nature and science

Volume 2, Numbers 1 - 18

1964 - 1965

nature and science

VOL. 2 NO. 1 / SEPTEMBER 21, 1964

What is happening to the lizards that have lived in the Galapagos Islands for thousands of years?

see page 3

THE CASE OF THE VANISHING IGUANAS

ABOUT THE COVER

In the 16th century, Spanish explorers discovered a group of rocky islands 600 miles off the western coast of South America. They found many unusual animals, including giant tortoises and lizards. Since the Spanish word for tortoise is *galapago,* the islands were named the Galapagos Islands.

The animal on our cover is a Land Iguana, one of three kinds of large lizards that have lived on the Galapagos for thousands of years. There are no other lizards quite like them anywhere else in the world.

No one knows just how these animals reached the Galapagos. One theory is that, long ago, some iguanas were swept from the South American mainland and carried west by the Humboldt Current to the Galapagos. These iguanas gradually changed through the years.

Today one species—the Marine Iguana—lives along the islands' shores and feeds on seaweed. The other iguanas live inland and feed on cactus and other plants. One kind of Land Iguana lives only on Barrington Island.

Recently, scientists have become concerned about the unusual animals of the Galapagos. Some species have died out and others seem to be vanishing. The story on page 3 describes how a scientist has tried to solve this problem.

nature and science

VOL. 2 NO. 1 / SEPTEMBER 21, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez

CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow

CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

CREDITS: Cover, pp. 2, 3, photos by Sam Dunton from the New York Zoological Society; p. 3, "The Case of the Vanishing Iguanas" adapted from *Animal Kingdom,* March-April 1964; p. 5, goats photo, The American Museum of Natural History, hawk photo by Dean Amadon; p.6, photo by Winston Pote from A. Devaney; p. 10, photo by George Cope, Educational Services Incorporated; p. 11, photo by Franklyn K. Lauden; pp. 4, 7, 8, 9, 10, 11, 12, 14, 15, 16, drawings by Graphic Arts Department, AMNH.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th St., New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

For thousands of years, giant lizards have lived on the Galapagos Islands. In the 1800's, they began dying out. Our problem was to solve...

The author examines a half-grown Land Iguana. He is trying to discover why these lizards are disappearing.

THE CASE OF THE VANISHING IGUANAS

by Herndon G. Dowling

■ Imagine a rugged, volcanic island rising out of the sea. It is covered with thorny bushes and cactus. Peering at you from the rocks are some lizards—four feet long, with scaly skins, spiny backs, and knobby heads.

This scene is not from the Age of Reptiles, millions of years ago. You can see it today in the Galapagos Islands, which are 600 miles off the west coast of South America *(see map)*. The lizards are called *iguanas*. These reptiles have fascinated explorers and scientists ever since the Galapagos were first visited by Europeans in 1535.

Although there are about 20 kinds, or *species*, of the large lizards called iguanas, none of the others is quite like the three species living in the Galapagos. One of these, the dark Marine Iguana, lives along the rocky shore and feeds on seaweed. It has a flattened tail for propelling itself through the water. The other two species, called Land Iguanas, live inland and eat cactus and other plants. They have stout, round tails and are usually a tan color.

In 1962, I led a party of scientists and spent two months in the Galapagos studying the unusual animals that live there. Each of us had our particular interest—I studied Marine Iguanas, another scientist studied the giant Galapagos tortoises, and so on. However, before long we all became interested in the Land Iguanas.

Dr. Dowling is Curator of Reptiles at the New York Zoological Park and a Research Associate at The American Museum of Natural History.

These animals have disappeared from Santiago and Baltra Islands, and have almost vanished from Santa Cruz Island. Why are they dying out? This was the problem that concerned us.

Man and the Iguanas

For many years humans have been blamed for the disappearance of the Land Iguanas. Sailing ships used to stop at the Galapagos to catch the iguanas for food. The tails of Land Iguanas are considered a delicacy.

During the 1700's, whalers also killed the Land Iguanas for food. So did the early colonists who settled on the islands. Thousands of iguanas were killed. However, as far as we can tell, humans have not wiped out a single iguana colony.

Santiago Island is a good example. Sailors hunted iguanas there for many years. Still, when Charles Darwin visited Santiago in 1835, he found a great many iguanas. There were so many that "... we could not for some time find a spot free from their burrows on which to pitch our single tent," he wrote in his diary. Yet, a few years later the iguanas of Santiago vanished completely. Why?

The Galapagos Island mailboat from Guayaquil, Ecuador left us at the settlement on Santa Cruz Island in early March, 1962. A few days later we set out to visit two islands where Land Iguanas were still plentiful. First we

(Continued on the next page)

headed for tiny South Plaza Island. We traveled in the fishing boat of Karl Angermeyer, a Galapagos resident for 25 years.

South Plaza is a few hundred yards off the coast of Santa Cruz Island. It is only about 600 yards long and 100 to 200 yards wide. As we explored the island, we found a small but thriving iguana population. Several adult lizards sprawled in the shade or basked on top of rocks. There were also many young iguanas. The young ones behaved differently from the adults. They hid in briar tangles or alongside fallen cactus stems. None of the adults seemed very large. I asked Karl about this.

"When my brothers and I first visited the island in the late 1930's," he said, "the iguanas were as big here as elsewhere. Then, as more and more fishermen came to the Galapagos and stopped for a meal of iguana tail, the large adults disappeared. But the number of lizards has stayed about the same."

The Mystery on Barrington Island

Next we visited Barrington Island, which is about five miles long and one or two miles wide. We went there on Miguel Castro's boat. He told us just where we could find the main iguana colony. Land Iguanas were supposed to be common there, as they were on South Plaza. This was true, but what a difference!

The Barrington iguanas were all large, old adults. We saw about 30 adult iguanas—but not a single young one. (In 1964, a University of California field party saw three young ones and about 40 adults.)

A population made up of adult animals alone cannot survive. I had a nagging thought about the Barrington Island iguanas. Could the same thing be happening here that led to the extinction of iguanas on Baltra Island? A United States military base was built on Baltra in 1941, and it was blamed for the iguanas' disappearance. But was this really the reason?

I began to re-read a book by William Beebe, a famous naturalist who was head of the Tropical Research Department of the New York Zoological Society. The book is called *Galapagos: World's End*. I had skimmed several pages when I came to a sentence that had lingered faintly in my memory. It described the Baltra Island iguana colony of 1923. Beebe wrote, "Throughout all of our explorations of this colony I saw not a single lizard under 24 inches and most were three feet and even more in length." Baltra, then, had a dying population of Land Iguanas in 1923— long *before* the military base was built.

Why did the iguanas thrive on South Plaza, while they died out on Baltra and were vanishing on Barrington? Here was a real puzzle—but we had a clue. We had noticed one striking difference between South Plaza and the other islands.

The only kinds of large animals living on South Plaza were the reptiles that have lived there for thousands of years. Animal life on several of the other islands is quite different. Through the years, donkeys, goats, cattle, pigs, dogs, cats, rats, and mice have been brought to these islands by man. All of these animals roam about freely. We suspected that one of these animals, or perhaps a combination of them, was making life impossible for the iguanas. But which one?

We began to check the reports of other expeditions that had explored the Galapagos. We looked for two things: 1) What animals had been released on the islands; and 2) What was the condition of the iguana population?

We found that one large island—Fernandina—still has large colonies of Land Iguanas; and no other animals have been brought to the island by man. In this way it is like tiny South Plaza, which also has a thriving colony of iguanas.

On all the other islands the iguana colonies were dying out, or had already vanished. *On all of these islands there were other animals.* There were so many, in fact, on Santiago and Santa Cruz, for example, that we could not begin to say which kinds were responsible for the dying iguana colonies. However, on Baltra there are only goats, rats, and perhaps house mice. On Barrington there are only goats.

Soon we noticed something peculiar about every island where iguanas have vanished or are dying out. *Goats live on all of them.* Another bit of evidence—the first goats released in the Galapagos were put on Santiago Island in 1813. Santiago was also the first island to lose its iguanas.

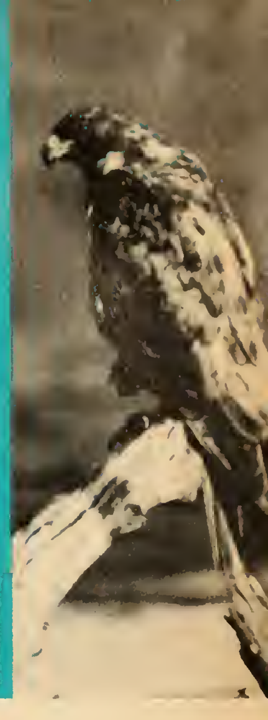
The Galapagos Islands are the remains of ancient volcanos, rising from the Pacific Ocean 600 miles from South America.

The Food Chain Puzzle

We were convinced that goats were the guilty animals, but we were puzzled about how they caused the death of young iguanas. We noticed that the goats on Santiago and Barrington Islands had eaten nearly all of the plants that they could reach. On Barrington the goats had cleared away all of the brushy undergrowth. They had also eaten so much of the larger trees, bushes, and cacti that the land looked trimmed and park-like.

Goats roam freely on many of the Galapagos Islands. They have eaten most of the brush where young iguanas hide.

With few hiding places, the young iguanas are easily caught by Galapagos Hawks.



However, the goats had not destroyed all of the cacti, which the iguanas eat. My first idea was that perhaps a combination of goats and rats were killing the iguanas. The rats ate the eggs of the iguanas when the rats' plant food became scarce. This might explain the situation on Santiago, which has both goats and rats. But there are only native rats on Barrington, and they eat only plants.

This was the stage of my thoughts when I had to leave the Galapagos in 1962. Back in New York, my thoughts kept returning to the islands. I tried to think of some Galapagos animals that might attack young iguanas, especially if the lizards had no brush to hide in.

There are three good-sized, meat-eating, or *predatory,* birds in the Galapagos—Lava Gulls, Short-eared Owls, and Galapagos Hawks. However, we had not heard of any reports of predatory birds feeding on young Land Iguanas. The young lizards are a foot or more long. They seemed to be too big for a bird to carry away.

How We "Solved" the Puzzle

I returned to the Galapagos in January 1964. Then something happened. It was like finding the last piece in a jigsaw puzzle.

Some scientists were camped on Fernandina Island, studying a colony of Marine Iguanas. One day, a Galapagos Hawk swooped down and sat on a rock among the iguanas. Then it dove into a crevice and flew off with a young iguana. The lizard was about 18 inches long! Later, when the scientists found the hawk's nest, they discovered the remains of several other young Marine Iguanas.

This was the first proof that the Galapagos Hawk ate lizards. Moreover, it meant that these hawks could catch and carry lizards of the size of young Land Iguanas. Hawks are common on Barrington Island, where the young iguanas have few places to hide. I am convinced that a combination of goats and hawks is the answer to the disappearance of Land Iguanas.

This idea, of course, is only a theory until it can be checked by an actual food study of the hawks on Barrington Island. I hope that a biologist from the newly established Charles Darwin Research Station on Santa Cruz will be able to make this study. Meanwhile, however, it is clear that the goat—the only "foreign" animal on Barrington—is somehow involved in the disappearance of the native iguanas of that island. If the goats can be wiped out, perhaps the plants will grow back in time to give the iguanas a second chance.

The New York Zoological Society is determined to give the iguanas—and all the other native plants and animals of the Galapagos—a second chance. It has already given funds to the Darwin Station for the salary of a Conservation Officer. Miguel Castro, our knowledgeable guide, has been hired for this job. Already he has reported the results of his first project. Two hundred and ten goats were killed on Barrington Island in a four-day hunt! Less than a hundred remain, and he hopes to rid the island of them soon. Then the plants can grow again. We hope the young iguanas will grow too.

Any new animal coming into a community of plants and animals that have lived together for a long period of time usually affects all of the plants and animals in some way. The situation on Barrington Island is the simplest case—a single animal was introduced into a small island community. Even so, it was difficult to discover just how the goats could cause the extinction of the iguanas. This is what makes *ecology,* the study of communities of plants and animals, one of the most difficult and one of the most fascinating of the fields of science ■

FLAMING AUTUMN LEAVES

Scientists can describe the changes that give leaves their brilliant colors in the fall and tell why the colors vary in different areas and years. How the changes take place is still a mystery.

■ What causes the brilliant colors of autumn leaves? Why do they appear only in the fall? And what makes the trees more colorful in some years than in others? After many years of study, plant scientists, or *botanists,* have found some of the answers to these questions. If you do certain things to leaves, you may be able to make them change color in your kitchen laboratory.

How Plants Get Their Color

Chemists have found that plants have different kinds of coloring matter, or *pigments*. You may already know the name of the pigment that makes plants green. It is called *chlorophyll* and is used by plants to make food.

Plants also have many other pigments. Some are yellow and give color to sunflowers, goldenrod, lemons, and ears of corn. Other pigments make up the orange and red colors of tomatoes, beets, certain roses, and carrots. Many of these pigments are in a group called *carotenoids*. They may be brown, yellow, orange, red, or even purple, depending on the chemicals in a plant's tissues and on the amount of pigment that builds up in a plant.

These bright pigments are also in green leaves. Along with chlorophyll, most carotenoids are located in tiny capsules that float in the sap of a leaf's cells *(see diagram)*.

However, because leaf pigments are mostly chlorophyll, the green hides the yellow and orange-red colors. All through the spring and summer, as chlorophyll is used up in making food, the tree keeps producing more of the green pigment. As long as the used chlorophyll is replaced, the leaves stay green.

But in the Fall...

Scientists are still not sure exactly why leaves begin to change color in the fall. They do know that the colors are caused by chemical changes in the leaf tissues. The aging of leaves causes some of these chemical changes. Others are caused by a lack of water in the soil, by the warm days and cool nights of autumn, and by the shorter fall days.

In most parts of the United States we take for granted the brilliant colors of autumn leaves. However, this yearly display of bright red, orange, and yellow leaves is seen only in a few parts of the world, as shown here. In areas such as western North America, the fall display is just yellow.

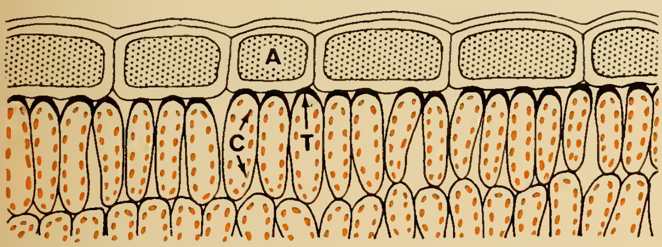
PROJECT

The amount of light a tree receives seems to have an effect on its fall colors. Look for a tree, such as a maple, that is close to a street light. How does the extra light that the tree receives affect its fall color?

As these seasonal changes take place, less and less chlorophyll is formed. It gradually disappears and the bright carotenoids become visible. The carotenoids themselves may become more plentiful and more kinds of these pigments may appear. When this happens, they turn darker, from yellow to orange and red. Brown pigments—called *tannins*—form as chlorophyll is used up. The tannins blend with the carotenoids in the leaf cells to give a brownish-orange color, as seen in oak leaves.

At the same time another group of pigments form. These pigments are called *anthocyanins*, and they give plants a variety of colors, from scarlet to purple and blue.

Unlike chlorophyll and the carotenoids, the anthocyanins are dissolved in the cell sap of certain leaf cells, like a drop of ink in water *(see diagram)*.



This microscopic view shows that anthocyanin pigments (A) form in the cell sap of the upper leaf cells. Chlorophyll and carotenoids (C) are in capsules within the inner cells. Tannins (T) form along the inner walls of the same cells.

Botanists are still trying to find out how anthocyanins are formed. However, these bright pigments seem to be most plentiful when sugars collect and stay in the leaves. (Usually these sugars, which are made in the leaves, flow from the leaves to the tree's trunk and roots.)

Have you ever seen leaves that have turned to fall colors in mid-summer? Scientists suspect that this happens when a leaf or branch has been injured by insects or disease. Sugars cannot flow from the leaves as usual, so they collect in the leaves. Then the anthocyanins form, changing the color of the leaves.

When Colors Are Best

With practice, you can identify different kinds of trees by their fall colors. Some kinds have no red pigments. For example, the leaves of sugar maple, beech, elm, sycamore, and poplar turn yellow when their chlorophyll fades. Also the brightness of fall colors varies from place to place and from year to year. Even individual trees may vary—one red maple may be brilliant while another is dull.

The brightest fall colors appear when plentiful anthocyanins are produced. This usually happens when a dry summer is followed by a clear, crisp autumn. Less anthocyanins are produced during warm, cloudy autumn weather.

As the leaves continue to age, more and more brown tannins are produced. About the same time, a corky layer of cells forms at the base of the leaves. Eventually, the leaves break off at this weak point. (Trees that shed all of their leaves in the autumn are called *deciduous* trees.)

With the coming of the frost the bright pigments fade quickly, for the leaf tissues are killed. Only the brown tannins are left. After the first few frosts, most of the leaves fall to the ground and winter is on the way ■

PROJECT

Here are some ways to preserve the brilliant colors of fall leaves. One is to dip the leaves in melted paraffin. (Paraffin should be heated on an electric heater—not over a flame.) Dip the leaves in and out quickly so that the coating of paraffin is thin. A thick layer of paraffin will dull the leaf colors.

Another way to keep colorful leaves from fading is to dry the leaves in warm sand. Put an even layer of clean, dry sand on the bottom of an aluminum cake pan. Then spread a leaf on the sand and cover it with another layer of sand. Set the pan over a 40-watt light bulb, keeping the bulb about six inches from the bottom of the pan. (The pan can be held up by juice cans or two stacks of bricks.) Keep the sand warm, but not hot, for about three days. The warmth helps dry the leaves, but the colorful pigments are preserved.

INVESTIGATION

Collect some twigs that hold several leaves from trees such as red and sugar maples, poplars, and oaks. Then try to make the leaves turn to their fall colors by setting the twig stems in glasses filled with different solutions. You might try salt and water, sugar and water, vinegar and water, and combinations of these. Place some of the twigs in the refrigerator each night. During the day, put them in sunlight, or place them about a foot from a strong (100-watt) light bulb. Be sure to put a twig or two in plain water. Then compare the results of your experiment with these "control" twigs.

So far, botanists know very little about how to make leaves change color. You may discover something new to science.

ROUND TRIP TO THE MOON

■ **For thousands of years men have obser the Moon, our nearest neighbor in space. T have worshipped it as a god, used it as a me of keeping time, and "explored" it in great de from their Earth-bound observatories.**

The most exciting step in Moon explorati however, will come when men land on its face. If all goes well, by 1970 two Ameri astronauts taking part in Project Apollo will

1. The Apollo spacecraft, carrying three astronauts, is launched from Cape Kennedy, Florida. The trip from the Earth to the Moon and back is expected to take about five days. In this period the Earth moves about nine million miles in its orbit around the Sun.

2. When the first stage of the Saturn V rocket has burned all its fuel, it drops off. The second stage engines then fire and put the third stage and the Apollo spacecraft into orbit around the Earth at a speed of about 18,000 miles an hour. When the second stage has burned out, it drops off.

3. At the proper time, the third-stage engine fires to start the spacecraft toward the Moon. This engine boosts Apollo's speed to about 25,000 miles an hour, fast enough for the craft to escape the Earth's gravitation.

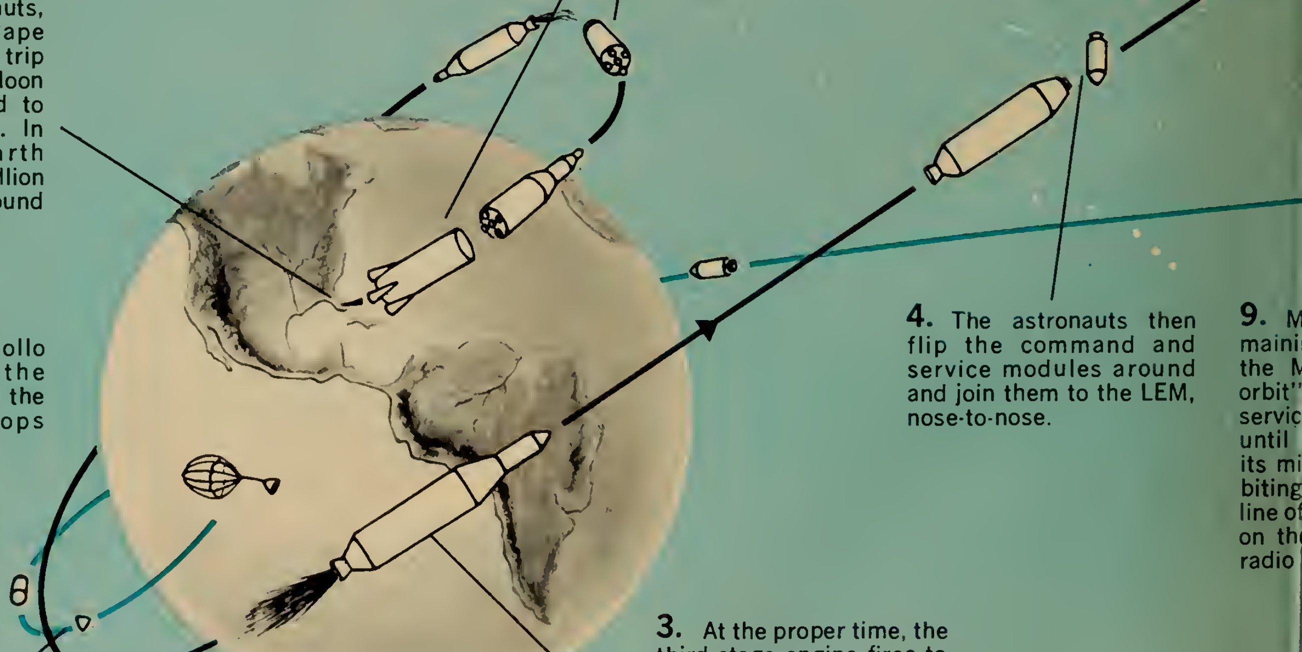
4. The astronauts then flip the command and service modules around and join them to the LEM, nose-to-nose.

