and to the numerous scientists and conservationists who stood shoulder-to-shoulder with them. Ironically, Fire Island's salvation as a seashore came about largely through a threat that would have meant total obliteration.

For a number of years after the Park Service's study report had been in print, the Fire Island Seashore idea generally had lain dormant. Then, in 1962, it was proposed that a four-lane "ocean boulevard" be run the length of the island, with a right-of-way of some 300 feet. (Over long stretches the barrier beach that constitutes the island is no more than 500 to 700 feet wide.) According to its proponents, the superhighway would have made the island more accessible. That threat was enough to stir up the island's inhabitants and many conservationists and scientists. The scenic shore environment and the rather extraordinary flora and fauna of Fire Island were too precious to be immersed in concrete. Largely through the efforts of this group, Congress authorized the 4,300-acre Fire Island National Seashore, to be set up under the provisions of Public Law 88-587. The authorization came on September 11, 1964—a little more than two years after the highway proposal. Two of the stipulations of the new law are that the seashore should be administered by the National Park Service "with the primary aim of conserving the natural resources located there," and that it should remain roadless. Despite the Service's gloomy prediction of earlier days, Congress appropriated $16,000,000 for acquisition of seashore lands.

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12-19—Richard J. Hartesveldt except 14-15—bottom, AMNH after Hartesveldt, 16—left, Shirley Fischer
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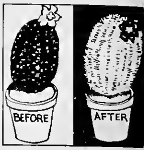

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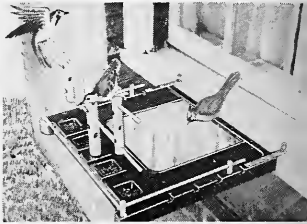

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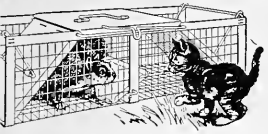

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FIRE ECOLOGY OF THE GIANT SEQUOIAS

THE REDWOODS OF COAST AND SIERRA. J. C. Shirley. University of California Press, Berkeley, 1937.

THE GIANTS OF SEQUOIA AND KINGS CANYON. H. R. Stagner. The Sequoia Natural History Association, Three Rivers, Calif., 1952.

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INTRODUCED MENACE

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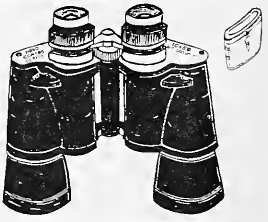

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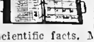

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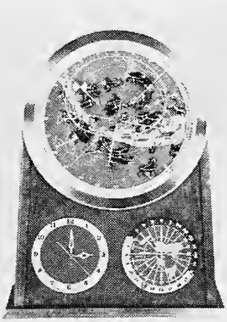

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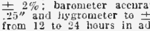

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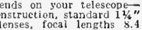

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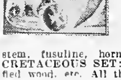

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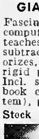

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Fascinating new see-through model computer actually solves problems, teaches computer fundamentals. Adds, subtracts, multiplies, shifts, complements, carries, memorizes, counts, compares, sequences. Attractively colored, rigid plastic parts easily assembled, 12" x 3½" x 4¾". Incl. step-by-step assembly diagrams, 32-page instruction book covering operation, computer language (binary system), programming, problems and 15 experiments.

Stock No. 70,683-E .... **$5.00 Ppd.**

SHIMMERING RAINBOWS OF GEM-LIKE COLOR DAZZLING DIFFRACTION JEWELRY FOR MEN AND WOMEN NOW AVAILABLE IN GOLD

This science-inspired jewelry glows with the twinkling magic of rainbows. It uses circular patterns of 1" DIFFRACTION GRATING REPLICA to break up light into all the rich, deep colors of nature's grandest phenomenon. Incorporated into beautiful jewelry, these exquisite new fashion accessories are now available in lustrous gold as well as silver. Other items available. Write for complete list.