5. The burned-out third stage drops away.

6. All three modules turn around so that the LEM faces forward. As Apollo approaches the Moon, small control rockets are fired to put the spacecraft into orbit.

9. M
maini
the M
orbit"
servic
until
its mi
biting
line of
on th
radio

10.
blast
join
servic



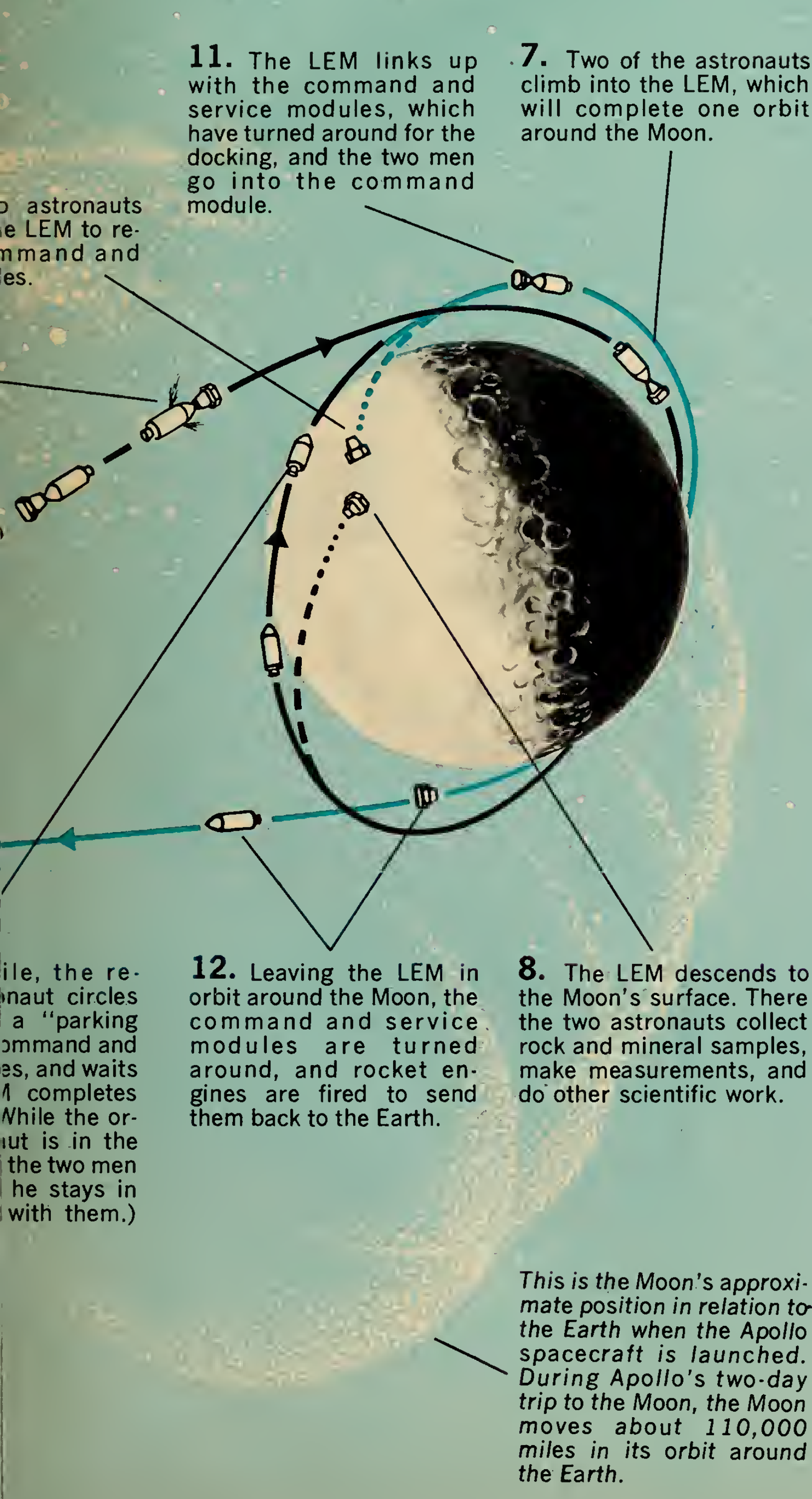
13. Before the Apollo spacecraft enters the Earth's atmosphere, the service module drops away.

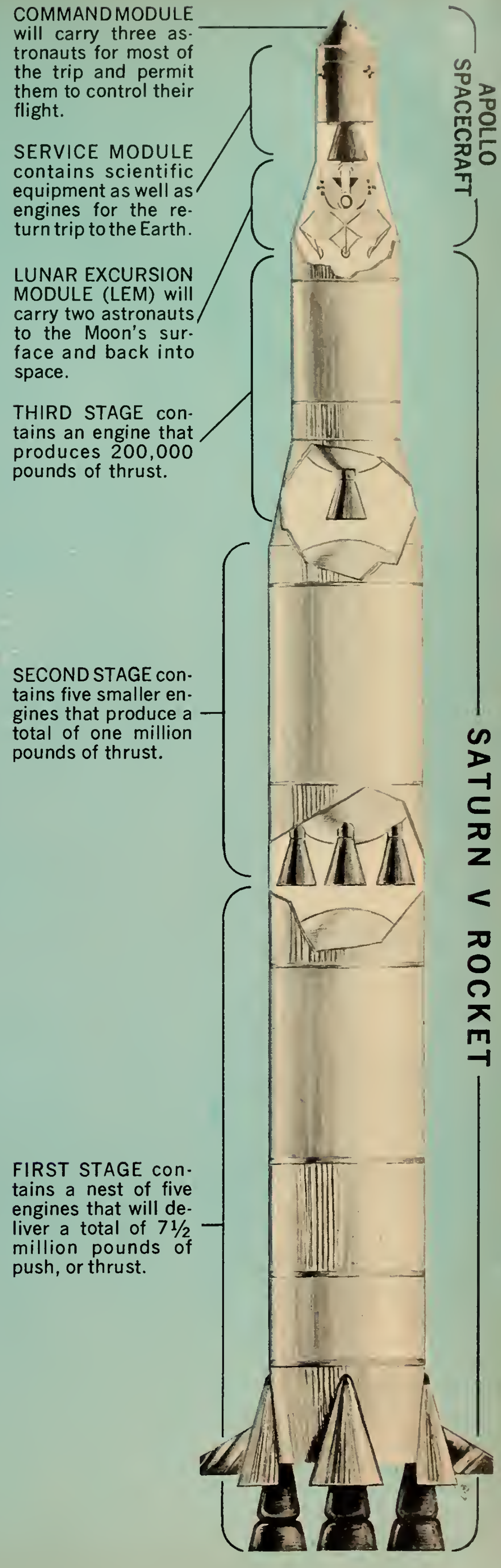
14. The command module, with the three astronauts inside, is slowed down by "braking" rockets. Then it enters the atmosphere and descends by parachute to the Earth.

foot on the Moon, 240,000 miles from the Earth.

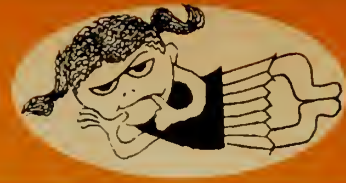
Three astronauts will leave the Earth in the three-part Apollo spacecraft, which will be launched into space by a three-stage Saturn V rocket (see diagram). The rocket and spacecraft together will stand 365 feet high on the launching pad.

This diagram shows the main steps of the trip from the Earth to the Moon and back ■





brain-boosters



prepared by
DAVID WEBSTER

MYSTERY PHOTO

WHAT BONE IS THIS?

■ Can You Do It?

Can you build a paper tower three feet high? Try it, using only one piece of paper 8½ x 11 inches. Cut the piece of paper any way you wish with a pair of scissors. You can't use tape, glue, staples, or anything else to hold it together.

■ What Do You Think Would Happen...

...If you stood on two bathroom scales at once? Would each one show your whole weight or only half of your weight? Or would the two scales be different? What weight would you get if you added both together? Try it. If you don't have two scales, borrow one from a friend.

■ Fun with Numbers and Shapes

Here is an addition Brain-Booster. What numbers go in the squares?

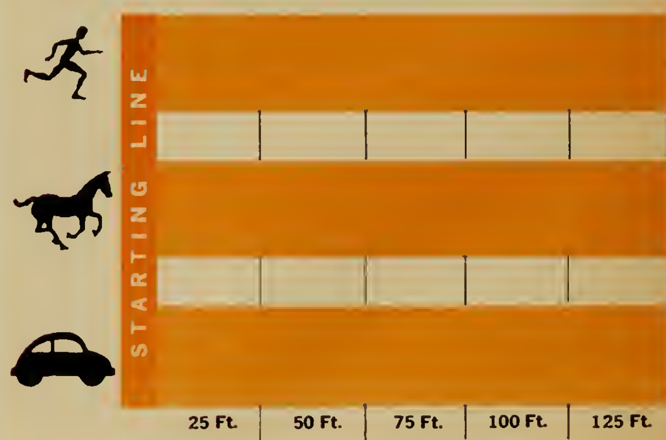
```
    1  ?
 +  ?  3
 -------
 1  ?  8
```

This is another one. The letters stand for numbers. "S" always stands for the same number. "E" also always stands for the same number, but a number different from "S." Can you fill in the seven numbers?

```
    S  A
 +  E  S
 -------
 S  K  E
```

■ For Science Experts Only

Who would win a 50 foot race: a man, a horse, or a car? Try to guess where each would be on this chart after 1 second; after 2 seconds; after 3 seconds.



Solutions to these Brain-Boosters will be printed in the next issue.

HOW HOT IS RED?

By making some heat boxes, you can also find out just how "cool" colors are.

■ In hot climates people usually wear clothes made of light-colored materials. In colder climates people wear darker clothing. Why? You may say because light colors are "cool" and dark colors are "warm." Yet, artists speak of green, blue, and violet as "cool" colors and yellow, orange, and red as "warm" colors.

Here is a way you can find out if the color of an object has anything to do with the amount of heat that it *absorbs,* or soaks up, from the Sun.

The best time to make this SCIENCE WORKSHOP investigation is on a cloudless, sunny day when there is hardly any wind. You will need two alcohol thermometers (the inexpensive kind you can buy in a variety store), some sticky tape, a piece of cardboard, and eight sheets of construction paper. The construction paper should include one piece each of red, orange, yellow, blue, green, violet, black, and white. If there is no white paper in the package, use a sheet of white writing paper about the same size and thickness as the construction paper. Keep these things indoors, or in the shade, until you begin the investigation.

First Make Some Heat Boxes

First, fold one sheet of the black paper in half and tape the two ends together *(see diagram).* Then open the fold, push the taped ends into the fold, and press the paper flat, so that it opens and forms an open-ended, square tube. At one end of the tube, push two opposite sides inward and press the other two sides flat together to make an accordion-fold top opening *(see diagram).* Make seven more heat boxes, each one of a color shown in the chart.

Next, slide one thermometer halfway into the top of the black heat box. Press the unfolded sides against the front and back of the thermometer. Then, seal the top of the box closed with a piece of tape so that the thermometer is sticking out *(see photo).* Seal the other thermometer into the white heat box in the same way. Attach both boxes open-end down to the cardboard base by using tape. They should be side-by-side with the thermometers facing the same direction. Before you move the boxes out of the shade, read the temperature of each thermometer. Write the temperature on the middle line of the chart on this page. You will have one "beginning" temperature for black and one for white. *(Continued on the next page)*

HEAT ABSORPTION CHART

TEMPERATURE	BLACK	WHITE	RED	YELLOW	GREEN	VIOLET	ORANGE	BLUE
AFTER SUN								
BEGINNING								
TEMP. RISE								

Next put the two heat boxes in the sunlight so that each one is facing the Sun. Leave them there for 15 minutes. (If a cloud should dim the sunlight for more than a half minute, bring the boxes back into the shade to cool.)

After 15 minutes in the sunlight, read each thermometer and write the "after-Sun" temperature on the top line of the chart. By subtracting the "beginning" temperature from the "after-Sun" temperature you will find how many degrees the air in each heat box has been warmed by the sunlight. Which box absorbed more heat—the black one or the white one? Can you guess which of the other boxes will absorb the most heat and which will absorb the least?

Finishing the Investigation

To find out, bring the cardboard base back into the shade, remove the black and white boxes and take the thermometers out. Wait a few minutes for the thermometers to cool, then put them into the red and yellow heat boxes and repeat the investigation. Next do the same thing with the green and violet boxes, and the orange and blue.

When you have finished, make a list of the colors you tested. At the top of the list write the name of the color that absorbed the most heat. The next color you list should be the one that absorbed the second highest amount of heat, and the last one should be the color that absorbed the least heat. Was your guess correct?

PROJECT

Will a dark shade of a color absorb more heat than a lighter shade of the same color? You can make a test with water-color or poster paints. Mix some black paint with some red paint and coat one side of a white sheet of paper. Mix some white paint with red paint and coat one side of another sheet of white paper. When the paint is dry, fold the sheets into heat boxes, insert thermometers into each, and test them in the sunlight.

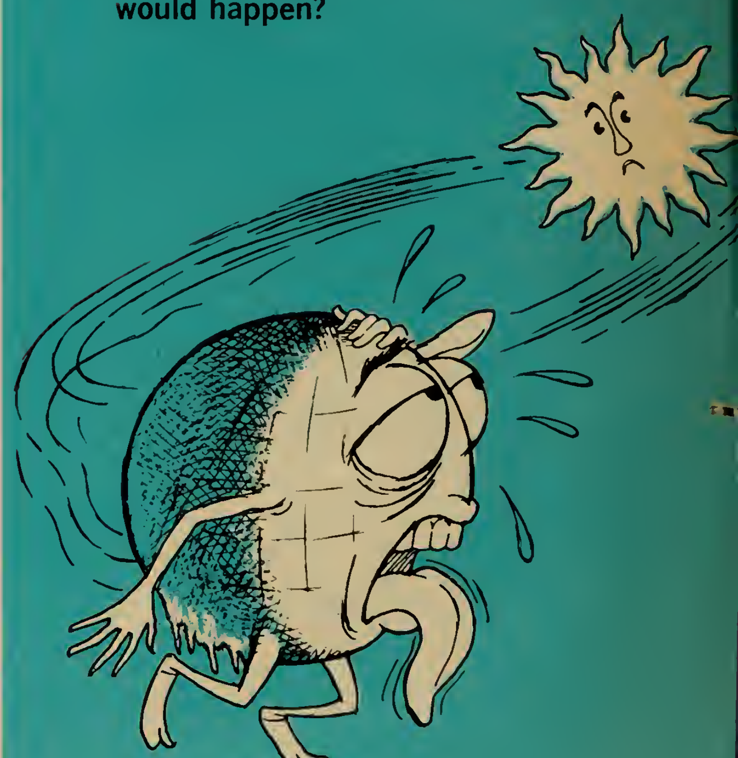
What makes a color "light" or "dark"? When light strikes an object, some light is absorbed by the object and some bounces off, or is *reflected*. If your eye catches some of the reflected light, you see the object. The more light the object reflects, the lighter its color will seem to your eye. Yellow, orange, and red reflect more light than do blue, green, and violet. Because sunshine and fire are warm, and usually appear to be yellow, orange, or red, those colors make one think of warmth. Blue, green, and violet may remind you of cool sea, grass, or shade. But if you are choosing a suit or dress to wear on a hot, sunny day, which colors would keep your body coolest?

—Earl M. Grotke

What Wou

THE EARTH

The Earth rotates, or turns completely around on its axis, every 24 hours. But suppose that the Earth slowed down so much that it took a full year for it to make one complete rotation. Can you guess what would happen?



From time to time this year we're going to tease your curiosity with WHAT WOULD HAPPEN IF . . . questions.

These will be big questions, and scientists cannot answer them completely. But this is one of the things that makes the questions fascinating. Think hard about them, and ask your parents and friends to think about them. See what answers they come up with.

In the next issue of *Nature and Science* we will publish an article giving some of the answers to WHAT WOULD HAPPEN IF . . . the Earth slowed down?

d Happen If . . .

SLOWED DOWN?

■ To help you think about this big question in an orderly way, on this page we ask several other questions—about the air, the oceans, animal and plant life, day and night and the seasons.

Now exactly what do we mean when we say "if the Earth slowed down"? Imagine that the Earth begins to slow down in its rotation, so gradually that we do not feel it. Let's say that it takes several months to slow down to the point where it rotates just once during one full year. The date when it reaches this point is June 21st, and the time is 12 o'clock noon where you live.

THIS IS IMPORTANT: From this time on, the Earth keeps the same face pointing toward the Sun all the time, just as the Moon keeps the same face pointing toward us as it circles the Earth. The Earth would be circling the Sun in the same way that the Moon circles the Earth.

You can imagine this if you walk in a circle around a chair, keeping your face pointed directly at the chair all the time. The chair is the Sun, and your head is the Earth. As you circle the chair with your face toward it, notice that your head and body make one complete rotation.

If the Earth slowed down so that it rotated just once in the course of a year, what would the world be like? How would our lives be changed? ■

IF THE EARTH SLOWED DOWN, WHAT WOULD HAPPEN TO . . .

DAY, NIGHT, AND THE SEASONS?

- Would there be sunrises and sunsets?
- Would all parts of the Earth have day and night?
- Would there be twilight anywhere on the Earth?
- Would there be seasons?
- Would we have to change our methods of keeping time?
- Would we be able to use our present-day clocks?
- Would there still be days, weeks, months, and years, as there are on our present-day calendars?

THE OCEANS?

- Would the temperature of the oceans change?
- What would happen to the oceans on the side of the Earth facing the Sun all the time?
- What would happen to the oceans on the far side of the Earth, that is, the side pointing away from the Sun all the time?
- Would there still be tides?

THE AIR?

- Where would it be hot?
- Where would it be coldest of all?
- Would it ever snow where you live? Would it ever rain where you live?
- How would the weather change?
- Would it still be cold in the Arctic and Antarctic?
- What would happen to the prevailing winds—the Westerlies and Trade Winds that move in great belts around the Earth?

ANIMAL AND PLANT LIFE?

- What would happen to plants on the land and in the sea?
- What would happen to fishes and other animals that live in the oceans?
- Would animals continue to live where they do today?
- Could you live where you live today?
- How would the "rhythm of life" of plants and animals be affected?

HOW IT WORKS

Refrigerators

■ Pour a little rubbing alcohol on the back of your hand and feel what happens. One thing you notice is that your hand feels cold. Another thing—the alcohol *evaporates,* or changes from a liquid to a gas, very quickly, leaving your hand dry as well as cool. To change from a liquid to a gas, heat is needed. The heat comes from your skin. Evaporation is a cooling process, because it uses up heat.

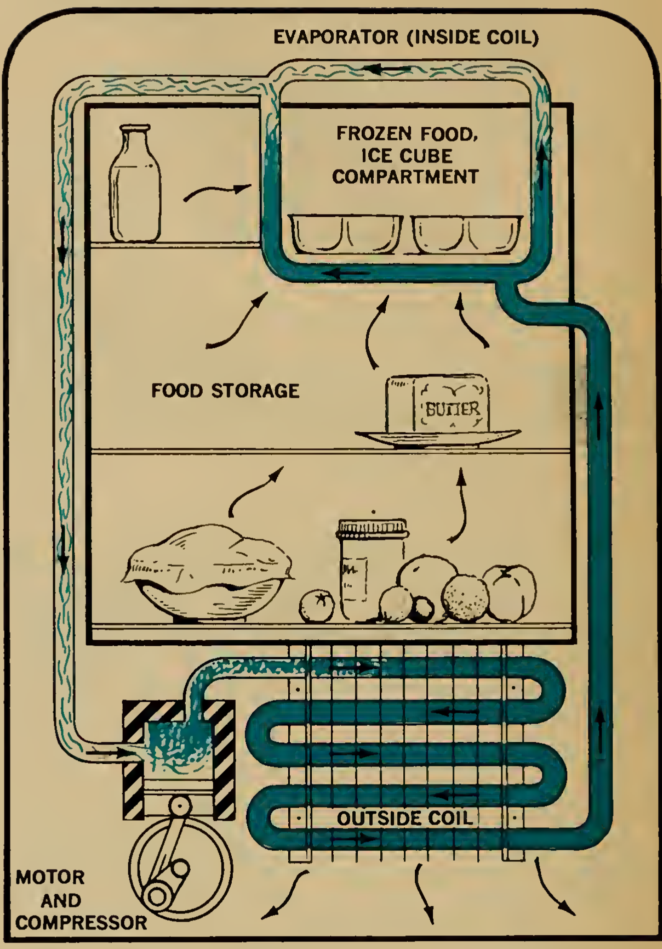
Ancient peoples learned to cool water in pottery jars by allowing some of the liquid to seep through the sides and evaporate. By this action the water inside lost some of its heat. Today, campers sometimes hang food up in wet cloths to keep it cool by evaporation. A camper's canvas water bag cools water by seepage and evaporation.

The refrigerator in your kitchen works very much the same way. But it does not use alcohol or water as a *coolant.* Instead, it uses a manufactured coolant called *Freon,* which can exist as a gas or a liquid. Let's trace the Freon as it makes one round trip through the refrigerator.

Liquid Freon is forced into the evaporator, a coil of tubing that surrounds the ice cube compartment *(see diagram).* As the liquid Freon changes to a gas, it draws heat from the air in the refrigerator. The air, in turn, draws heat from the food in the refrigerator. The gas now flows from this coil to a *compressor.* The compressor is a pump, driven by an electric motor. It squeezes the gas into a small space so that it becomes a liquid, or *condenses.*

As the Freon condenses, it moves through an outside coil, where the liquid gives up its heat. The heat is carried away from this coil by room air circulating through it. If you place your hand on the outside coil of your refrigerator, it will feel warm. (This coil is in the bottom of some refrigerators and on the back of others.) Next, the liquid flows from the outside coil back into the evaporator coil, where it changes into a gas.

This process happens over and over again. The coolant evaporates and condenses many times each day. But you have probably noticed that your refrigerator does not operate all the time. You can find out how often the electric motor turns on and how long it runs each time. Listen to the humming noise it makes, and time these events.



Refrigerators Are Also Heat Pumps

Refrigerators take heat from the food inside and release the heat outside, where it heats the air in the kitchen. So they are heaters as well as coolers. Any machine that transfers heat this way is a *heat pump.*

A home air conditioner is another heat pump and operates much like a refrigerator. Air from the inside of the house is pulled around a coil in the air conditioner by an electric fan. A coolant evaporates in the coil, taking heat from the inside air, which is then blown back into the room. The coolant then condenses in a second coil, where it gives off heat to the outside air.

A home deep freezer is simply a very cold refrigerator. While your refrigerator keeps the temperature of the air inside between 40° and 45° F., a deep freezer keeps it about 0° F. A control dial permits you to set the refrigerator to the desired temperature ■

TEACHER'S EDITION

VOL. 2 No. 1 / SEPTEMBER 21, 1964 / SECTION 1 OF TWO SECTIONS

Dear Colleague:

With this issue, Nature and Science starts its second year of service to teachers of the middle and upper elementary grades. Frankly, we are pleased with the wonderful response. More than 14,000 teachers and 200,000 youngsters subscribed to Nature and Science in its first year.

We are impressed not only by the numbers; we have seen many a copy of Nature and Science that was so dog-eared that we know the young people have been reading it, pondering it, and working out its challenging activities and investigations.

Just as encouraging is the high percentage of first-year teacher-subscribers who have already signed up for classroom subscriptions for the 1964-65 school year. This is solid evidence that we are approaching the magazine's initial goal: To present science as an exciting and rewarding way to look at and to understand the ever-changing world around us. Thus, the magazine always tries to show science as an open-ended inquiry in which the individual--professional and amateur, teacher and pupil, parent and child--is always discovering something new for himself, and occasionally something new for mankind.

In our role as educators, we at The American Museum of Natural History want Nature and Science to continue to bring to you and your pupils the very best in science articles and science workshops that range over a broad spectrum of science--plants and animals, Earth science, physics, astronomy, chemistry, and mathematics.

We hope that we have begun to succeed and we also hope that during the year you will be suggesting ideas that will help make Nature and Science one of your most effective teaching aids.

James A. Oliver
DIRECTOR
The American Museum of Natural History

IN THIS ISSUE

(Suggestions for classroom use of articles preceded by a dot (●) begin on page 2T.)

● The Case of the Vanishing Iguanas
A zoologist discovers that goats introduced into the Galapagos Islands have eliminated underbrush, exposing young iguanas to predatory birds.

Flaming Autumn Leaves
Scientists can describe the chemical changes in leaf tissues that produce colorful fall displays, but they cannot yet fully explain them.

● Round Trip to the Moon
The WALL CHART shows component parts of the Apollo spacecraft and Saturn V rocket and a step-by-step projection of the trip to the Moon and back.

How Hot Is Red?
A SCIENCE WORKSHOP investigation of how much heat different colors absorb from the Sun's rays.

● What Would Happen If... the Earth Slowed Down?
A hypothetical question for your pupils to ponder and question each other about.

Winter Homes for Pond Animals
A SCIENCE WORKSHOP investigation of how pond animals behave and develop in an indoor aquarium.

How It Works—Refrigerators
The refrigerator is a heat pump that transfers heat from food and air inside the compartment to the air outside.

IN THE NEXT ISSUE

Spiders and their webs... How lenses bend light rays... Scientists suggest some answers to "What would happen if the Earth slowed down?"... Exploring life in a rotting log.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 12 What Would

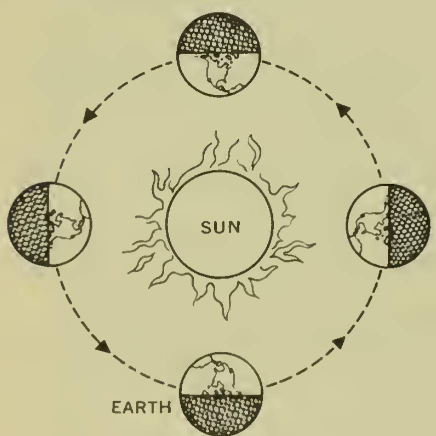
happen . . . if the Earth slowed down?

This and the related hypothetical questions are posed to give your pupils something to wonder about—a framework in which to apply their knowledge and to check one another on their understanding of scientific principles and the causes of events.

In your discussions, don't attempt to answer these questions completely, for we doubt that there could be any answers that would cover all of the different possibilities. The purpose of this article is not to find all the answers, but rather to stimulate thinking and critical discussion.

Suggestions for Classroom Use

You could have each pupil make a list of things that might happen in each of the four sub-question areas. Their ideas could then be reported, and discussed by the entire class. Or you might assign each of the four sub-question areas to a group of pupils for discussion, with a member of the group reporting its suggested answers to the entire class for further discussion.



If the Earth slowed down until it made only one rotation in the course of a single revolution around the Sun, the same half would always be toward the Sun.

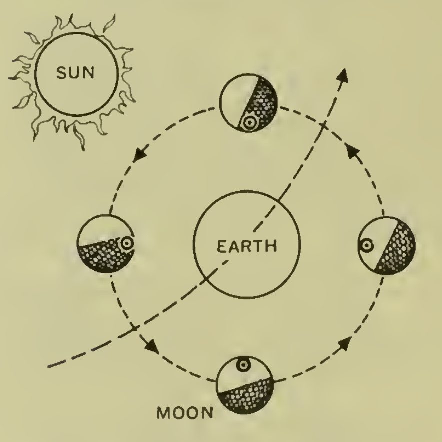
Before assigning any work or opening discussions, it's a good idea to make sure that the situation that we are supposing is well understood—that is, that the Earth *does not stop* spinning. It spins very slowly, taking 365 days to make a single rotation (one turn on its axis). This is the same length of time it takes for the Earth to make one revolution around the Sun.

Work out the relationship as suggested in the article, by having one pupil move around a chair, facing the chair at all times. Have your pupils make drawings on the board representing the Earth at different times of year *(see diagram)*. Keep in mind that in our highly hypothetical case, the Moon's motion is not affected—it continues to make one revolution around the Earth in about 28 days.

Topics for Class Discussion

Each of the questions that are posed offers discussion possibilities. What would happen to plants and animals would depend on what happened to the air, the oceans, day and night, and the seasons, so it might be well to take up the sub-questions in the order in which they are presented.

Here is a way you might consider the first question, "Would there be sunrises and sunsets?" Ask your pupils what causes these phenomena. Sunrises and sunsets (and day and night) are caused by the rotation of the Earth. The part turning *toward* the Sun has the sunrise, the part turning *away* from the Sun has the sunset.



As the Moon revolves around the Earth, the same half is always toward the Earth, but each spot on the Moon is exposed to the Sun during a revolution.

SOME WAYS of thinking about these questions and some possible answers to them suggested by scientists will be published in the October 5 issue of *N&S*.

If your class discusses the question before receiving that issue, we'd like to know what kinds of answers—and additional questions—your pupils come up with. If the response is sufficient, we will report on it in a student's edition later this semester.

We would also like to know how you present these questions to your class and your reactions to this kind of article. Perhaps you or your pupils can suggest some "What would happen if . . ." questions for future presentation.

The Moon moves around the Earth in the same time that it takes for the Moon to make a single rotation, and the Moon has sunrises and sunsets—but they occur at intervals of about 14 Earth-days. Now the Earth, in our case, would move in the same manner around the Sun, so it might seem that the Earth should have sunrises and sunsets but that they would occur at very long intervals. However, one has to consider the two situations. In one case, the Moon is going around the Earth with the same half always toward the Earth. This means that all faces of the Moon are toward the Sun at some time during a single revolution. In our case, the same half of the Earth is always toward the Sun, so there would be no sunrises or sunsets.

Similar reasoning applied to the other questions can lead to interesting and highly productive discussions.

PAGE 8 Trip to the Moon

To show the difficulties of getting Apollo to the Moon while the Earth

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . . *(Continued from page 2T)* and Moon are in motion, you might have four pupils act out an Apollo Moon shot. This should be done in an open area, such as a playground. You may want to have the actors practice a bit before performing for the class. Make "Apollo," "Sun," "Earth," and "Moon" signs for the actors to wear around their necks.

Direct the "Sun" to stand stationary. About 30 feet away, start the "Earth" slowly moving in a circle around the "Sun." At the same time make sure that the "Earth" rotates on its own axis. Then instruct the "Moon" to circle the "Earth" 15 feet away.

Ask "Apollo" to join hands with the "Earth," make a half-circle this way, then break hands and move toward the "Moon." "Apollo" should join hands with the "Moon" for several orbits and then return to the "Earth."

Because the Earth and the Moon revolve in about the same plane, this performance is a fairly accurate representation of the actual motions. The distances, of course, are not to scale, and your space-borne youngsters will not be moving at speeds comparable to those of the rocket and the Moon. The important thing for them to understand through this demonstration is this: To reach the Moon, the Apollo rocket will have to be aimed at a point in space that will be occupied by the Moon at the time the spacecraft reaches that point.

Have your pupils act out the trip to the Moon. "Earth" moves slowly in a circle around "Sun," turning around as he goes, and "Moon" slowly circles "Earth." "Earth" must release "Apollo" so that "Apollo" and "Moon" reach the same place at the same time.

PAGE 3 Vanishing Iguanas

The plight of the Galapagos land iguanas demonstrates several basic concepts of ecology, the study of organisms in relation to their environment:

1. Plants and animals live in communities, or ecological systems.
2. Man unwittingly may upset the "balance" of those communities; but, correspondingly, may be able to restore it with appropriate remedial measures.
3. The survival of populations depends on many external and internal factors.

Suggestions for Classroom Use

It may be helpful for your pupils to think of the basic needs of all animal communities—food, water, and shelter from weather and predators. Have them consider what happens when shelters in a human community are destroyed by a flood or earthquake.

As the iguanas of the article are threatened primarily by destruction of the young, have your pupils consider the importance of protective measures human parents take with their babies. What hazards confront the young of cats, dogs, and birds? Are humans subject to the same hazards? Can humans meet such hazards more effectively than other animals? How and why?

Topics for Class Discussion

The growth and survival of populations are often thought of simply as problems of starvation and competition. To give your pupils some idea of the complexities of the problem, you might raise some of these questions:

1. *What might happen if the hawks, rather than the goats, were killed?* Scientists can only guess. The iguanas should increase, but perhaps another predator—such as the Lava Gulls—also eats iguanas. Until scientists learn more about the animal life on the Galapagos, killing the goats seems to be the best solution. The goats are an introduced, or "exotic" species; the hawks and iguanas have lived together for thousands of years.

2. *What have been the effects of introducing plants and animals into the United States?* Some "foreign" organisms of dubious value that your pupils may know of are the starling, Norway rat, and gypsy moth. Most such animals have proved to be costly nuisances. The Ring-necked Pheasant is an exception.

3. *Why do we care about preserving the iguanas?* Usually, conservation efforts are directed toward animals that are of some use or esthetic delight to man. Perhaps the iguanas could again be a food supply some day, with careful harvest. But in this case the interest is primarily historic and scientific. The Galapagos Islands form a unique laboratory for studying the continuing processes of evolution.

Activities

1. A desert-like, volcanic island is one kind of living community; a lawn is another. Have the class list as many others as they can think of—woodlands, swamps, ponds, prairies, orchards, and so on.

2. Take a close look at a patch of school lawn. Is there only one kind of grass? What small animals are associated with the grass? Or examine a rotting log. Mosses, ferns, mushrooms, and even small trees may be growing on and around it. Possibly insects have made homes in it. Do the lawn and log form small communities? How do the two communities differ?

3. Youngsters intrigued with the strange life and appearance of the creatures in the article may wish to build a desert terrarium. Into a large terrarium with a tight-fitting screen lid, place about 3 inches of sand and several large rocks. Add some cactus and a shallow pan of drinking water. Keep the bottom of the sand moist and the temperature between 80 and 90 degrees in the daytime, and about 70 degrees at night. A small electric bulb may supply the heat. Put in appropriate desert animals, such as the horned "toad" or lizard, which is a distant relative of the iguanas on the Galapagos. Live specimens can be ordered from larger pet stores or biological supply houses.

4. Investigate the extinction of the dodo bird. When and how did it happen? The circumstance somewhat parallels that of the iguanas.

Find out what other creatures are threatened with extinction and what is being done to save them. The Grizzly Bear, California Condor, and Whooping Crane are a few.

References

An excellent book on plant and animal communities is *The Web of Life*, by John H. Storer, Devin-Adair Co., New York, N.Y., 1953, $3 (paperbound, Signet 2265, 60 cents).

For brilliant pictures of the Galapagos creatures, as well as many articles of ecological interest, see *The Wonders of Life on Earth*, by the editors of *Life*, New York, N.Y., Golden Press, 1960, $5.

For an account of Darwin's findings in the Galapagos see "The Voyage of the Beagle," by Millicent E. Selsam, in *Nature and Science*, May 15, 1964, and the accompanying Teacher's Edition.

A Preview of Articles, Features, and Special-Topic Issues **nature and science** Will Bring Your Pupils This Semester

SPIDERS AND THEIR WEBS As your pupils become skilled spider watchers, they develop both esthetic and scientific appreciation for the structural wonders of spider webs with the guidance of Alice Gray, an American Museum expert on insects and spiders and a frequent contributor to *N&S*.

WHAT WOULD HAPPEN IF...THE EARTH SLOWED DOWN? In answer to questions posed in this issue of *N&S*, an astronomer, a meteorologist, an oceanographer, and a biologist come up with some theories against which your students can match their wits.

BENDING RAYS OF LIGHT This clear introduction to lenses includes several projects and demonstrations to help your pupils understand the principles of optics.

THE MYSTERY OF MIRAGES In pictures and words, a noted photographer, David Linton, explains the mirages of the desert and Antarctica that he has captured on film

BUILDING A GREAT BRIDGE This is the dramatic story of the building of the Brooklyn Bridge nearly 100 years ago by the father-and-son team of John and Washington Roebling, told afresh by Donald Barr, who is an engineer, teacher, and writer.

FROM FINGERS TO COMPUTERS Highlights of the evolution of today's computers. Your pupils will become familiar with everything from the operation of the abacus and slide rule up to the 19th century contraptions of Babbage and the efficient modern electronic computers.

NATURAL HISTORY OF THE RAT How this tough and adaptable creature has influenced the health of mankind and how it survives, even in the most unlikely places.

SCIENCE ADVENTURES

EXPLORING IN THE RAIN FOREST In two articles, a widely traveled plant scientist relates his recent adventures in searching for useful plant species in the rain forest of Surinam in South America as he explores this dim, damp world by canoe and on foot.

TURTLES OF A JUNGLE RIVER A Museum scientist tells of his adventures while studying the Arrau turtles that lay their eggs on the remote beaches of the Orinoco River in Venezuela. These turtles have survived great hazards for millions of years, such as vultures and crocodiles that prey on their new hatchlings. Today they face obliteration from the encroachments of human civilization.

BROADCASTING BEARS: RADIO TRACKING OF ANIMALS Bears, skunks, porcupines, and many other animals are being fitted with radio transmitters so that scientists can get a better picture of animal behavior in the wild.

SCIENCE WORKSHOPS

LIFE IN A ROTTING LOG Fallen trees teem with life. Wave upon wave of small animals and plants reduce a mighty tree to a more humble role in the environment. A forestry expert tells what to look for in the autumn and winter months.

PLANTS AND LIGHT How does the amount of light that a plant receives affect its size, color, and form? Your pupils can find out by using some simple equipment and bean seedlings.

GETTING TO KNOW THE MICROSCOPE Written by a seasoned teacher who has had much experience in introducing the microscope to elementary school children, this useful article explains how the microscope works and how to take care of it, and suggests a number of interesting projects that will introduce your pupils to the fascination of the microscopic world.

HOW TO PROVE THE CASE AGAINST A GERM By means of a carefully controlled investigation, your pupils will learn how to track down and identify the bacterial nature of Ich, a common affliction of aquarium fishes.

N&S WALL CHARTS

LOOKING INTO SPACE Simple diagrams of the two basic types of telescopes—the reflecting telescope and the refracting telescope—that your pupils will want to study time and again.

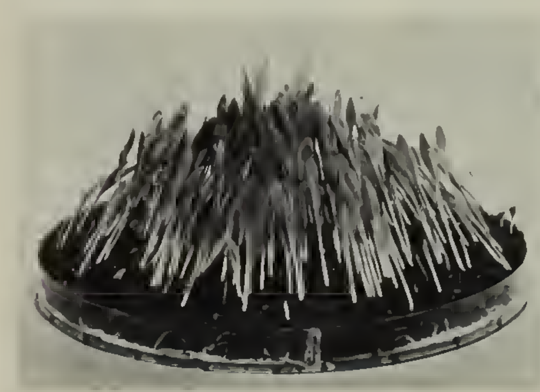
SEED TRAVEL Autumn begins a season of busy biological activity when seeds and spores are cast loose for often extensive journeys during the winter months. This WALL CHART shows the mechanics of this remarkable phenomenon—how seeds of different plants are adapted for dispersal through the air, in the water, by animal carriers, and in other ways.

THE WORLD OF VALVES Through diagrams, this WALL CHART shows the remarkable similarities of mechanical valves, electrical valves, hydraulic valves, and valves in the human body.

THE TRACKS ANIMALS LEAVE BEHIND Drawings of animal tracks in the soil or snow will help your pupils identify many of the creatures that made them. (Accompanying this WALL CHART will be a SCIENCE WORKSHOP article explaining how to track animals.)

BRAIN-BOOSTERS

Mystery Photo...Can You Do It?...What Do You Think Would Happen?...Fun With Numbers and Shapes...For Science Experts Only The questions, problems, and puzzles on this popular and instructive fun page take on a new fascination this year under the editorship of David Webster, Massachusetts elementary school science teacher and a frequent contributor to *N&S*. For example, here is a preview of the "Mystery Photo" for issue Number 2. Can you tell how these seedlings were grown? (Hint: Which way would you lean if you were riding on a fast merry-go-round?)



SPECIAL-TOPIC ISSUES

BIRDS ON THE MOVE (October 19, 1964)

THE INCREDIBLE TRAVELS OF BIRDS How does the sandpiper, which weighs less than an ounce, navigate its annual round-trip of 4,800 miles between Massachusetts and Venezuela? This article will describe the incredible feats of bird navigation and tell how scientists have answered some—but not all—of the mysteries of bird migration.

BE A BIRD WATCHER Simple basic instructions on how to identify birds, study them in their natural surroundings, observe their remarkable behavior patterns, and finally how to make bird feeders. This introduction to scientific bird watching will provide countless hours of study for your class throughout the winter months.

HOW BIRDS FLY This *N&S* WALL CHART will show diagramatically the aerodynamics and physiology of bird flight and compare bird flight with the flight of man-made machines.

THE FAMILY OF MAN (December 21, 1964)

IN SEARCH OF THE FIRST MAN Deep in a canyon in East Africa, a famous anthropologist, Dr. Louis Leakey, and his wife have found fossils of a two-million-year-old creature who *may* be the earliest man. How he was found, what he looked like, how he lived, where he came from, and who are the other candidates—these questions are answered in an article tracing the story of man's search for his evolutionary ancestors.

MAN'S FAMILY TREE A WALL CHART showing the course of human evolution from the tree shrew to man-like apes and ape-like men to one of the world's most successful animals, *Homo sapiens*.

FOUR FINGERS AND A THUMB A child takes the use of his hands for granted, but the human hand—spotlighted in this article by Dr. Harry Shapiro, Chairman of the Department of Anthropology at The American Museum of Natural History—has played a crucial role in human evolution and in the development of culture.

WHAT IS A FAMILY? Colin Turnbull, an anthropologist at The American Museum of Natural History, examines the institution of the family as it exists in different societies of the world, to give your pupils a way of thinking clearly about the differences and similarities among human groups.

nature and science

VOL. 2 NO. 2 / OCTOBER 5, 1964

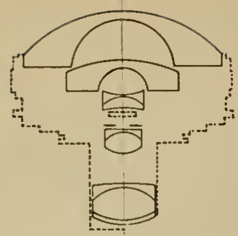
Spiders climb and drop, "balloon" through the air, and trap and wrap their food in threads of silk.

SPIDERS AND THEIR SILK

see page 3

HOW WAS THIS PICTURE TAKEN?

SEE PAGE 2



nature and science

VOL. 2 NO. 2 / OCTOBER 5, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

ABOUT THE COVER

Most camera lenses take in a view of about 50° of a circle. Our cover photograph was taken with a "fisheye" lens that "sees" 180°—half a circle!

The "fisheye" is made up of nine lenses *(see diagram)*. Its outer lens bulges out like a fish's eye, enabling the lens to "see" a wide view, and causing the distortions in the picture. To find out why the bulging lens causes objects to be distorted, see "How To Bend Light," on page 5.

MANAGING EDITOR Franklyn K. Lauden; **SENIOR EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** David Whieldon; **EDITORIAL ASSISTANT** Linda Britton; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Don Cailliez

CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; **SUBSCRIPTION SERVICE** Charles Moore

Contents

CREDITS: Cover by Juliana Wang; p. 2, photo from Nikon, Inc.; p. 3, web photo by Cesco Ciapanna from National Audubon Society; pp. 4, 5, 6, 7, 8, 9, 11, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, photo by V. Cioffero, from Fundamental Photographs; p. 8, Yerkes Observatory photograph; p. 9, photographs from the Mount Wilson and Palomar Observatories; p. 12, photo by Harry L. Bcedc; p. 13, frog and False Solomon's Seal by Rod Cochran, others from AMNH; p. 14, snail, centipede, and squirrels by Rod Cochran, others from AMNH; p. 15, photo by George Cope, Educational Services Incorporated.