ITEM	GOLD	SILVER	Price Postpaid
EARRINGS	No. 1814-E	No. 1704-E	$2.20
CUFF LINKS	1827-E	1714-E	2.20
PENDANT	1818-E	1729-E	2.20
¾" Tie Clasp & Cuff Link Set	1831-E	1743-E	3.85
BRACELET (Six ¾" gratings)	1816-E	1735-E	7.70

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EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY

or CHRISTMAS GIFTS!

SCIENCE TREASURE CHESTS

Science Treasure Chest—extra powerful magnets, polarizing filters, compass, one-way mirror film, prisms, diffraction grating, and lots of other items for hundreds of thrilling experiments, plus a Ten Lens Kit for making telescopes, microscopes, etc. Full instructions.

No. 70,342-E .... **$5.00 Pstpd.**

e Treasure Chest Deluxe—Everything in Chest above xciting additional items for more advanced experi- including crystal-growing kit, electric motor, mo- set, first-surface mirrors, and lots more.

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NEW! STATIC ELECTRICITY GENERATOR

Sturdy, Improved Model

See a thrilling spark display as you set off a miniature bolt of lightning. Sturdily made—stands 14″ high. Two 9″ plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping 24 page illustrated booklet included.

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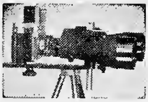
NEW BINOCULAR-TO-CAMERA HOLDER

Will Fit Any Camera



:xciting Telephoto Pic- Bring distant objects es nearer with a 35mm 1. 7x50 binocular and EW BINOCULAR TO- :RA HOLDEB. Ideal for ange shots of wild life, people, vistas. Camera inoculars attach easily. ny binocular or monocu- ny camera, still or movie. Take color or black and Attractive gray crinkle and bright chrome finish ong. Full directions for taking telephotos included.

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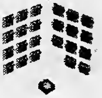
Dust-Free! Transparent! Low Cost!

COLLECTORS DISPLAY CASE



-fitting, crystal clear, edge-to- overs enable you to see all con- . . . rocks and minerals, fish science knick-knacks, gems, s, etc. Covers securely hinged, en with twist of fingers. Large arent display box (5″x7″x1¾″) to approx. 10¼″x7″. Mounted lly or horizontally for perma- display, or closed and stored for future reference. flocked inserts cut to securely hold 24 individual bottomed boxes (each 1″x1″x¾″ deep).

No. 60,459-E—Display box with compartments inserts 24 specimen boxes .... **$2.75 Ppd.**
No. 60,456-E—Pkg. of 12 specimen boxes **$1.00 Ppd.**
No. 60,457-E—Display box (without rts) .... **$0.75 Ppd.**

Terrific Buy! American Made!

OPAQUE PROJECTOR

Projects illustrations up to 3″ x 3½″ and enlarges them to 35″ x 30″ if screen is 6½ ft. from projector; larger pictures if screen is further away. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and-white. Operates on 115 A.C. current. 6 ft. extension cord and plug included. tes on 60 watt bulb, not included. Size 12″ x 8″ x W. 1 lb., 2 oz. Plastic case with built-in handle.

No. 70,199-E .... **$7.95 Postpaid**

INATING NEW KALEIDOSCOPE INSERT. Same above, but provides endless additional projects with anging kaleidoscope patterns.

No. 70,714-E .... **$10.00 Ppd.**

BUILD A SOLAR ENERGY FURNACE

A fascinating new field. Build your own Solar Furnace for experimentation—many practical uses. Easy! Inexpensive! Use scrapwood! We furnish instructions. This sun powered furnace will generate terrific heat—2000° to 3000°. Fuses enamel to metal. Sets paper aflame in s. Use our Fresnel Lens—11″ Sq. F.L. 19″.

No. 70,533-E .... **$6.00 Postpaid**

7 x 50 MONOCULAR MAKES INEXPENSIVE, LIGHTWEIGHT TELEPHOTO SYSTEM FOR ANY CAMERA

Optimum in optical performance. Field of view at 1000 yards is 376 Relative light efficiency is 75. Exit pupil measures Has socket to attach to photographic tripod. Pre- Japanese made. Approx. 16-oz. Includes case, straps.