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
(Act of October 23, 1962; Section 4369, Title 39, United States Code)

1...Date of filing: August 19, 1964. 2...Title of publication: Nature and Science. 3...Frequency of issue: Fortnightly, October through November and January through May; monthly, September, December, June and July. 4...Location of known office of publication: 501 Franklin Avenue, Garden City, N.Y. 11531. 5...Location of the headquarters or general business offices of the publishers: 501 Franklin Avenue, Garden City, N.Y. 11531. 6...Names and addresses of the publisher, editor and managing editor: Editor and Publisher, Richard K. Winslow, 277 Park Avenue, New York, N.Y. 10017; Managing Editor, Franklyn K. Lauden, The American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024. 7...Owner: Natural History Press Division of Doubleday & Co., Inc., 501 Franklin Avenue, Garden City, N.Y. 11531. The names and addresses of stockholders owning or holding 1% or more of total amount of stock are: Dorothy Babcock, Madeleine Davidson, Ellen Doubleday, Nelson Doubleday, Janet Douhleday, Lawrence McNaughton, Madeline McNaughton, Robert McNaughton, Katherine Morse, Patricia Rockwood, Neltje Sargent, Ellen Violett (all c/o Doubleday & Company, Inc., 277 Park Avenue, New York, N.Y. 10017); Brown Brothers, Harriman & Co., 59 Wall Street, New York, N.Y. 10005; C. A. England & Co., c/o Chemical Bank New York Trust Co., P.O. Box 1316, Church Street Station, New York, N.Y. 10008; J. C. Orr & Co., c/o Chemical Bank New York Trust Co., P.O. Box 1316, Church Street Station, New York, N.Y. 10008. 8...The known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities are: None. 9...Paragraphs 7 and 8 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, also the statements in the two paragraphs show the affiant's full knowledge and helief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Names and addresses of individuals who are stockholders of a corporation which itself is a stockholder or holder of bonds, mortgages or other securities of the publishing corporation have been included in paragraphs 7 and 8 when the interests of such individuals are equivalent to 1 percent or more of the total amount of the stock or securities of the publishing corporation. 10...This item must be completed for all publications except those which do not carry advertising other than the publisher's own and which are named in sections 132.231, 132.232, and 132.233, Postal Manual (Sections 4355a, 4355b, and 4356 of Title 39, United States Code). The average number of copies each issue during the preceding 12 months are: (A) Total number copies printed (net press run): 210,977; (B) Paid circulation: (1) To term subscribers by mail, carrier delivery or by other means: 195,394; (2) Sales through agents, newsdealers or otherwise: 150; (C) Free distribution: 10,372; (D) Total number of copies distributed: 205,916. The number of copies single issue nearest to filing date are: (A) Total number of copies printed (net press run): 83,706; (B) Paid circulation: (1) To term subscribers by mail, carrier delivery or by other means: 61,637; (2) Sales through agents, newsdealers or otherwise: 150; (C) Free distribution: None; (D) Total number of copies distributed: 61,787. I certify that the statements made by me above are correct and complete.

Richard K. Winslow
Publisher

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send **notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

SPIDERS AND THEIR SILK

BY ALICE GRAY

Bridges, escape ropes, aerial "balloons," complex webs—these are just a few of the ways that spiders use the silk threads they spin.

■ "Spider" means "spinner." The very name of the animal declares its ability to make thread. Wonderful thread it is, too—silk, finer than a human hair, stronger than a steel wire, and sometimes more elastic than a rubber band.

Of course, spiders are not the only silk-spinners. Some mites and other close cousins of the spiders also spin silk. Insects like the Silkworm are very good at it. However, spiders out-do them all in the variety of the silk they spin and the uses to which they put it.

How Spiders Use Their Silk

Spider silk is formed as a liquid in organs called *silk glands*. These glands take up most of the back half of a spider's body. Glands of different shapes produce different kinds of silk, and scientists have found seven kinds of silk glands in spiders of one sort or another. No one spider has all seven kinds, but none has less than three.

All female spiders have a silk gland that makes a thick silk used in weaving egg cases. In addition, all spiders can make three other kinds of silk. One is called *dragline,* and it has more uses than any other kind of silk. As long as a spider lives, it leaves a dragline behind it wherever it goes. Dragline serves as a safety-line, escape rope, ladder, bridge, and to make burrow linings or the framework of webs.

Another common kind of silk is used to make *attachment discs*. These patches of fine crosswise threads are used to fasten dragline to surfaces as a spider moves about.

A third kind of silk that most spiders make is very fine. It is used for tying up prey and insulating egg cases, and it is so light that it can be lifted by a breeze. Sometimes this light line becomes a "balloon," carrying a baby spider (or a small adult one) to a place where there may be more insects to eat. "Ballooning" spiders have dropped onto ships more than 200 miles from land.

The three less common kinds of silk glands make special silks for webs. One gland makes foundation threads for sticky webs. Another kind makes the sticky silk itself. Finally, certain spiders have glands that make very fine crimped thread for "hackled" webs. "Hackling" is a weaver's word for the process of combing raw fibers before spinning. Spiders actually do comb this kind of silk with a pair of bristle combs on their hind feet. The combing does not straighten the silk but "teases" it into a snarl in which the claws of insects become entangled.

Spinning Silk

The silk glands open through tiny holes, usually at the tips of little tubes called *spigots* on the ends of the spider's

(Continued on the next page)

PROJECT

You can make a collection of the spider webs that you find. For equipment, you will need some sheets of cardboard (as big as the webs you hope to collect), a spray can of paint (of a color that will contrast with the cardboard), some pieces of transparent plastic or glass (the same size as the cardboard), a pair of sharp scissors, and some adhesive tape.

Find a web in a place where you can bring a piece of cardboard against it without running into twigs or other obstacles, and where a splattering of paint will do no harm. Coat the web lightly but thoroughly with paint, on both sides if possible. Begin about two feet away from the web and spray from an angle. (If you begin too close and right in front of the web you may blow a hole in it.)

While the paint is still "tacky," press the cardboard lightly against it. Cut all the supporting threads around the edge of the web. Now the web is stuck to your cardboard. When the paint is dry, cover the web with a sheet of glass or plastic and tape the cover and the cardboard together at the edges.

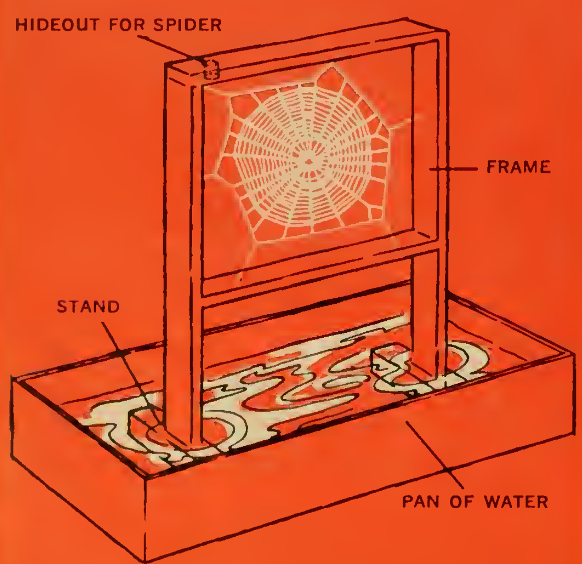
On the back of the cardboard, write the location of the web, the date you collected it, your own name, and if possible, the name of the spider.

Spun-to-Order Webs

Web-making spiders cannot swim. If you put a spider onto a frame standing in a pan of water it will make its web where you can easily collect it.

Make the frame (like a picture frame) a little bigger than your web-mounting cards. Drill a hole inside of the frame at one upper corner to serve as a hideout for the spider. Attach the frame to a stand and set it upright in a pan of water *(see diagram)*. The pan must be longer than the width of the frame so the spider cannot get off by letting itself down on a silk thread.

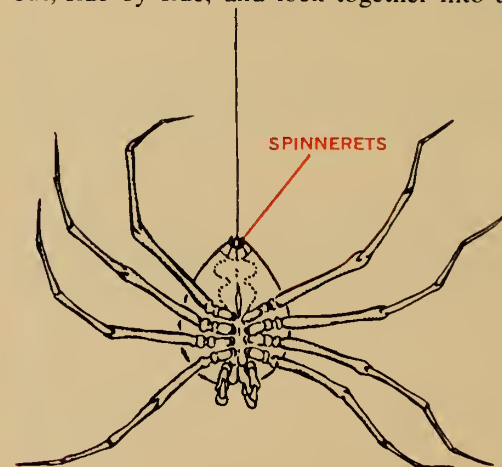
It usually takes two or three nights for a spider to get used to the frame. After that it should spin every night, if you are careful not to kill it with paint from your spray can.



spinnerets. The spinnerets are the finger-like organs at the back end of the spider's body *(see diagram)*. Some spiders have eight spinnerets, but most have only six, and a few have four or even two.

There are no muscles in the walls of silk glands to squeeze out the silk. It has to be pulled out. Usually the spider glues the end to something solid by touching its spinnerets to the surface, then lifts them and moves away. The back feet often help in drawing out and handling the thread.

The thread becomes solid as it is being drawn. The molecules of liquid silk are long spirals, like coiled springs. As they are drawn through the spigots they straighten out, side by side, and lock together into a solid thread.



Come into My Parlor . . .

All spiders feed on small living animals, mostly insects. However, not all of them use webs. Some, like the crab spiders, lie in ambush, waiting for some insect to blunder into their grasp. Some, like the jumping spiders, capture their prey by running after it.

Those which do use webs follow many patterns in spinning them. The form of a web tells a lot about the kinds of insects likely to be caught in it. For instance, a flat sheet of silk stretched over a hollow in the ground (with the spider hanging upside down beneath it) will catch things that walk on the surface of the earth. The spider strikes right through the silk, drags the victim through, and patches the hole after dinner.

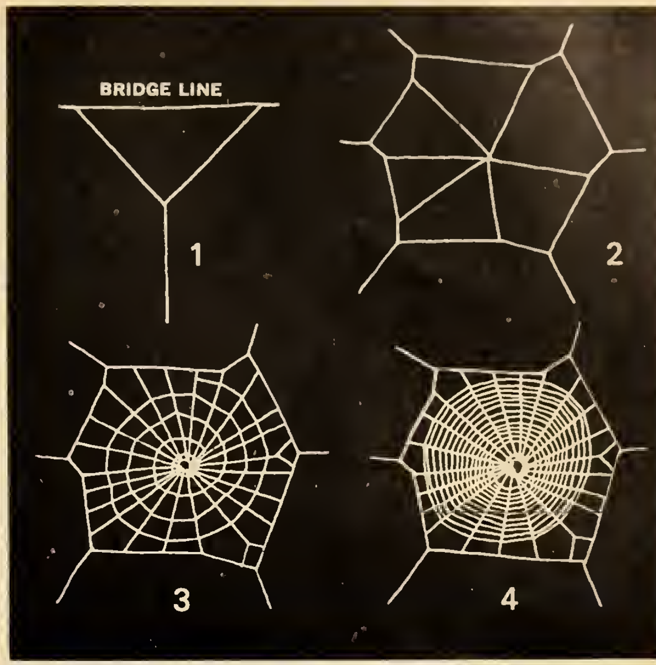
A silk cup with a tangle of widely-spaced threads above it stops jumping and low-flying animals and drops them into the cup, where the spider is waiting.

No better trap for high-flying insects can be imagined than the beautiful wheel-shaped ones which scientists call "orb webs" (*see diagram*). Actually the word "orb" means "round like a ball," but these webs are round like a plate—discs rather than orbs. Most orb webs are sticky, but some are hackled instead and a few are just dry, smooth nets.

The nets are so easily torn that most orb-spinning spiders make new ones every night, either in the evening or just before daylight. A few kinds patch a net which has not been too badly torn and use it over again. Once a spider has found a good place for spreading a net, it uses the same spot over and over. Sometimes the spider sits in the middle of its web. More often, it waits in a silk-lined hideaway nearby, with one foot resting on an "alarm thread" leading to the web. The struggles of a captured insect set up vibrations which guide the spider to the spot.

Both in using its web and in building it a spider depends almost entirely upon the sense of touch and a second "muscular" sense—the one that tells you which of two rubber bands is the stronger if you test them in the dark. The ability to feel changes in tightness of stretched threads is as important to the spider as sight and hearing are to you.

The entire operation of web spinning takes the spider between 20 minutes and an hour. You can easily watch it from beginning to end. You may even be lucky enough to see how the trap works when it is done. The more spiders you watch, and the less similar they are, the more variations in the art of web-spinning you will see. "Spinners" they are named and spinners they are, without equal in all the world ■



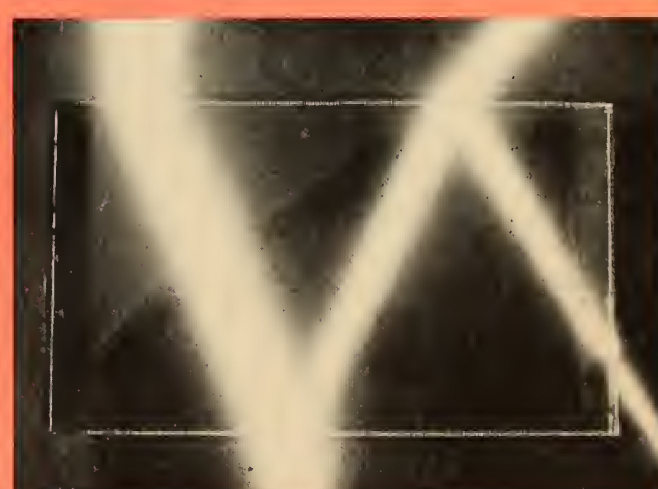
To spin an orb web, a spider begins with a bridge line and three "spokes," or radii (1). The spider adds three more radii and an outer frame (2). Next come more radii and a spiral (3) that strengthens the web and serves as a guide for spinning the sticky spiral (4) that traps insects.

SCIENCE WORKSHOP

HOW TO BEND LIGHT

by Paul E. Sanborn

By making a water-drop magnifier and studying these diagrams, you can find out how lenses make things appear larger or smaller.



Light bends as it enters and leaves a block of glass. Some of the light is reflected from the inside glass surfaces.

■ The curved piece of glass called a lens is one of the most important tools of the modern world. By arranging lenses in certain ways we can reveal a fascinating realm of living things far too small to be seen with the unaided eye. And by arranging lenses in another way we can bring the world of the stars within our visual grasp. A drop of water is a lens; so is a magnifying glass. Most of us probably know more about the lens in a camera than we know about the miracle of all lenses—the lens of the human eye (*see page 16).*

To find out how a drop of water magnifies an object, let's follow light as it travels through the air and then enters some transparent material.

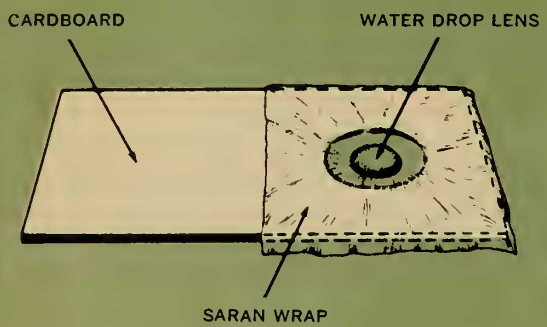
(Continued on the next page)

PROJECT

MAKING AND USING A WATER LENS

You have probably used a magnifying glass to enlarge things. Here is a way to make a simple magnifying lens from a drop of water.

Cut a piece of cardboard about two inches wide and six inches long. Cut a round hole about one inch in diameter near one end. Cement a sheet of clear plastic wrapping material (such as Saran Wrap) to one side of the cardboard so that it covers the hole (see *diagram*).

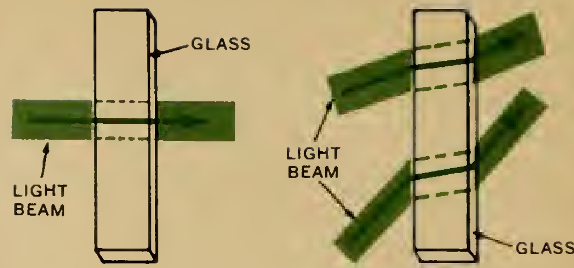


Make sure the plastic is not wrinkled. Hold the cardboard with the plastic side up, then with the eraser end of a pencil build up a large drop of water by dipping the pencil in a glass of water three or four times and transferring the water to the plastic. The large drop should be on the plastic over the center of the hole. The drop will form a lens.

Place the cardboard on a table so that the lens hangs over the edge. The cardboard can be held in place with a book. Now hold a postage stamp, or something else with small printing on it, under the lens. Hold your eye quite close to the lens. Start with the stamp almost touching the lens, then move the paper away slowly. What happens?

What happens, for example, when a beam of light moves from air into a different medium, such as glass? If the beam strikes the glass head-on—at a 90-degree angle—it continues to move in the same direction as before, but at a slower speed. It keeps moving at this slower speed as it passes through the glass. When it comes out of the glass, the beam speeds up again and keeps moving along the straight path.

Now what happens if a light beam enters the glass at a slant? As the diagram shows, the beam is bent. Why? The edge of the beam that strikes the glass first is slowed down before the other edge of the beam reaches the glass. Because of this, the beam bends in the direction of the edge that first entered the glass.

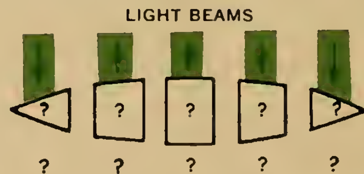


How much the beam is bent as it enters the glass depends, for one thing, on the angle at which the beam strikes the glass; the smaller the angle, the greater the bending. It also depends on how fast light travels in each of the two materials (the air and the glass). For example, glass slows down a light beam more than water does, so a beam moving from air into glass bends more than a beam moving from air into water. One thing you will notice in the third diagram is that the beam coming out of the glass bends in the opposite direction to the beam entering the glass. Realizing this, try to figure out how the light beams in the following illustration will bend.

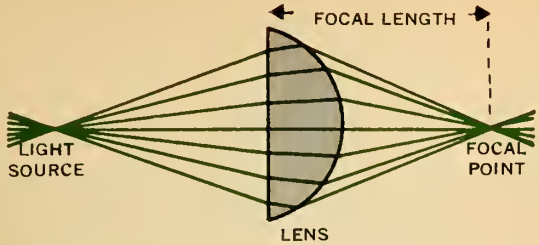
Changing the direction of a light beam by passing the beam from one material into another is called *refraction*. Since lenses are made of transparent materials, they refract the light that enters and leaves them. However, a flat piece of glass that refracts light rays cannot do the things a lens can do.

All lenses have one or two curved surfaces. Look at the top surface of your water lens. The curved surface of a lens bends light rays in a special way. Light from every single part of the postage stamp held under your lens goes through the lens. As the light passes through the lens it is bent and meets at a point called the *focal point* (*see diagram*). The distance from the lens to the focal point is the *focal length*. Try to find the focal length of your water-drop lens—the distance from the lens to the position of your eye where you see the postage stamp clearly. Is it as far away from the lens as one inch? Maybe it will be only half that distance, or less.

CAN YOU FIGURE IT OUT?

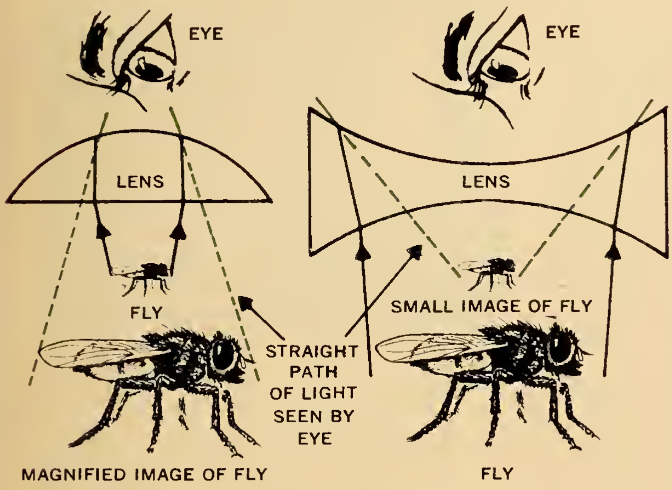


With a pencil try to complete the paths of the light beams as they: 1) enter the glass and pass through it; 2) leave the glass and continue through the air.



How Your Lens Magnifies

Your water-drop lens is a magnifying lens. When you look through it the world seems bigger than it actually is. As the light from the fly in the diagram enters the lens, it is bent. The light reaching your eye from the lens (solid lines in color) travels in a direction different from the light

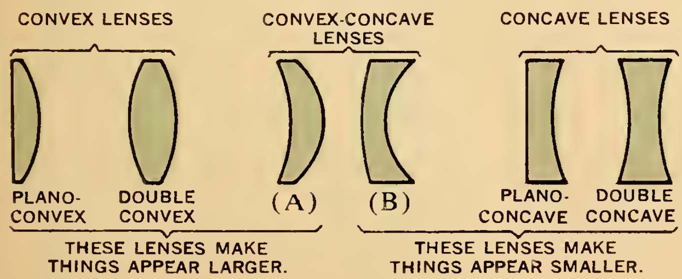


coming from the fly and entering the lens. But your eye sees the light as if it had been traveling in a straight-line path (solid and broken lines in color), *not a bent path* That is why you see a magnified image of the fly.

Lenses of Different Shapes

Your water lens has one *plane* (flat) surface and one *convex* (outward-curving) surface. For this reason it is called a *plano-convex* lens.

Another type of magnifying lens is the *double-convex* lens, which has two convex surfaces instead of one. The double-convex lens works almost exactly the same way as the plano-convex lens.



A lens with one or both surfaces hollowed out is called a *concave* lens. Because of its shape, a concave lens makes an object look smaller and closer than the object really is. It works in the same way as your water-drop lens (*see diagram*), but produces the opposite effect.

A *convex-concave* lens has one convex surface and one concave surface. Lenses of this type are made in two different shapes, each of which works differently from the other. One kind of convex-concave lens is thicker in the middle than it is near the edges (*see diagram A*), just as a convex lens is. Therefore, this lens forms images the same way a convex lens does. The other convex-concave lens (B) is thicker at the edges than at the center, just as a concave lens is. Therefore, it acts just like a concave lens.

Lenses that are thicker in the middle magnify; lenses that are thicker at the edges make things appear smaller ■

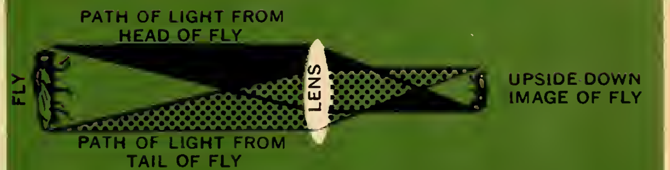
INVESTIGATION

FORMING REAL IMAGES WITH A LENS

The magnified image and the reduced image of the fly described in this article are *virtual* images. They are given this name because they only *seem* to be where you see them. You cannot project a virtual image onto a screen.

With a magnifying glass you can also form a *real* image—one that you can project onto a sheet of white paper.

Turn off the room lights and stand a few feet inside a window. Hold a magnifying lens so it catches light from the scene outside the window. Hold a piece of white paper or cardboard on the other side of the lens. Now change the distance between the lens and the

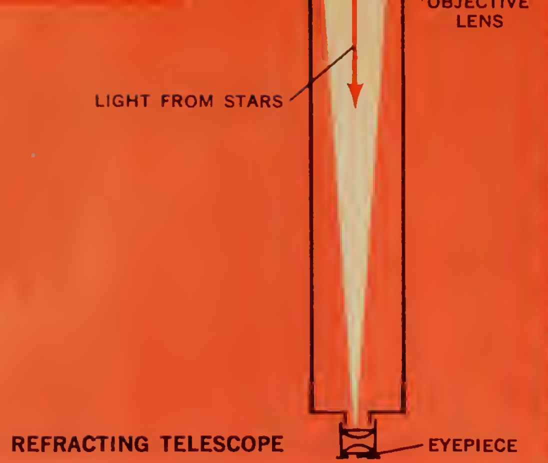


HOW REAL IMAGES ARE TURNED UPSIDE DOWN

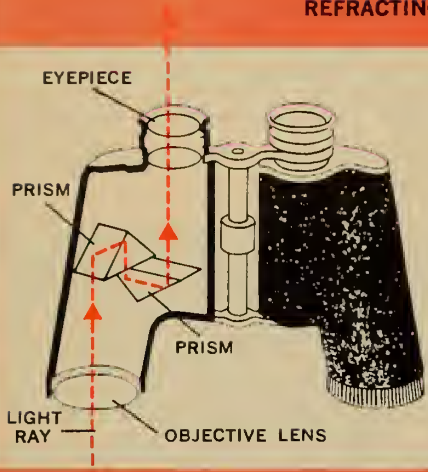
screen until you see a clear image on the screen. How far from the lens must the screen be to form a sharp image of a distant object? Can you change the size of the image just by changing the distance from the lens to the screen? The image you see is upside down. Is it also reversed from left to right?

Using an electric light bulb as a light source, hold a color slide between the bulb and the magnifying glass. Can you project a slide image onto the wall?

■ For further reading, look for the books **Experiments with Light,** by Nelson F. Beeler and Franklyn M. Branley, Thomas Y. Crowell Company, New York, 1957, $2.95, and **The Wonder of Light,** by Hy Ruchlis, Harper & Row, New York, 1960, $3.95. The Edmund Scientific Company, Barrington, New Jersey, publishes a booklet, "Fun With Optics," 50 cents, as well as a free catalog listing project leaflets at small cost.

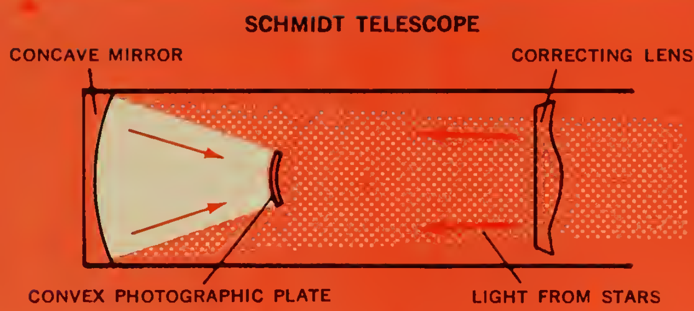


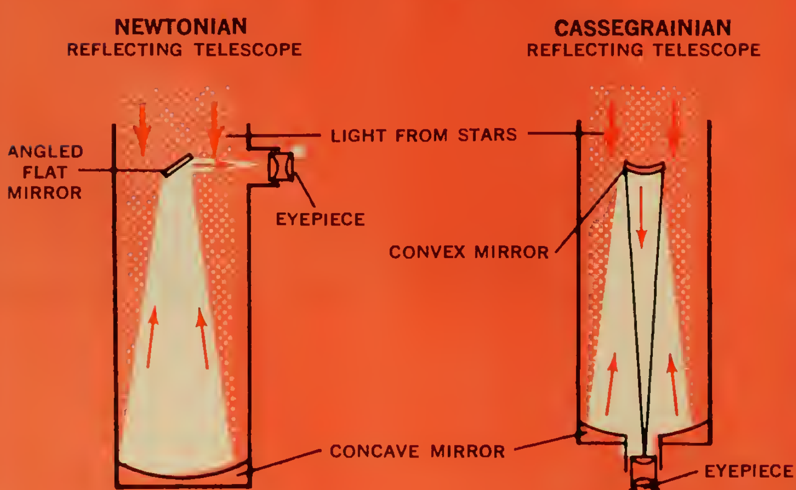
The Y
telesc
long a
can lo
the lo
refers
jective
the s
The d
this te



Amateur astronomers often use binoculars to study the Moon, planets, and variable stars. Light enters the objective lens and is reflected through two prisms (three-sided blocks of glass). The inside surfaces of the prisms act like mirrors. The light rays leave through the eyepiece and form the image seen by the eye. A 7 x 50-size binocular is especially good for sky viewing. The "7" tells you that the binoculars magnify 7 times. The "50" tells you that the objective lens is 50 millimeters across, or about 2 inches. Larger objective lenses make dim objects appear brighter.

big e





■ When the Italian astronomer Galileo poin
telescope into the sky more than 350 years
things never before seen by man. On th
observed craters, mountains, and valleys
turned his "optik tube" toward Jupiter, he
four moons circling the planet. (Today we
Jupiter has 12 moons.) He discovered t
Saturn, and found that the planet Venus w
phases, as the Moon does. Galileo's refractin
were among the first ever made.

As shown on these pages, there are two m
telescopes. Their names tell how they work

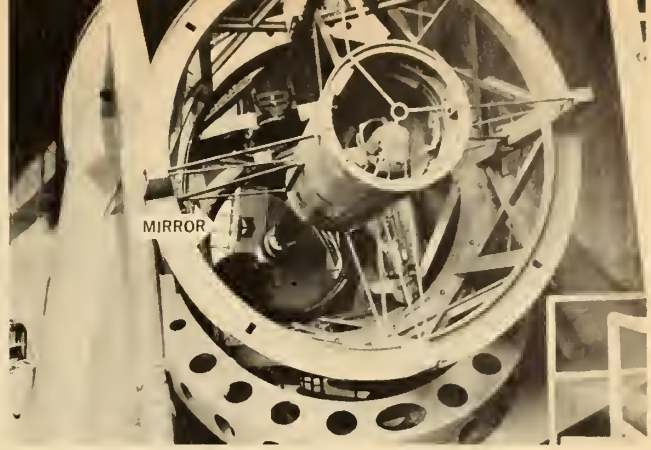
Reflecting Telescopes

In reflecting telescopes, light rays from
any other object travel down the open tel

The 48-inch Schm
at Mount Paloma
is a reflector. A co
is mounted at the
telescope. The "Bi
used for photogr
areas of the sky.
can then be studie
tail with the 200-in
scope. The astron
here is exposing a
plate located insi
The diagram at lef
this telescope work

servatory 40-inch
all refractors, is
w. The observer
h an eyepiece at
"Forty inches"
ameter of the ob-
ich is located at
f the telescope.
left shows how
works.

An astronomer sometimes sits inside the sky end of the Hale reflecting telescope to make observations. The 200-inch glass mirror (see arrow) is located at the far end of the telescope "tube." The diagram (below, left) shows how light from the stars enters a Cassegrainian reflecting telescope and reaches the eyepiece, through which an observer may look.



yes on space

new
saw
he
he
red
hat
of
ugh
pes

s of

s or
ube

and onto a *concave* mirror. (A concave mirror is slightly hollowed on its front surface.) The rays bounce off the concave mirror and come to a focus on a second, flat mirror. The flat mirror is set near the front end of the tube at a 45° angle. The flat mirror reflects the rays to small eyepiece lenses which magnify the image. It is here that the observer sees the image of the star, or whatever else he is looking at.

That is the way a *Newtonian reflector* works. It is named for Sir Isaac Newton, who perfected it in the 17th century. There is another type, the *Cassegrainian reflector*, named for a French scientist of the same period. It is somewhat like the Newtonian reflector. First, the light rays are gathered by a large concave mirror at the bottom end of the telescope tube. As the diagram shows, this mirror has a hole in it. The rays are reflected back up the tube and onto a second mirror, which is convex. (A convex mirror bulges slightly on the reflecting side.) The convex mirror reflects the rays back down the tube and through the hole.

cope
tory
lens
d of
" is
arge
reas
de-
tele-
own
phic
ube.
how

The Cassegrainian has an important advantage: The observer looks through an eyepiece at the lower end of the tube rather than through the side. When an astronomer is using a large Cassegrainian reflector, he doesn't have to climb up high to do his viewing.

The largest Cassegrainian reflecting telescope in the world has a mirror 200 inches (17 feet) in diameter *(see photo)*. This telescope is at the Mount Wilson and Palomar Observatories, near Pasadena, California.

Refracting Telescopes

A refracting telescope is based on the use of lenses rather than mirrors. Light from the sky first passes through an *objective lens*, which is mounted at the front end of the telescope tube. The objective lens is convex: it bulges outward slightly *(see diagram)*. The rays pass down the tube to the eyepiece lenses, where they are brought to focus, and to the observer's eye. The eyepiece magnifies the image formed by the objective lens.

The largest refracting telescope in the world is the 40-inch refractor at the Yerkes Observatory, Williams Bay, Wisconsin *(see photo)*. Through this telescope the Moon appears to be only 80 miles away ■

What Might Happen If... The Earth Slowed Down

Here are some reasonable guesses, based on what scientists know about the Earth, its air and oceans, and living things.

It's spring in the Northern Hemisphere, and the days are getting longer, as they do each year at this time. But something is wrong. The nights are getting longer, too! Scientists say that the Earth is slowing down—each rotation of the Earth on its axis takes longer than the one before it! The days and nights get longer and longer. Finally, when the Earth is making only one rotation in the course of a year's trip around the Sun, it keeps rotating at that slow speed. The half of the Earth bearing the continents of North and South America is facing the Sun all the time, and the other half is in constant darkness.

■ The Earth will never slow down like this (except in science fiction). But suppose that it did. What would happen to the Earth, to the air and the oceans, to you and the other animals and plants living on the Earth? In the last issue of *Nature and Science* we asked this question and a number of other questions to help you think about what would happen if the Earth slowed down in this way.

No one knows, of course, exactly what would happen. But scientists who have studied the Sun and the Earth, the atmosphere, oceans, plants, and animals can make some reasonable guesses. We asked several scientists to make such guesses, and this article is based on their answers. There may be more answers that seem just as possible as these. Did you come up with some?

Day and Night, Clocks and Calendars

You can figure out the answers to one part of this puzzle—"What would happen to day, night, and the seasons?"–without guessing. As the Earth was slowing down, each day and each night would last longer than the one before. But when the Western Hemisphere faced the Sun all the time, it would always be "day" there and it would always be "night" in the Eastern Hemisphere, which would not receive any sunlight.

There would be a "twilight" zone all around the Earth along the boundary dividing the sunlit and dark halves. In that zone, the sunlight would not reach the surface of the Earth, but it would light and heat the atmosphere above it.

In the course of a year, the twilight zone would move back and forth across the North and South Poles with the change of seasons. Remember that the seasons are caused by the Earth's *inclination,* or tilted position, as it moves around the Sun each year *(see diagram).* The northern half of the Earth is tilted toward the Sun during half of the Earth's yearly trip. Coming from overhead, the Sun's rays warm the northern half of the Earth and light up the North Pole for six months. For the next half year, the southern half of the Earth is tilted toward the Sun, leaving the North Pole in darkness.

Even if the same half of the Earth always faced the Sun, the Earth's rotational axis would keep its tilt. So there would still be seasons. The regions around the North and South Poles would still have a slow sunrise followed by a six-month "day," a slow sunset, and a six-month "night."

What about time? Our 24-hour day is based on the time it takes for the Earth to complete one rotation, as determined by successive appearances of the noonday Sun. If the Earth kept the same face toward the Sun all the time, Sun time would stop.

It might be possible to devise a new system of setting clocks by the Moon, which would still rise and set once each month as it circled the Earth. (However, it would rise in the west and set in the east instead of the reverse, as it does now.) The Sun would still reach its highest point above the Northern Hemisphere at the beginning of summer and its lowest point at the beginning of winter, so we could keep track of years the way men have for thousands of years.

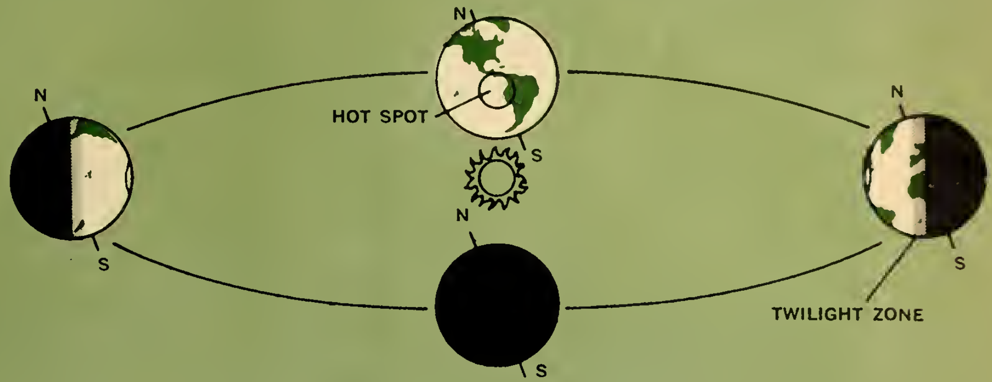
On the Sunlit Half of the Earth...

As the Earth was slowing down, the longer days would give the Sun more time to heat the Earth and its atmosphere. The nights would grow colder as well as longer, because the ground and air would have more time to cool off.

When the Earth had slowed to the point that the Western Hemisphere always faced the Sun, the temperature there would begin to rise. There would be no nighttime for the hemisphere to lose some of its heat. Just how hot it might get, no one knows, for this is the point where we can no longer be sure what would happen. We can only make guesses based on the experience and knowledge of scientists.

There would be one particularly hot spot. This would be an area—many miles across—from which the Sun would appear overhead. The "hot spot" would slowly move from the North American continent to the South American continent and back again as the Earth made its annual trip around the Sun. Winter would not bring much relief from the heat.

In the hot spot region, the air would get hotter than else-here and would rise to great heights. Some of the oceans' ater would evaporate and rise in the air. The rising air ithin the region of the hot spot would produce enormous, wering clouds, dense with water vapor. These clouds would



otating once a year on its tilted axis, e Earth would keep the same half cing the Sun. As the Earth moved round the Sun each year, the "hot pot" would move from the northern the southern hemisphere and back, nd the "twilight" zone would move ack and forth at the poles.

pread out in all directions from the hot spot, and would radually cover most of the Western Hemisphere. Rain would ll continually and there would be thunderstorms more iolent than any we can imagine.

In the Western Hemisphere, the temperature might level ff at perhaps 140 to 150 degrees F. This would be a fairly eady temperature, because the cloud cover would keep re-ecting much of the Sun's heat back into space.

leantime, on the Dark Half...

With no sunlight reaching it at all, the Eastern Hemisphere ould soon cool to temperatures of perhaps 100 degrees elow zero F. Water vapor in the cold air would form frost r fall as snow on all the land areas, and the oceans would egin to freeze solid.

Since cold air is heavier than warm air, cold air from e dark half of the Earth would flow across the surface of e twilight zone into the sunlit half, where it would be eated up. At the same time, warm air carrying water vapor ould flow above the cold air to the dark half of the Earth, here it would quickly cool and lose its moisture.

For thousands of years these conditions would last: trop-al thunderstorms on the sunlit half of the Earth; intense old and heavy snowstorms on the dark half. Eventually, the unlit half would lose its oceans. The amount of water re-urned to the oceans as rain would be less than the amount vaporated, because the air flowing around to the dark half ould carry water vapor with it.

Would there be tides as long as there was some water left the oceans? We now have two high tides and two low ides each day in most places. These are caused by the pull of he Moon and the Sun on the oceans as the Earth rotates ach 24 hours.

With the same half of the Earth always toward the Sun, nd the Moon continuing to move around the Earth about 13½ times a year, there would probably be two high tides and two low tides each time the Moon went around the Earth, or 26 of each in a year.

As water evaporated from the oceans, the minerals in the sea water would become more and more concentrated. Eventually the minerals would form crystals on the sea floor. The crystal formations would gradually build up into glittering, mountain-like formations.

When the rains stopped and the last clouds disappeared, the direct rays of the Sun would cause the surface temperature of the sunlit half of the Earth to soar. The last puddles of water would boil away from the Western Hemisphere.

On the dark half of the Earth, the last traces of what was once the Earth's oceans would be locked up as frost clinging to huge ice mountains. By this time several millions of years would have passed. The temperature on the dark half would drop lower —possibly as low as 400 degrees below zero F. On the sunlit half, it would be about 240 degrees F.

Life on the Slowed-Down Earth

What would happen to us, and to all the other animals and plants living on the Earth? Since our answer to this question must be based on our guesses about what would happen to the Earth, the air, and the oceans, this must be the biggest guess of all.

When the Earth first slowed down, people and most other animals could only survive in or near the twilight zone. Even after the cloud layer had formed and the temperature leveled off at perhaps 140 to 150 degrees F., it would be worse than living in the tropics now. The constant rain and heat would probably change land areas under the cloud cover into tropical rain forests, perhaps as far north as Canada. On the dark half of the Earth, men and most animals could not survive in a temperature of 100 degrees below zero F.

Life might continue on parts of the sunlit side for thousands of years, but only if plants and animals became adapted to the new climates and were able to get enough food. All living things need water to survive, however. So the disappearance of water from the sunlit half would also mean the disappearance of life from the Earth ■

You can find an amazing variety of animals living in and on a fallen tree. Here is how to explore...

LIFE IN A ROTTING LOG

by Rod Cochran

■ Take a piece of crumbly, punky wood from a rotting log in your hands. Break it open. Break it again and again. You will discover that a dead log is far from dead. With all the living things found in a dead log—with their creeping and crawling, scurrying and scratching—you'll wonder why the log doesn't crawl away.

But the only movement a dead log makes is downward as it slowly "melts" into the forest litter and becomes part of the soil from which it grew. The life you find in, around, on, and under a dead log all help in the log's destruction. From the time a tree falls to the ground, thousands of plants and animals use it as home.

Life in a Log

Living trees are full of animal homes—in knotholes, dead limbs, and under the bark. Whether it has fallen or is standing, a dead tree is host to a variety of life. The kinds of living things you find in a log depends on where the tree grew, the climate of the area, and the season during which you find the log. It also depends on how long the tree has been dead and the kind of tree it was.

An important point to remember is that all kinds of life—lichens, mushrooms, tree seedlings, sow bugs, carpenter ants, centipedes, deer mice—do not rush all at once to live in a fallen log. Nature is more orderly than that. There are waves of inhabitants, and each wave paves the way for the next group. This change is not sudden or easy to see. Each new wave begins to move into a log long before the other plants and animals disappear completely.

Log exploring is fun, just as bird watching, rock collecting or going to a zoo is fun. You can nearly always count on seeing something new and different.

A lot of the time you will be down on your hands and knees, so wear old clothes. The top layer of forest soil—called *humus*—is often a rich black color. This is not the usual kind of dirt, however, and it feels good in your hands. It even smells good. Humus is made up of tiny particles of decayed leaves, roots, bark, and other plant material.

Take along a shovel or trowel to loosen chunks of wood. I find that a garden cultivator (a claw-like hand tool) helps in scratching my way through a log. You should have a can or jar and some plastic pill bottles along to collect specimens. Later you will want to identify them. Bring a notebook and pencil to keep a record of your findings.

If a log is hollow, I try to see what animals have been living inside. There you will often find mammals, or signs of them. These animals will usually dash away quickly when you start examining the log. You may see chipmunks, red squirrels, a rabbit, or any of several kinds of mice. Watch out for snakes if you live in an area where poisonous kinds live. Snakes often hunt in logs for food because there are so many living things in dead logs. Logs also offer shelter to these shy reptiles. I have found snakes in, on top of, and under logs. Sooner or later you will add snakes to your list of animals from rotting logs. Most of them will not be dangerous—but be careful.