No. 70,639-E .... **$17.50 Postpaid**

.PHOTO ADAPTER

:yecup, accepts Series V adapter ring

No. 40,680-E .... **$1.50 Postpaid**

BE READY FOR THE MOON SHOTS

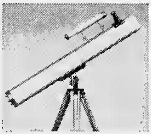
Ranger, Surveyor, Lunar Orbiter unmanned space probes will shed exciting new light on the mystery of the moon and outer space. See the results close-up. Edmund low-cost, top-quality equipment and accessories put you right there—provide valuable and complete information to keep you on target.

See the Stars, Moon, Planets Close Up!

3″ ASTRONOMICAL REFLECTING TELESCOPE

Photographers! Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon!

60 to 180 Power—Famous Mt Palomar Type! An Unusual Buy!



See the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Phases of Venus. Equatorial mount with lock on both axes. Aluminized and over-coated 3″ diameter high-speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens. Optical Finder Telescope included. Hardwood, portable tripod. FREE with Scope: Valuable STAR CHART plus 272-page "HANDBOOK OF HEAVENS" plus "HOW TO USE YOUR TELESCOPE" BOOK.

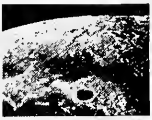
Stock No. 85,050-E .... **$29.95 Postpaid**

Intriguing Low-Cost Moon Model

Exciting outer space display and conversation piece. Exact replica, 30,000 formations—peaks, craters, Ocean of Storms, etc.—all in relief. Scaled to size. Accurate distance relationships. Proper lighting shows moon phase, "black light" produces startling effects. Tough, washable plastic. Three colors. Far side blank—can be used for space data. Excellent gift item. 12″ dia., wt. ¾ lb.

Stock No. 70,515-E .... **$12.50 Postpaid**

A SLIDE TRIP TO THE MOON—MOON TOPOGRAPHY STUDY AID



As the universe shrinks, interest in astronomy increases. This highly informative series of 29 black and white slides features such topography as the southwestern limb and Mare Imbrium—the "pearl" of the moon. Also, full moon taken with Mount Wilson 100-inch reflector and the crater Clavius through the 200-inch.

Stock No. 60,348-E .... **$5.00 ppd.**

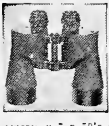
BIG DETAILED 35″ x 46″ MOON MAP

Black and white photo reproduction of full moon with all named lunar formations clearly marked. Complete index to locations and other valuable information.

Stock No. 9297-E .... **95¢ Ppd.**

WAR SURPLUS! American-Made!

7x50 BINOCULARS



Big saving! Brand new! Crystal clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx field at 1,000 yds is 376 ft. Carrying case included. American 7 x 50's normally cost $274 50. Our war surplus price saves you real money

Stock No. 1544-E .... **only $74.80 pstpd.**

7 x 35 AMERICAN MADE BINOCULARS

Stock No. 964-E .... **$60.50 pstpd.** (Tax incl.)

6 x 30 Binoculars—Similar to above and a terrific bargain.

Stock No. 963-E .... **$33.00 pstpd.** (Tax incl.)

WOODEN SOLID PUZZLES

12 Different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals and geometric forms to take apart and reassemble, give a chance for all the family, young or old, to test skill, patience and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now.

Stock No. 70,205-E .... **$3.00 Postpaid**

New! 2 in 1 Combination! Pocket-Size

50 POWER MICROSCOPE and 10 POWER TELESCOPE

Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range Handy for sports, looking at small objects.

Order Stock No. 30,059-E **$4.50 ppd**

CRYSTAL GROWING KIT

Do a Crystallography project illustrated with large beautiful crystals you grow yourself. Kit includes the book "Crystals and Crystal Growing" and a generous supply of the chemicals you need to grow large display crystals of potassium aluminum sulfate (clear), potassium sulfate (purple), potassium sodium tartrate (clear), nickel sulfate hexahydrate (blue green) or heptahydrate (green), potassium ferricyanide (red), and copper acetate (blue green).