Layers of Life in a Log

Once I have rattled a log, kicked it, and poked sticks into its hollow (if it has one), I start a closer examination, beginning on the outside. Mosses and fungi grow on a log's surface, except in very dry climates. You may find several kinds of each. Certain kinds of mushrooms will not grow on a newly-fallen tree. The pioneers will be *sugar fungi* which prepare the way for others to follow. Not until a tough substance in the wood cells—called *lignin*—has begun to decay do the mushrooms appear. They are among the last fungi to grow on a rotting log.

Primitive plants such as mosses and fungi are not the only ones you will find. If the decaying log receives summer sunlight, seedlings will grow on it. In some forests you may find a few trees growing in straight lines. They may have all started growing on a rotting log.

You will probably find some insects on the log's surface, but more will be found in the darkness of the log itself. You may also find amphibians at or near the surface—a toad by the side of the log, or a salamander under a scrap of bark (especially if the site is damp).

Now strip away a slab of rotten bark. If the bark is all gone, remove the first layer of loose wood. Here you are likely to find sow bugs, members of the *Crustacea* class of animals. Sow bugs are related to crayfish and crabs. You also may find spiders, representing the class *Arachnida;* millipedes (with a "thousand" legs) from the class *Diplopoda;* centipedes (with a "hundred" legs) from a class called *Chilopoda;* and beetles, representing the class *Insecta.* Where else could you find such fertile hunting grounds—five classes of animals represented in the first layer of a rotting log!

Many kinds of insects live in logs. Beetles and ants will probably be the most common. Also look for crickets, termites, cockroaches, and—in hollow logs—wasps and bees. If you do not find the adult forms of these insects, you may find their eggs or larvae.

If the log has decayed and you can dig through it easily, you may find plant growth all through it. In some places you will see masses of roots. Plants begin to use a rotting log for minerals and support even before the log has become part of the forest soil. From some logs you will be able to tear handfuls of ropy or string-like material. This is the *cellulose* that makes up most of a plant's cell walls and remains after the lignin has decayed.

As you dig your way toward the middle of a hollow log you will discover signs of mammals or reptiles that left earlier. You may see the dry, leaf nests of chipmunks, or maybe the shed skin or white oblong eggs of a blacksnake. Once I discovered a nest of finely-shredded inner bark. In it were four young flying squirrels.

Where the Log Meets the Soil

A log decays inside as well as outside. Rain comes in through holes, and the leaves, nuts, and acorns stored by animals decay. The rotting of the log goes on.

Eventually you will come to the point where the log touches the soil, but the trick is to find this point. There is no clear-cut surface of either soil or log, unless the dead tree has just fallen. The log begins to merge with the soil.

(Continued on the next page)

Plants that grow on rotting logs include mosses and wildflowers such as False Solomon's Seal (1). Fungi like these Honey Mushrooms (2) grow on logs that are well rotted.

Look for amphibians such as Green Frogs (3) and Dusky Salamanders (4) in or nearby rotting logs that are near water. Some kinds of salamanders lay eggs in moist nests of rotted wood.

Beetles (1) are just one of many kinds of insects you may find in a rotting log. Centipedes (2) are attracted to logs because they feed on insects and lay their eggs in the moist wood.

Deer mice (3) sleep in a log nest by day and prowl the forest floor at night. Besides seeds and insects, deer mice feed on land snails (4), which also live on or near rotting logs.

Life in a Rotting Log (continued)

The rotting action of a log usually works fastest from the ground up. Moisture in the soil helps the growth of the bacteria and fungi that bring about decay. When you reach the soil, look for other animals and signs of them—a mole tunnel, earthworms, mites, and springtails. The soil is also teeming with life!

There is a long period between the time a tree dies and the time it is buried. This gives you a chance to watch the process, and to make lists of plants and animals you find taking part. Try scraping, chopping, and scratching your way through a log or two.

By looking at fresh logs, logs rotted to the soft stage, and logs that are little more than humps of earth, you will see that a fallen tree is a miniature "community." Since each rotting log is "alive," do not tear apart all of the logs in one area. Leave some, especially hollow logs, alone.

The tempo of life in a log follows the change of the seasons. Autumn is an especially interesting time to search in rotting wood. As winter approaches, the plant and animal inhabitants get ready for the cold and deadly period ahead. Right now you will find cocoons of certain butterflies and moths in cracks and crevices. Spiders often spin a protective web and fold up in a tiny nest.

A number of insects spend the winter in colonies. Masses of ants gather in rotting wood where they are insulated from freezing temperatures. Bees also will be inactive, or *dormant,* in their nests.

Snakes often spend the winter in logs. Some kinds gather and hibernate in groups. Squirrels and chipmunks use logs for storing nuts and acorns. You may find such a cache. With the coming of autumn and winter, life in a log slows down—but it never stops ■

The author found this nestful of young flying squirrels in a rotting log. The squirrels were nearly full-grown and probably left the nest a few days after he put them back.

To identify the animals and plants you find in and on a rotting log, look for these books in your library or bookstore: **Field Book of Insects,** by Frank E. Lutz, Putnam, 1935, $3.95; Golden Nature Guides, **Mammals** (1955), by Herbert Zim and Donald Hoffmeister, **Reptiles and Amphibians** (1953), by Herbert Zim and Hobart Smith, Golden Press, $1, paperbound; **Fieldbook of Natural History,** by E. Laurence Palmer, McGraw-Hill, 1949, $11.95.

brain boosters

prepared by DAVID WEBSTER

Mystery Photo

What do you notice about the way these plants are growing? What was done to make them grow this way?

Can You Do It?

If an egg is dropped into water, it will sink. What can you do to make it float?

What Do You Think Would Happen . . .

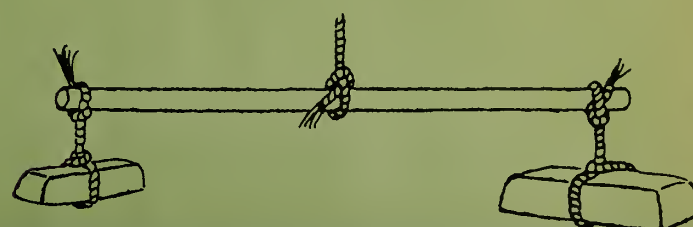
. . . if you let a glass of milk stand in your room for two weeks? You probably know it will get sour. But what will it look like? Will it still be white like milk? How will it change? *Try it and find out*. Look at the milk every day so you can see what happens. You can even keep it longer than two weeks if you want.

Fun with Numbers and Shapes

You have 5 coins which are worth 18¢ altogether. What coins are they?
What 50 coins will equal a dollar?

For Science Experts Only

A piece of iron and a piece of aluminum are balanced on a stick. The aluminum is bigger because it takes more aluminum to equal the weight of the iron. If the whole thing is put under water, will it still balance? (Remember, things weigh less when they are in water.)

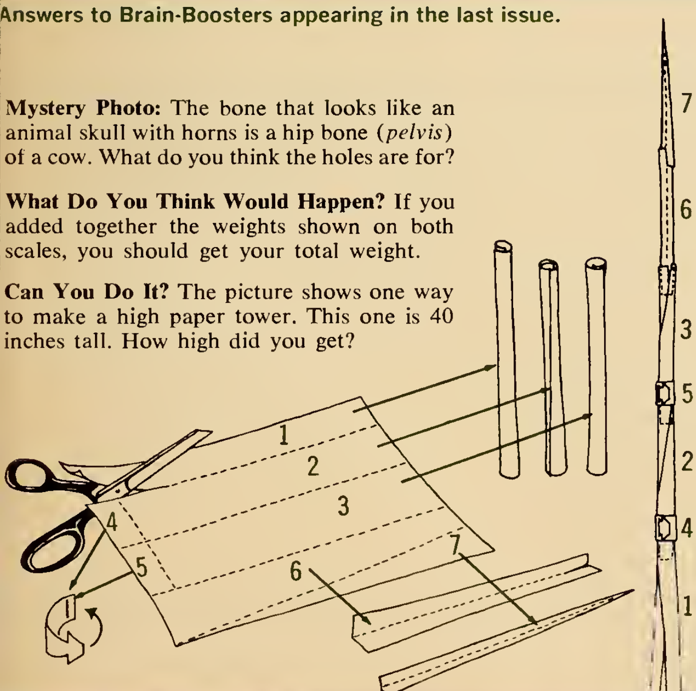


Answers to Brain-Boosters appearing in the last issue.

Mystery Photo: The bone that looks like an animal skull with horns is a hip bone (*pelvis*) of a cow. What do you think the holes are for?

What Do You Think Would Happen? If you added together the weights shown on both scales, you should get your total weight.

Can You Do It? The picture shows one way to make a high paper tower. This one is 40 inches tall. How high did you get?

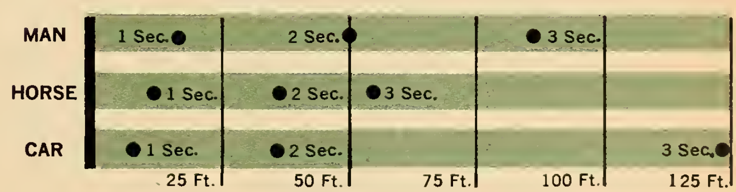


Fun with Numbers and Shapes:

This was a hard one. Were you able to do it?

```
  1 5        S A          18
+ 9 3      + E S   =   + 91
-----      -----       ----
1 0 8      S K E        109
```

For Science Experts Only: A 50 foot race could be won by a man. Since the car and horse are much heavier, it takes them a longer time to reach top speed. The drawing shows about where each might be after 1, 2, and 3 seconds.



Have you an idea for a Brain-Booster? Send it with the solution to *Nature and Science*, The American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024. If we print it, we will pay you $5. Be sure to send your name and home address. If several readers submit the same idea, the one that is most clearly presented will be selected. Ideas will not be returned or acknowledged.

HOW IT WORKS

Camera and Eye

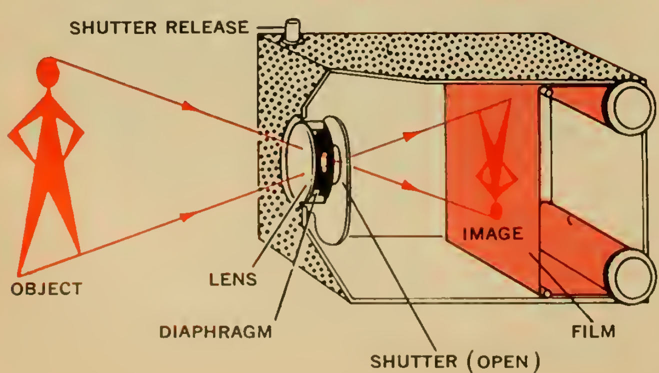
■ If you carried out the investigation on page 7, you made a very simple "camera." Cameras work in much the same way that your eye does. Like your eye, a camera is a light-tight box with an opening and lens at the front and film at the back. Your eye also has a lens at the front and a "film" at the back *(see diagrams).*

Suppose that you are looking at an aardvark and want to photograph it. Light reflected from the animal enters the lens of your eye and the lens of your camera. As the light enter the lenses, it is *refracted,* or bent *(see page 6),* and forms an image. In your eye the image is projected on the back wall, called the *retina.* In a camera the image is projected onto the film. You can think of your retina as a special kind of "film."

Cameras other than simple box cameras have several devices that help you control the brightness and sharpness of the image projected onto the film. One of these is called a *diaphragm.* It is a circular opening that you can make large or small. If you allow too much light to strike the film by opening the diaphragm too wide, your picture will be overexposed and will look faint. If you set the diaphragm opening too small, you underexpose the picture and it comes out dark.

Your eye's "diaphragm opening" is called the *pupil.* Muscles in the eye automatically adjust the size of the pupil so that just the right amount of light enters the eye. You have probably seen the pupils of a cat's eyes change size.

SIMPLE CAMERA

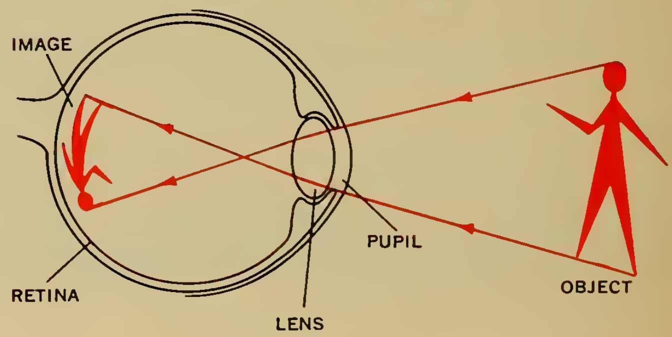


A camera also controls the amount of light striking the film by means of the *shutter.* The longer the shutter stays open, the more light falls on the film. By leaving the shutter open too long you can overexpose a picture; and by leaving it open too short a time, you underexpose the picture. In a sense, our eyelids are shutters. By closing them we cut out all light entering our eyes.

When you take a photograph, you press the button called the *shutter release.* In a split second the shutter flicks open and closes again. During the instant it is open, light rays from the object you are photographing strike the film and cause a chemical change on the film. When the film is developed another chemical change takes place. You see this chemical change as the film negative.

You have probably noticed some pictures that come out all fuzzy, or out of focus. When a photograph is fuzzy it is because the camera lens was not adjusted properly. It was

HUMAN EYE



either too far away or too close to the film. Some cameras have a window of ground glass that you can look through and see the object that you want to photograph. (If you make the water-drop lens described on page 6, you will see what an object looks like when it is out of focus.)

When we look at an object we do not have to think about bringing it into focus. The eye muscles do this for us automatically. When we look at an object far away, our eye muscles tend to make the lenses of our eyes slightly flattened. When we look at an object close up, the muscles shorten the eyeball, making the lens bulge out slightly.

The shape of a camera lens cannot be changed, so we produce a sharp image by moving the lens closer to or farther away from the film.

The lens of a camera and the lens of an eye both produce an upside-down image *(see diagrams).* In a photograph we can correct for this simply by turning the picture around when we look at it. It is the brain that turns the upside-down image on our retina to a right-side-up position ■

TEACHER'S EDITION

VOL. 2 NO. 2 / OCTOBER 5, 1964 / SECTION 1 OF TWO SECTIONS

A Quantitative Approach to Elementary School Science

by Clifford Swartz

(Another in a series of N&S articles about new approaches to science teaching in the elementary school.)

■ We start with the assumption that time is going to be devoted to the teaching of science from the earliest grades right through high school, and so do not raise the question as to whether or not it should be. In most schools these days the assumption is justified. Science study has been added to the grade school curriculum by the expedient of providing graded science texts which the teacher uses more or less, according to her interests and available time.

One of the troubles with the textbooks is simply that they are usually not used as the author intends. The class does not follow through most of the suggested work because it would be time consuming and is not required by the school system.

There are definite goals set for each grade for accomplishment in reading, writing, arithmetic, social studies, etc., but none for science. One school of thought is that the goals for science training in the grades consist of certain attitudes, mental habits, and understandings. Since these cannot easily be tested, they cannot be required.

A Definition of Goals

In designing our particular program, we have tried to meet the set of requirements which follows. Some of these requirements, we feel, represent realities in the present system that are not easily enough changed to struggle against. On the other hand, most of the underlying specifications reflect our understanding of the inescapable nature of children and their educational processes and needs.

1. *The average grade teacher should be able to teach the science program with a minimum of special extra training.*

This is a drastic criterion for the projects to satisfy, since we assume that the school will not have science specialists and that the grade teacher will not attend any training course.

Technology vs. Science

2. *Science in the grades should not be confused with technology, nor should it involve the study of complex mechanisms, physical or biological.*

Technology in general is not the stuff of science. The fear that it is seems to have a particularly discouraging effect on girls and many teachers.

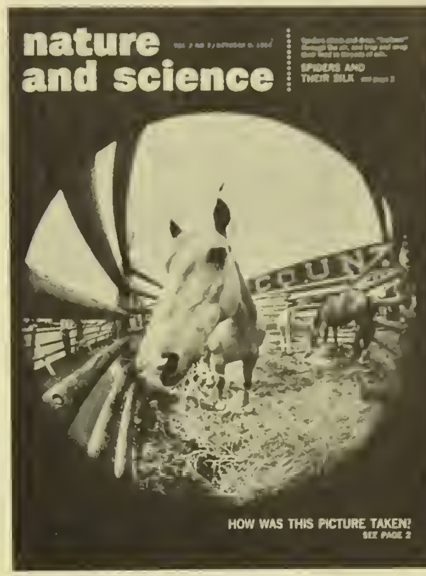
Grade school children are seldom able to comprehend the workings of complex phenomena which depend on many variables. If the study of these is attempted, the truth is usually cheated.

The solution to all this is easy and satisfies our first requirement of not having to give special training to teachers: Since technology is not science, do not teach it as such. There are far more basic things to do, and we suggest that these studies will be more interesting to more children, and far easier for the teacher to present and supervise.

A Base for Future Studies

3. *The science program in the grades should be designed as a base for future science studies in the junior and senior high schools.* *(Continued on page 4T)*

Dr. Clifford Swartz is an Associate Professor of Physics at State University of New York in Stony Brook, N. Y., a consultant to the Brookhaven National Laboratory, and author of college and high school science texts. This article was adapted from his presentation to the National Science Foundation, which financed a workshop on the subject last summer. Scientists and teachers who participated completed over 100 units for teaching the quantitative approach to science in grades one through six (see page 4T). *The complete article and detailed information may be obtained by writing to Dr. Swartz.*



IN THIS ISSUE

(Suggestions for classroom use of articles preceded by a dot (●) begin on page 2T.)

IN THE NEXT ISSUE

Special-Topic Issue on birds: What scientists have learned about bird migration ...The aerodynamics of bird and airplane flight...How to become an amateur ornithologist.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 SPIDERS

Spiders and their webs are superficially so familiar to us that we take them for granted. This article should spark interest in the amazingly varied uses of spider silk.

The initial discussion may disclose "anti-spider" attitudes. Advise your pupils to suspend judgment and to look for clues in the article that would indicate whether spiders are beneficial or harmful to man.

As the reading proceeds, have the class compare an orb web with a suspension bridge. The bridge line of a web is analogous to the large suspension cables of the bridge. There is another similarity between the bridge line and suspension bridge cables. The cables are made of many wire strands and the bridge line is made of several strands of silk.

Suggestions for Class Discussion

• *Have your pupils recall what they have learned about insects. Are spiders insects?* No, spiders belong to a class of arthropods known as *arachnids.* They have four pairs of legs, no wings or antennae, and two body parts (the head and thorax are fused together in one piece).

• *Why doesn't an orb weaver get caught in its web?* The spider steps over the sticky threads and walks on the dry radii. Spiders also have oily feet which do not stick easily.

• *How does "ballooning" help the spiderlings?* It acts as a scattering device so that they do not all compete for the same food supply. (Have the class discuss what other animals do when their living area becomes overcrowded.)

• *How do spiders fit into communities of plants and animals? What do they eat and what animals eat spiders?* Spiders play an important part in keeping the insect population under control. They eat insects, and in turn, are eaten by other creatures–mostly birds, wasps, and other spiders.

• *Are spiders dangerous to people?* Should they be killed? Spiders are beneficial to man and, since most of them harm neither humans or plants, they should not be killed.

Few spiders are large enough or strong enough to pierce human skin. As far as is known, the only spiders in North America with a poisonous bite are the Black Widow and the so-called Brown House Spider.

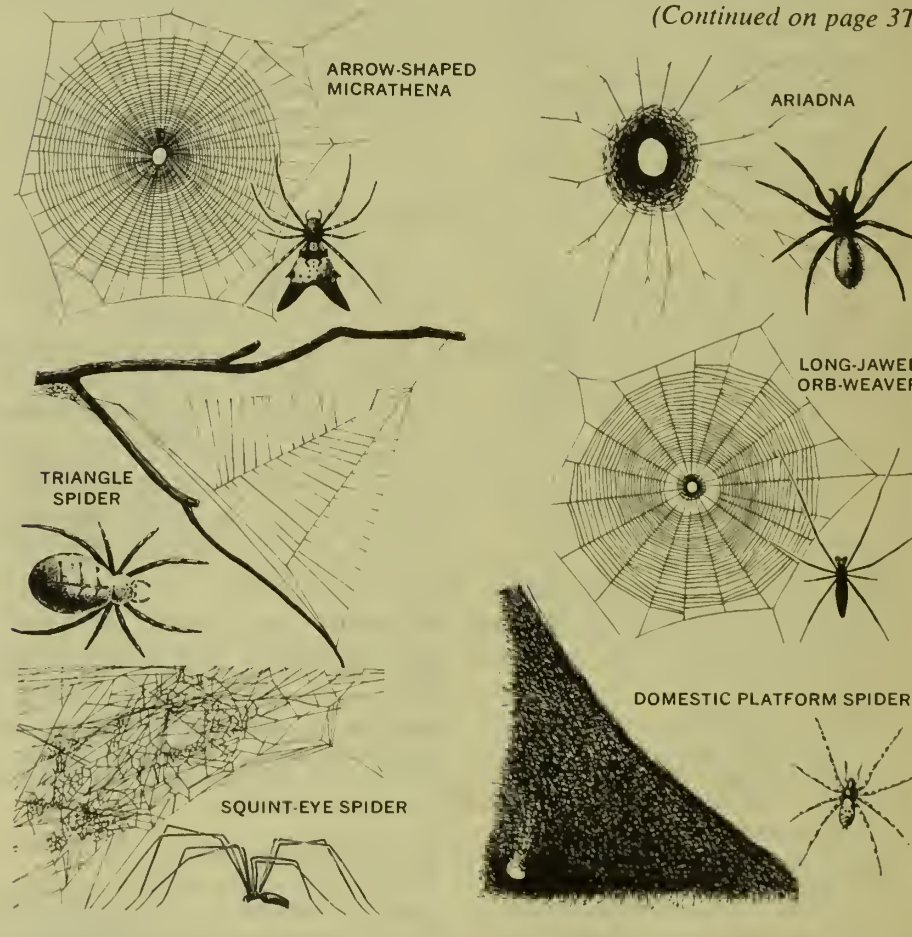
When these spiders are approached, they usually "play dead" or run away. Very few people who are bitten by these animals die as a result of the bite. Many brown spiders found in houses are not the Brown House Spider, which lives only in the southern and southwestern United States. The Black Widow ranges throughout the United States and southern Canada.

• *Why is spider silk not used to make fabrics?* In the 18th century a Frenchman did make a pair of stockings and a pair of gloves from spider silk, but large-scale fabric making is impractical. Each spider must be kept in a separate container and be fed live insects.

Activities

• *Encourage your pupils to look for examples of the four basic types of webs.* The orb, funnel, and sheet webs are generally found in gardens and fields; the irregular webs of house spi-

(Continued on page 3T)



This gallery of six spiders and their webs shows how the webs range from simple, closely woven sheets to intricate orb webs. Some orb webs, such as that of the triangle spider (above), are just portions of an orb, like a piece from a pie.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . .
(Continued from page 2T)
ders, inside homes and garages.

• *The class can collect a few spiders and study their behavior.* Put each spider in a separate jar. Orb weavers should be put in gallon jars or larger containers to provide space for their webs. Spiders that spin smaller webs can be kept in pint or quart jars.

Cover the jar with its normal top and punch a hole big enough to push insect food through. Plug the hole with a piece of cotton when not feeding the spider. One good-sized, soft-bodied insect, such as a fly or cricket, is enough food for a week. When these insects are available, feed the small spiders fruitflies and the large spiders mealworms. The food must be alive and moving.

Your pupils can learn a lot about spiders by watching them spin webs and catch their food. Put some non-food item in the webs and see what the spiders do with it. Also, see how spiders react to a "bad-tasting" insect such as a stinkbug or ladybug.

A tuning fork held against a web sets up vibrations very much like those of a struggling insect. See how many times different spiders rush out to attack the fork before they learn that it is not food.

PAGE 5 BENDING LIGHT

Three articles in this issue of *N&S* — lenses (pages 5-7), telescopes (pages 8 and 9), and camera and eye (page 16)—complement each other. They may be used as supplementary material for a unit on light.

Every student should understand at the beginning that light has its source in some luminous body, whether the Sun, a star, a flame, or an electric light. We can see non-luminous objects only because they reflect light into our eyes. Our eyes do not emit light, as the ancient Greeks believed! Explain, too, that the Sun's light, no matter how often reflected or how much diffused, illuminates most of what we see in the daytime.

Here are important concepts that your students should grasp:

• Lenses and mirrors alter the straight-line paths of light by refraction and reflection.

• The shape and size of lenses and mirrors, and their arrangements in optical systems, determine how light rays are bent and where images are formed.

• The magnifying power of lenses makes it possible to learn much about extremely small and extremely distant objects.

Suggestions for Classroom Use

After students have read the article, you might start a discussion by asking them to mention all the familiar devices that incorporate lenses. Some not mentioned in the articles are eyeglasses, movie and slide projectors, field glasses, reflectors of various kinds, floodlights, and pocket lenses.

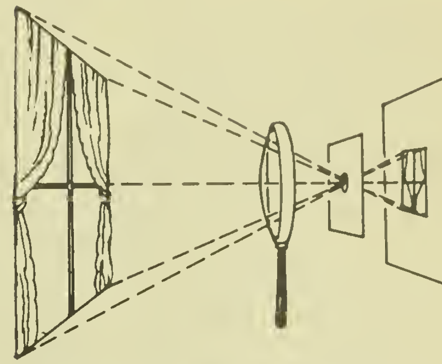
Eyeglasses might be another starting point for discussion. Ask pupils with glasses to describe how things look to them without glasses. Then explain that in these cases the eye is unable to bring light rays to a focus on the retina. By changing the direction of light rays somewhat, eyeglass lenses bring them to proper focus.

An important principle to discuss is the refraction of light. You can demonstrate the bending of light as it passes from one medium to another. Fill a glass tank, fishbowl, or other transparent container with water. Add a few drops of milk, or a pinch of flour or starch. Stir the water so that the suspended matter is uniformly distributed. Direct a beam of light from a flashlight or from the Sun itself (through a pinhole in a black sheet of paper) into the water at the surface. The beam will be noticeably bent, especially if you decrease the angle between beam and water. This demonstration is more effective in a darkened room.

Light passes through various materials at slightly different speeds. The more *optically dense* the material, the slower is the speed of light through it. Here are a few common substances ranging from the least optically dense to the most: air, ice, water, ethyl alcohol, glycerin, quartz crystal, glass (which varies according to the kind), rock salt, and diamond. As density increases, so does the amount of refraction. In other words, light is bent more in passing from air to diamond than from air to glass. This characteristic helps to make identification of such materials highly accurate.

Activities

• The lens article describes how to form real images with a magnifying lens. The lens and screen comprise a crude camera. As a special project, some of your pupils might add a diaphragm to this "camera," which they could explain to the rest of the class *(see "How It Works—Camera and Eye," page 16).*



Hold cards with different sized holes between a lens and a projected image to change the brightness of the image as a camera diaphragm does.

To make a diaphragm, cut up light cardboard into six-inch squares. Cut a circular hole in each, varying them from about ¼ inch to about 2 inches in diameter. Hold each card in turn behind the lens *(see diagram)* to demonstrate how the brightness of the image decreases in proportion to the size of the diaphragm opening.

• Your ambitious pupils might be interested in building a pinhole camera to record images on film. Plans for this project are described in the Cornell Science Leaflet on light *(see References).*

• Another interesting project is making a telescope with lenses available singly or in kit form from the Edmund Scientific Company, Barrington, New Jersey. A kit (Stock No. 2) of 10 chipped lenses with an eight-page project booklet costs $1. A complete 8-power refracting telescope kit (No. 70,238) is $3. Minimum order is $2; there is no charge for postage.

• Other activities might include tracing light rays through common lenses; studying a model of the human eye, if one is available; shining a flashlight in a subject's eye to reduce the diameter of the pupil.

References

• *700 Science Experiments for Everyone,* compiled by UNESCO, Doubleday, 1964, $4.

• *Light,* Cornell Science Leaflet, Vol. 53, No. 3, New York State College of Agriculture, Cornell University, Ithaca, New York, 1960, 25 cents.

• *Experiments in Seeing,* by Harry Asher, Basic Books, 1961, $4.95.

• *Light and Sight,* by Charles Gramet, Abelard-Schuman, 1963, $3.75.

A Quantitative Approach . . .
(Continued from page 1T)

Very few school systems have at the present time any coordinated program of science education from grade school to junior high to senior high. However, many of the present graded science texts are designed for cyclic learning. As the student grows older, he meets over and over again the same subject material but treated at different levels to match his growing understanding.

Cyclic learning certainly has its usefulness, but in both college and high school we have experienced the annoyance of having to make the student "unlearn" a garbled view. Worse yet is the frustration that comes from having students so familiar with memorized terminology that they are bored with any attempt to attack the material from an analytic basis.

There is no need to make science study each year a complete unit within itself. In particular, there is no need to make little scientists out of the children during a given year. Grade school children do not figure things out in the way mature scientists would, and there is not the slightest evidence that they can be taught to do so. Setting up pseudo experiments in hope that pupils will use or learn a scientific method is an adult delusion.

Specific Tasks for the Grades

There are, however, some very specific tasks that can be accomplished in the grades and which would form a useful base for future work in the sciences. The detailed proposals for a grade school science program that follow are designed to form such a base.

4. *From the very beginning, science should be presented as a discipline usually requiring quantitative treatment. Grade by grade the science program should be tied to the math studies.*

The theme of our whole attempt is measurement and functional dependence. It should be carried out first by counting, then by observing simple phenomena involving addition and subtraction, and finally in the higher grades by compounding measurements. From first grade on, everything from grades to shoe sizes should be measured by the students and graphed. (First graders have made such graphs with only the worksheets from our units as guides.)

If, by the time they get through the grades, children could be familiar with measurements of length, mass, time, temperature and a few compound variables, and if they had had the continual experience of analyzing—usually graphically—the dependence of one variable on another, they would have a reasonable basis for more advanced work in the junior high.

EXAMPLES OF PROJECTS

Here are some examples of the units developed during the summer workshop. Each unit consists of a one-page work sheet for each student and a one-page instruction sheet for the teacher.

Grades 1 & 2: Pan balance comparison of small objects; measurements and graph of class height distribution; measurement and graph of temperature during day; timing races; measuring speed of solution as a function of temperature; counting of bones in arm and hand.

Grades 3 & 4: Measurement and graphing of class weight distribution; force-exerting contests; weight of objects in salt water, fresh water, and air; treasure-map following; temperature versus time in water being heated; measurement and graphing of pulse rates.

Grades 5 & 6: Graphing of water pressure versus depth; school mapping by angles and pacing; estimation of insect populations; measuring velocities of thrown ball, bike, running, walking; voltage of various cell combinations.

Many of the projects and phenomena to be studied *(see box)* are common to any grade school science program. In every case, however, we stress the *quantitative* treatment, appropriate to the grade level, of phenomena which can be *immediately observed and measured* by the student. Most existing elementary texts and programs are so qualitative that it would be hard to bend too far backward in this regard.

Projects will not be presented to the students as pure measuring problems; instead the problems will consist of quantitative determinations of the natural science relationships usually studied in school under the heading of science.

Tools for More Mature Learning

We consider the elementary grades to be primarily concerned with the preparation of tools for more mature learning. One set of proper tools that can be taught youngsters is the quantitative attack. It consists of a mental framework for thinking in terms of one variable being a function of another. It consists of the practical experience of measuring quantities and graphing one against another. It consists in the physical use of measuring apparatus and first-hand experience in the limitation of accuracy. Such tools and experiences are the ABC's of science.

5. *The grade school science program should not deal with any generalizing model that cannot be examined directly by the students.*

Insistence on this point is probably the most drastic departure of the proposed program from traditional ones. It rules out all mention of atomic theory, solar systems, magnetic domains, invisible genes, and convervation laws.

We want to avoid these magnificent models and organizing schemes, not because we think they are unessential but because they are far too important to suffer the ignominy of false understanding. A sixth grader in our house knows that energy is conserved; she does not, however, know what energy is. Our fourth grader has memorized the names of the planets and their distances from the Sun, but she does not know how far a mile is, nor did she learn in school where to find the planets or how they progress through the heavens at night.

Measurements in Astronomy

There are, however, many sensible things to do in the grades concerning astronomy. At the fourth or fifth grade level, pupils can take turns timing sunrise and sunset (and describing in detail to the class the phenomena they observe at those times on Earth and in the sky). The duration of daylight could then be graphed throughout the school year. In the fifth or sixth grade, the class delegate could measure with compass and protractor the angles the rising and setting Sun makes with the east-west line. (How many adults know where the Sun really rises?) Another reading taken each noon could produce data for the making of three-dimensional models of the ecliptic.

Quantitative observations such as these are within the competence of grade school pupils. Would they not surely learn more about our universe this way than by memorizing names of Solar System models hanging from the classroom ceiling in defiance of all rules of scale?

6. *The science program must not entail large expenditures of money for equipment.*

The experience of the high schools and colleges has been that expensive equipment designed exclusively as a teaching tool is usually not very effective. All of the projects in this proposal can be and are best performed with a few simple, inexpensive tools. Most are commercially available, although a few would at the present time have to be specially constructed.

7. *The science program must have specific grade by grade goals which can be tested.*

We define these goals in terms of sample examinations for the students. The exams emphasize not the student's knowledge of natural science facts, but rather his ability to perform specified tasks of measurement and analysis ■

nature and science

VOL. 2 NO. 3 / OCTOBER 19, 1964

SPECIAL-TOPIC ISSUE

BIRDS ON THE MOVE

How they find their way
How they fly
How to study them

ABOUT THIS ISSUE

As you read this, many birds have already flown southward on their autumn migration. The huge flock of migrating grackles on our cover sets the theme for this special-topic issue: Birds on the Move.

Bird migration has puzzled and amazed man for centuries. The article beginning on page 3 describes the incredible journeys of birds, and tells what scientists have learned about migration. The article is adapted from a new book, *Bird Migration*, by Donald R. Griffin, published in paperback (Science Study Series, Doubleday Anchor Books, New York, $1.25) and in hardcover (The Natural History Press, New York, $4.50).

The WALL CHART on pages 8 and 9 shows how birds fly, and how their body structure makes flight possible. A SCIENCE WORKSHOP beginning on page 10 tells how to "spy" on birds—how to identify them and study their lives.

Radar has been used by scientists to study bird migration. How radar works is explained on page 16.

This special issue was prepared with the advice of Dr. Wesley E. Lanyon, Associate Curator of Ornithology, The American Museum of Natural History. Editor of the issue for *Nature and Science* was Laurence P. Pringle.

nature and science

VOL. 2 NO. 3 / OCTOBER 19, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez

CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow

CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore.

Contents

CREDITS: Cover, p. 2, photo by Leon D. Harmon from Photo Researchers, Inc.; pp. 3, 4, 6, 7, 8-9, 11, 13, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, photo from Fish and Wildlife Service; p. 6, photo from Donald R. Griffin; pp. 7 (map), 8-9 (bird wing), 12, 15, 16, drawings by R. G. Bryant; p. 10, photo by Don Wooldridge from National Audubon Society; p. 13, photo by George Cope, Educational Services Incorporated; p. 15, photo by Franklyn K. Lauden; p. 16, U.S. Weather Bureau photograph from "Watching Bird Flights by Radar," by Patrick E. Hughes, *Audubon Magazine*, May-June, 1964.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

THE INCREDIBLE TRAVELS OF BIRDS

How do birds find their way as they migrate thousands of miles? Scientists are beginning to solve the mysteries of bird migration.

■ It is a clear night in early autumn. A man sits in his back yard, peering at the Moon through a telescope. Sometimes he pauses to write on a notepad held in his lap.

No, he is not looking for a house lot on the Moon! He is helping to solve one of many puzzles still left on Earth—the mystery of bird migration. His telescope reveals birds passing between him and the Moon as they fly southward in the night sky.

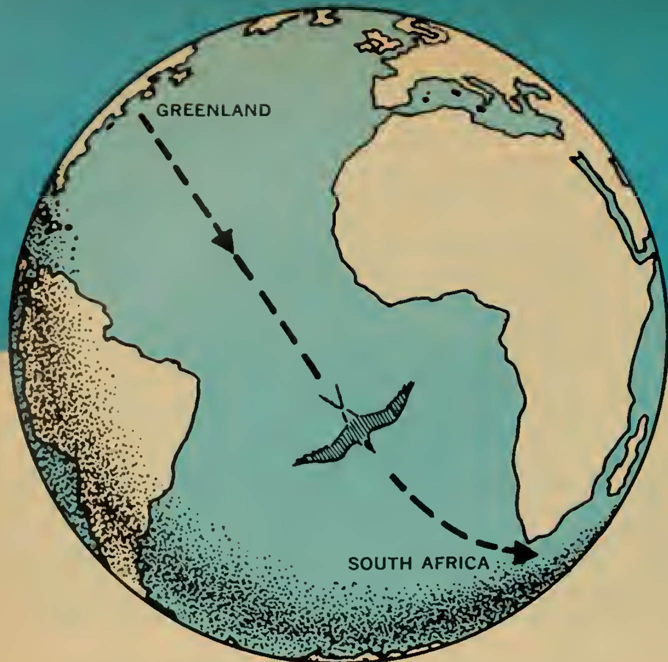
Bird migration has caused amazement for centuries. At first, men simply wondered where birds went in the winter. Did they sleep in hollow trees, in caves, or in mud? Many people thought so.

Gradually, people discovered that most of the birds in the northern half of the world fly south to warmer climates in the fall, and then return in the spring. But this discovery led to dozens of new mysteries.

How can a small bird—say a swallow that weighs only half an ounce—fly as far as 5,000 miles *twice* each year? Why do some birds migrate while birds of another, closely related, species stay in the same area year round? How do robins and bluebirds, for example, find their way, returning each spring from wintering areas in the southern United States to the same garden or birdhouse in the north? How do young Golden Plovers—flying the route for the first time and *without* their parents—find their way 8,000 miles from the arctic to a winter home in South America?

Some of these questions are still unanswered. However, scientists have solved many of the mysteries of bird migration. They use equipment such as telescopes, radar, airplanes, and identity bands, and they are aided by the keen eyes of thousands of amateur *ornithologists*—people who study birds. Members of bird study clubs keep careful records of the comings and goings of different kinds of

(Continued on the next page)



This Arctic Tern, banded in Greenland, flew at least 9,500 miles to South Africa in a few weeks time. Birds often fly a hundred miles or more each day as they migrate.

The Incredible Travels of Birds (continued)

birds. The migration routes of many birds have been traced by simply comparing the sightings of "bird watchers" who live throughout the world.

Tracing the Paths of Migration

Another source of information on bird migration is *banding*. Numbered identity bands are attached to the legs of birds by scientists and amateurs who have special banding permits. Then the birds are released. So far, about 15 million birds have been banded in North America and Europe. Through the years, enough bands have been recovered to help scientists discover where most kinds of birds spend the winter months. Bands have also helped reveal the amazing distances that some birds fly between their summer and winter homes.

Once, a Lesser Yellowlegs—a robin-sized shore bird—was trapped and banded in Massachusetts on August 28. Six days later it was shot on the island of Martinique, north of Venezuela, South America. If the bird flew a perfectly straight course to Martinique, it must have flown an average of 322 miles a day.

Another time, a downy young Arctic Tern was banded in Greenland on July 8. It was captured on October 30 near Durban, Natal, in eastern South Africa *(see map)*. Between these two dates, the tern had lost its coat of down, grown feathers, and flown at least 9,500 miles!

Not all birds migrate so far. However, these records show that bird migrations are not limited by the strength of birds, but by the size of the Earth!

Most of the time birds come and go, twice each year, without calling our attention to their actual migratory flights. One reason we don't notice them is that many birds migrate at night. If you peer at the Moon through a telescope or binoculars on nights of heavy migration, like the man we mentioned earlier, every few minutes you may see a bird flying across the Moon's face. Moon watching brings into view only a tiny fraction of the night-flying birds passing by.

Mystery of the Angels

Radar is another tool for studying bird migrations. Radar stations send out beams of radio waves to detect aircraft. If the radio waves hit an object, they bounce back-like an echo *(see page 16)* and cause a spot of light to form on the radar screen.

As radar equipment was developed in the early 1940's, certain echoes on the radar screens could not be identified. These echoes moved about on the screens, appearing and disappearing. Radar operators called the echoes "angels."

For several years, the angels remained a mystery. Gradually, however, evidence built up that radar angels were like birds in many ways. They moved at about the right speed; they were most abundant in spring and fall; and they didn't fly higher than a few thousand feet.

Finally, someone investigated some of the places where

Numbered bands have been put on the legs of about 15 million birds. When the bands are recovered, they enable scientists to discover where and how far birds travel.

the angels appeared most often and found huge flocks of roosting starlings. The strongest angels appeared on the radar screen just as thousands of starlings left their roosts and scattered in all directions to search for food. There are still some unexplained types of radar echoes, but most of the angels have turned out to be birds.

Sometimes birds can be identified by their radar echoes. For example, fast-moving angels are probably echoes from flocks of shore birds.

How Do Birds Navigate?

Of all the mysteries of bird migration, the most puzzling is bird *navigation:* How do birds find their way? One by one, different explanations have been suggested, tested, and rejected.

Birds have excellent eyesight. Do they find their way by simply following landmarks that they remember? This theory may explain the "homing" of birds when they are in familiar country. But it does not explain the long night-time flights of migrating birds. Also, young birds (Golden Plovers, for example) often migrate thousands of miles without their parents—along routes that they have never traveled before.

Do birds fly south because they can detect the warmer temperatures in that direction? At first, this theory seems to be a wonderfully simple explanation of the annual migrations. However, land features such as lakes, mountains, and deserts affect the air temperature near them. For example, a bird just north of Lake Superior in the summer would find warmer air *north,* not south, of the cold body of water.

In 1950, an English scientist named Dr. Geoffrey Matthews made an important discovery about bird navigation. In his experiments, he put some pigeons in closed boxes and drove several miles north of Cambridge University. Then the birds were released, one by one. Even though they were in strange territory, the pigeons usually headed south—back to Cambridge.

How did the birds know which way to fly? By releasing pigeons in all kinds of weather, Dr. Matthews found an important clue—the birds did not head south as often when the sky was overcast. When they could not see the Sun, they flew in all directions. It seemed incredible that a bird might use the Sun as a "compass" to find its way. The idea had been suggested long ago, but it seemed far-fetched. Wouldn't a pigeon be thrown off course as the Sun changed position in the sky? Dr. Matthews decided to investigate the idea further.

He began a different experiment, using birds that were used to finding their way to Cambridge when let go in the middle of the day. The birds were divided into three groups and taken 127 miles from Cambridge. One group was released early in the morning, another in the late afternoon, and the third group at midday, as usual.

Each group of pigeons headed for home with equal accuracy. It made no difference that the Sun was not in the position where the birds might have come to expect it. It seemed that the pigeons found their way by the Sun, *even as the Sun's position in the sky changed during the day.*

Dr. Matthews tested another kind of bird, the Manx Shearwater (a pigeon-sized sea bird), in a similar experiment. The shearwaters did as well or better than the pigeons. Other scientists have tried the same sort of experiment with different birds, but without much success. Nevertheless, it seems that some birds navigate with a "Sun compass."

Experiments with Starlings

At about the time that Dr. Matthews was experimenting with pigeons, a German scientist, Dr. Gustav Kramer, was also investigating bird navigation. He decided to experiment with starlings, which migrate in the daytime.