Stock No. 70,336-E .... **$9.50 Postpaid**

BIRDWATCHERS SEE WITHOUT BEING SEEN

The "one-way" mirrors described above have always been fascinating, but their costs cuts down their usefulness. Now Edmund Scientific has duplicated in a sturdy plastic film at a fraction of their cost. Actually, as these films cut down light transmission 70% as compared to 50% or less for the mirrors, they are much more useful. For example: you can build a bird feeding station on the sunny side of your house next to a window. Fasten a piece of this film to the window and you'll be able to watch the birds from a few inches away.

Stock No. 70,326-E a sheet 21″ x 36″ .... **$3.00 Postpaid**

IDENTIFY 430 BIRDS WITH FULL COLOR AUDUBON BIRD CHARTS

Two 25″ x 38″ beautifully printed charts containing 48 separate color plates by naturalist-artist Don Eckelberry. Excerpted from the famous "Audubon Land Bird Guide." 430 small birds (over 200 species) of Eastern and Central N. America grouped by plumage for fast identification. Heavy coated stock especially suited for wall mounting or framing. Includes 24-pg. book containing color key and valuable training method.

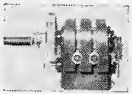
Stock No. 70,675-E (The Pair) .... **$3.50 Ppd.**

TINY LAMP GIVES SUN-LIKE BRILLIANCE FOR WORK, INSPECTION, EXAMINATION

New, low-cost, miniature, high-intensity lamp gives concentrated daylight. Uses low-cost 12-volt auto bulb (GE 1133) yet gives light equivalent to 150-watt bulb, full 33 candlepower. Excellent all-purpose lamp for bench inspection of parts and assemblies, soldering, or as microscope light. Used as examination lamp by physicians and dentists, as work lamp by jewelers, technicians, artists, etc. Also attractive in any office or room, on desk, at bedside. 12″ brass-finished gooseneck bends and holds to any position. No clamps or stands needed. Durable black metal trimmed in white. Base 4″ dia. x 2½″ high, has off-on switch, 5′ cord. Reflector 2¾″ dia. x 5½″ long, white enameled inner surface.

Stock No. 70,694-E .... **$7.98 Ppd.**

WAR SURPLUS ELECTRIC GENERATOR



Brand new Signal Corps Electric Generator for scientific experiments, electrical uses, demonstrations. Generates up to 90 volts by turning crank. Use in high impedance relays. Charge ground and bring up night crawlers for bait or study. 2 Alnico Magnets alone worth original price. Wt. 2 lbs. Cost to Govt. $15

Stock No. 50,225-E .... **$6.95 Postpaid**

Same type generator, mounted, with light, as electricity demonstrator

Stock No. 50,365-E .... **$11.95 Postpaid**

'FISH' WITH A WAR SURPLUS GIANT MAGNET

Bring Up Under-Water Treasures

Real fun! Profitable, too! Simply trail this powerful 5 lb. Magnet out the stern of your boat—retrieve outboard motors, fishing tackle, anchors, other metal valuables. Alnico V-Type Magnet has terrific lifting power—2000 Gauss rating—lifts over 150 lbs. on land—more under water. Many industrial uses, too; recover tools and parts from inaccessible spots, hold work in place, rid shop floors of metal fragments, pins, etc.

Stock No. 70,571-E 5-lb. Magnet .... **$12.50 Pstpd.**
Stock No. 70,570-E 3½-lb. Lifts 40 lb. .... **$ 8.75 Pstpd.**
Stock No. 70,572-E 7½-lb. Lifts 175 lb. .... **$18.75 Pstpd.**
Stock No. 85,152-E 15¾-lb. Magnet Lifts 350 lbs. .... **$33.60 FOB**

BLACK LIGHT MAGIC-GLOW KIT

With this Kit, you can collect fluorescent rocks, paint with living light, write secret messages, learn invisible detection methods, even make a fluorescent Christmas tree! Kit uses long-wave blacklight, which is completely harmless to eyes, but causes fluorescence in over 3,000 substances. Includes Magic Glow Lamp, universal laboratory lamp stand, invisible water paints and ink, fluorescent crayon, tracer powder, pen, 3 brushes, specimens of fluorescent rocks: wernerite from Canada, fluorite from England, willemite from U.S.A. Plus book of 40 experiments

Stock No. 70,256-E .... **$11.95 Postpaid**

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