The birds were put in special circular outdoor cages. The cages had perches in their centers and around their edges. The floors of the cages were made of transparent plastic, so that Dr. Kramer could watch the birds' motions from underneath.

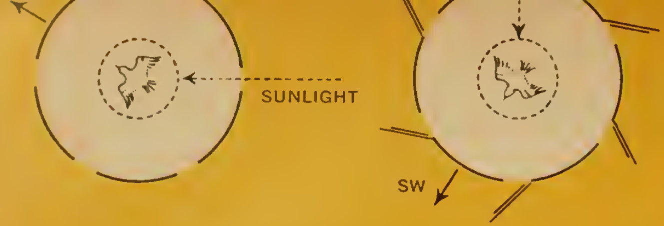
In the spring, he noticed one bird that tended to fly back and forth from the center of its cage to the perches on the cage's northwest side. This direction was the normal one for the bird's spring migration. Dr. Kramer rotated the cage, to see if there was something on one side that attracted the bird. It kept heading northwest.

Next, Dr. Kramer built a wall all around the cage, cutting off the view of the surrounding landmarks. The bird still headed northwest. It was not finding its way by local landmarks.

The starling could still see the sky. Dr. Kramer wondered if there was something in the sky that helped the bird find directions. To find out, the cage was enclosed so that the bird could see only the sky through six windows. Then shutters were placed on the windows. A mirror was put on the inside surface of each shutter and the shutters were closed partway.

Because of the mirrors, when the bird looked out the window it saw a part of the sky that was 90° to one side of the sky that was actually beyond the window. When the mirrors showed the sky 90° to the left, the starling headed about 90° to the left of its former direction *(see diagram on next page).* When the sky was overcast, the bird did not choose any particular direction. Dr. Kramer's experiments agreed with Dr. Matthews'—the starling was finding its migration direction by a "Sun compass."

(Continued on the next page)



This caged starling faced northwest during its spring migration season. When mirrors were arranged so that the sunlight appeared to come from 90° to the left, the bird headed 90° to the left.

The Incredible Travels of Birds (continued)

Studying Birds under the Stars

Dr. Kramer next experimented with birds that migrate at night—European warblers. They were kept in the same sort of cages as the starlings. The tops of the cages were open to the night sky, but the birds could not see any local landmarks. From beneath the clear plastic floors of the cages, Dr. Kramer and his assistants watched the birds.

They studied the birds' *intention movements*—small scale versions of the birds' migratory flights. Sometimes the warblers faced in one direction on a perch and fluttered their wings. Like the starlings, they flew back and forth between the center of the cage and the perches on one side. Dr. Kramer noted how many seconds the birds spent heading in various directions.

The warblers tended to head in directions roughly the same as those in which they would have been migrating. Also, the directions changed with the seasons—roughly south in the fall and north in the spring. In between seasons of migration, the birds were not very restless and headed in no particular direction. Most important, Dr. Kramer discovered that the warblers scattered widely when the night sky was overcast.

Were the warblers finding directions by something in the night sky? The idea had to be investigated further. A few years later, two German scientists, Dr. Franz Sauer and his wife, began experimenting with warblers. (The Sauers are now studying bird navigation at the University of Florida in Gainesville.)

The Sauers used circular cages like Dr. Kramer's. They studied the headings of their birds not only under the natural sky but also in a *planetarium*—a domed building where pictures of the night sky can be projected on the ceiling. This "artificial sky" had several advantages. Cloudy weather was no problem, and the sky could be changed to show a view of the stars in another season.

The Sauers were excited with their findings. Certain warblers consistently headed in the direction that was nor-

A MAN WHO TRACKS BIRDS WITH AN AIRPLANE

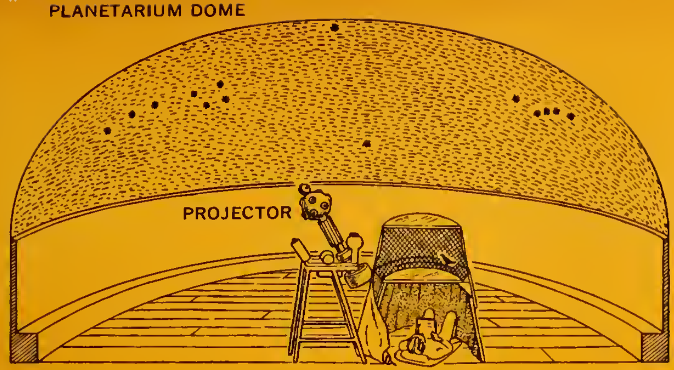
■ How do birds find their way home when they are let go in a place that is strange to them? For 25 years this question has puzzled Dr. Donald R. Griffin *(left)*, now Professor of Zoology at Harvard University in Cambridge, Massachusetts. Now he has written a book, *Bird Migration,* upon which this article is based *(see page 2)*.

In the 1940's, Dr. Griffin tackled the puzzle of homing birds in the most direct way. "I decided to learn to fly myself and trace the actual routes flown. I managed to do this with a number of gulls and gannets, circling in a Piper Cub for as long as 10 hours at a stretch while the bird did its cross-country flying."

In one series of experiments, gannets (sea birds that are about twice as big as gulls), were captured at their nests on Bonaventure Island and taken to an airport in Caribou, Maine *(see map)*. When the birds were released, one by one, Dr. Griffin followed them in an airplane.

He followed nine gannets for distances ranging from 25 to 230 miles. They seemed to wander in all directions *(see map)*.

His observations show that gulls and gannets manage to get home without any highly developed ability to pick the right direction. However, Dr. Griffin does not believe that this applies to all birds. In fact, another scientist has



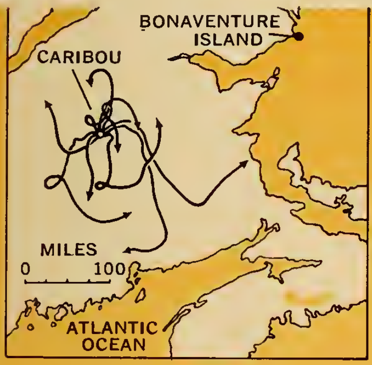
As the stars of the autumn night sky were projected on a planetarium dome, scientists watched the motions of caged warblers (left). The lines in the circles above show the amount of time that a warbler headed in various directions. When the stars were shown, the bird tended to head southeast (left circle). When the dome was dimly lit without stars visible, the warbler headed in many directions (right circle).

mal for their migration *(see diagram)*. These headings were equally accurate whether the birds were shown the sky itself or the star pattern in the planetarium. Clearly, *the birds were finding their way by the stars.*

What made these findings even more remarkable was the kind of birds that the Sauers used in some of their experiments. They had collected eggs from warbler nests, hatched them, and raised the birds in windowless rooms. The birds had never seen the sky before. Yet, when they saw the night sky in spring or fall, most of them turned toward their normal migration direction. This meant that the warblers were born with a built-in "star compass."

A great deal has been learned about bird navigation, but scientists are careful not to jump to conclusions based on their findings so far. The experiments show that some birds can find their way by the Sun and stars. However, the experiments must be repeated again and again, using great numbers of different kinds of birds. Only after careful checking will this *theory* of bird navigation become a *fact*.

Meanwhile, each new discovery about bird navigation leads to a new puzzle. Do birds find their way by a whole pattern of stars? Or do they use one star (such as the North Star) as a beacon? Exactly how can a bird find its way by simply seeing the Sun's position in the sky? Scientists admit that bird migration is still one of the most challenging mysteries on Earth ■



This map shows routes flown by nine gannets when they were let go at Caribou, Maine. Four of the birds returned to their home on Bonaventure Island, but Dr. Griffin could not follow them that far.

followed flocks of racing pigeons that were let go in strange country and found that they took a much more direct route home than the gannets.

Studying Mice, Birds, and Bats

When Dr. Griffin was a boy living on Cape Cod, Massachusetts, he hunted and trapped animals and became fascinated with the lives of small mammals, such as mice and shrews. "I always found small mammals enough like ourselves," he says, "to feel that I could understand what their lives would be like—and yet different enough to make it a sort of adventure and exploration to see what they were doing."

A biology teacher interested him in bird banding while he was a student at Phillips Academy in Andover, Massachusetts. Then he wondered, "Why not put bands on bats too?" At the age of 17, he became one of the first persons to band bats in the United States.

His interest in the lives of bats continued when he studied zoology at Harvard University. Using an instrument that detects sounds too high for human ears to hear, he discovered that bats make high-pitched squeaks which echo back from objects and guide the bats in their flight. In one experiment, he covered the mouths of bats so the animals could not send out any sounds. The bats bumped into objects because they had no echoes to guide them.

Dr. Griffin lives with his wife and four children (including 16-year-old twins) in Belmont, Massachusetts. So far, none of his children plan to follow their father's science career. Dr. Griffin sometimes relaxes by sailing, but his science job is also his favorite hobby. He is still interested in bats. "We are beginning to understand some of the ways in which birds navigate," he says, "but what about bats? Many bats migrate hundreds of miles each spring and fall. Their vision is very poor when compared with that of birds. How do they find their way?"

That is a mystery that some future scientist—perhaps you—may solve ■

Birds On The Wing

The wavy line above shows how rapidly the "hand," or outer part, of a bird's wing beats to push the bird forward. The "arm" moves a shorter distance. These drawings were made from high-speed motion pictures of a chickadee in flight.

■ As birds developed from the reptiles millions of years ago, they changed in many ways that enabled them to become flyers. Their "front legs," or wings, lengthened and developed feathers and strong muscles. Their bones grew lighter and fewer in number, and their lungs, hearts, and digestive systems changed in ways that give birds the greater energy they need for flying.

In spite of what many people believe, the flapping of a bird's wing is not enough to get the bird into the air. Like an airplane, a bird must have a wing of a definite shape. If you could look closely at a cross-section of a bird's wing near its body, you would see that it is curved outward on top and inward below. The airplane has a wing of similar shape. The name for this shape is *airfoil.*

In 1738 Daniel Bernouilli, a Swiss mathematician, made discoveries that help us to understand the airfoil. He learned that the faster a fluid flows—and air is a fluid—the less strongly it presses against the pipe or whatever it is flowing through.

As a bird or airplane wing cuts through the air, some of the air flows over the top and some underneath (*see diagram*). The air moving over the bulge on top has to travel farther, and therefore faster, than the air moving under the wing. Because of its faster speed, the air on top does not push down with as much force as the air underneath pushes upward, so the wing rises. This upward force is called *lift.*

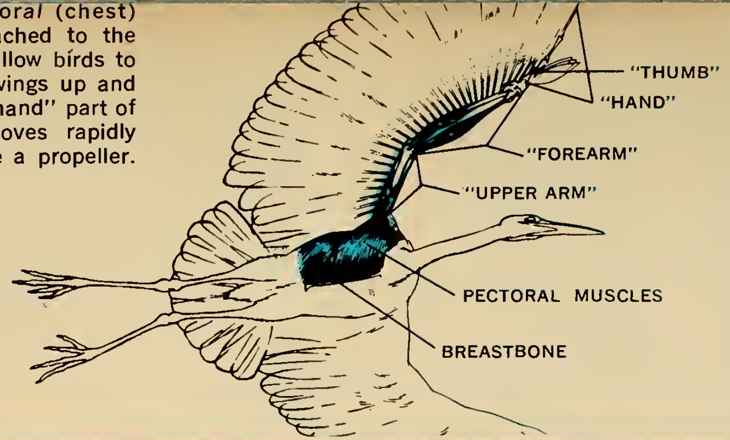
When a wing is tilted upward, as in a climb, air strikes the bottom of the wing at an angle. This force pushes upward, too, just as water pushes up against a water ski. But most of the lift of a bird's wing comes from the low-pressure effect of its airfoil shape.

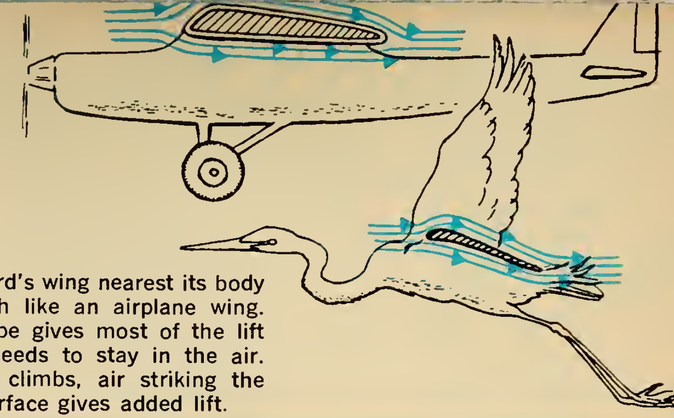
A bird or airplane needs more than lift. A second force, called *thrust,* must push or pull in a forward direction. In an airplane, a piston engine and propeller or a jet engine provides thrust. But a bird's wing tips are actually its propellers! A bird gives itself thrust by rapidly moving its outer wing, or "hand," up and down. Only the downstroke produces thrust; the upstroke brings the wing into position for another downstroke. This is something like rowing a boat. A rower dips his oars into the water and pulls. Then he moves the oars into position for another power stroke.

All these special features permit birds to perform almost unbelievable feats. The Golden Plover migrates up to 2,400 miles without stopping. Some swifts can fly briefly at more than 100 miles an hour.

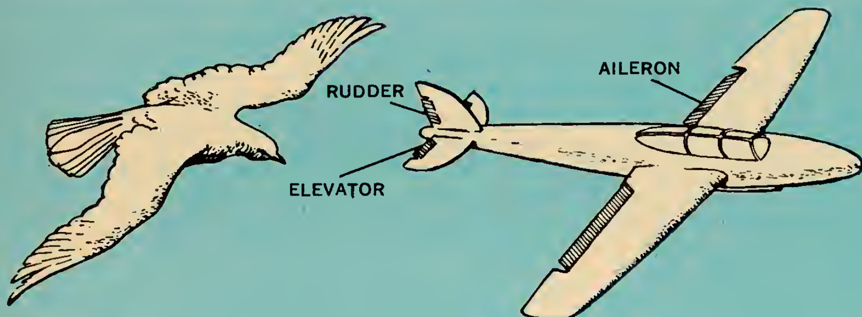
Many birds, of course, can't fly so well, and a few don't fly at all. But most of the 8,600 *species*, or kinds, of birds have adapted themselves well to living in the Earth's air ■

Strong *pectoral* (chest) muscles attached to the breastbone allow birds to move their wings up and down. The "hand" part of the wing moves rapidly and acts like a propeller.

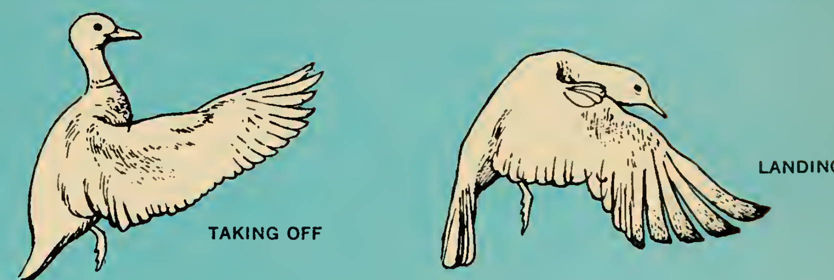




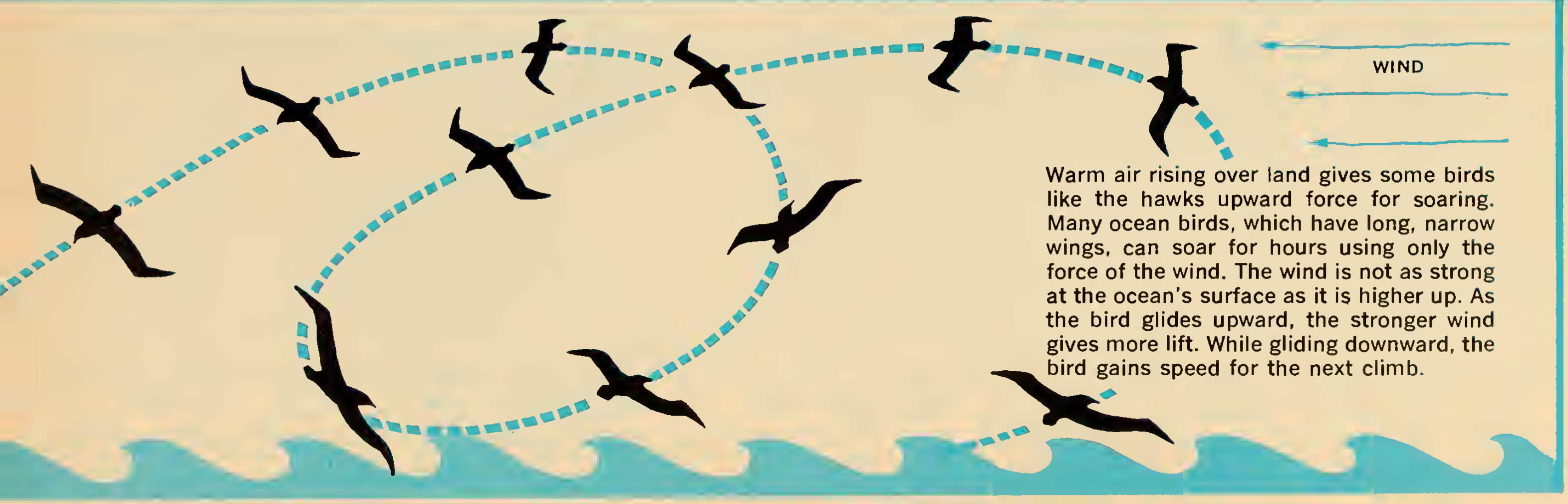
The part of a bird's wing nearest its body is shaped much like an airplane wing. This airfoil shape gives most of the lift that the bird needs to stay in the air. When the bird climbs, air striking the wing's lower surface gives added lift.



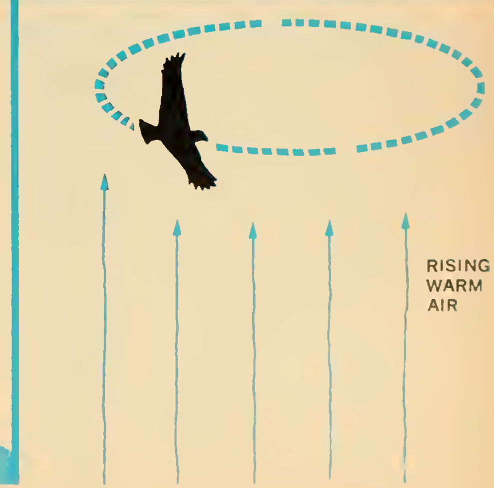
Birds steer mainly by tilting their wings and adjusting their wing feathers. A bird's tail helps in making sudden turns. An airplane has adjustable control surfaces called a rudder, elevators, and ailerons. When one of these hinged surfaces is tilted by the pilot, air pushes that surface in the opposite direction.



When taking off, a bird bends its "wrist" and moves its "hands," or outer wings, up and down. When the bird has enough lift, it begins to fly in its usual way. When landing, a bird brings its wings forward to increase air resistance and cut its speed. The bird spreads its tail feathers, too, in braking to land.



Warm air rising over land gives some birds like the hawks upward force for soaring. Many ocean birds, which have long, narrow wings, can soar for hours using only the force of the wind. The wind is not as strong at the ocean's surface as it is higher up. As the bird glides upward, the stronger wind gives more lift. While gliding downward, the bird gains speed for the next climb.



HOW TO SPY ON BIRDS

by Laurence Pringle

The lives of birds are full of mysteries. You may discover something new to science through the fascinating hobby of bird study.

■ I am a birdwatcher. Some people think that birdwatchers are funny, and I don't blame them. Birdwatchers do some odd things.

Sometimes we get up before dawn, put on old clothes, and hurry to the nearest swamp. Once in the swamp, we may sit for hours, or sneak around, peering into the bushes.

Birdwatchers also seem odd to some people because of the names of the birds that we "watch." If you listen to birdwatchers, you may hear, "There goes a Yellow-bellied Sapsucker!" Or, "Did you see that Roseate Spoonbill?"

Birdwatchers admit that some birds have funny-sounding names. But many of the names *do* describe the bird—a Yellow-bellied Sapsucker is a woodpecker with a yellow belly. It pecks holes in trees and licks up the sap that seeps out. A Roseate Spoonbill is a rose-colored wading bird that strains food from swamps with its spoon-shaped bill.

There are about ten million birdwatchers in the United States. Actually, many of these people do much more than *watch* birds. They *study* birds—taking censuses, learning about the mysteries of bird migration (*see page 3*), and observing bird behavior. Bird study is a popular hobby because people are fascinated by the beauty, sounds, and movements of birds, and because there is so much unknown about birds.

Anyone who doubts that he can discover something new about a bird should ask an *ornithologist* (a person who studies birds) about Mrs. Margaret Nice. Beginning in the 1930's, Mrs. Nice studied the song sparrows that lived near her home in Columbus, Ohio. She made all of her observations in her spare time while doing housework and raising five children. When her findings were published, ornithologists were amazed at the information she had gathered about song sparrows—their nests, eggs, territories, weights, movements, and so on. Even today, scientists use Mrs. Nice's research as a model for their own bird studies.

Learning To Identify Birds

Before you can study birds, you must be able to identify them. Autumn is a good time to begin. You can learn the birds that spend the winter in your area and then be ready to identify the many kinds that return in the spring.

You don't need much equipment: a field guide (*see list on page 12*), a pocket notebook, and a pen or pencil. Eventually you will want binoculars. However, they are expensive and you can get along without them for a while. I had over 60 birds on my "life list" (the total number of different kinds identified), before I bought binoculars.

Even if you live in a city, you probably know a few birds already. Knowing a few common birds helps to identify others, because you can compare the strange birds with those you know.

Here are some things to look for (and jot in your notebook) when you see an unfamiliar bird:

SIZE. How big is it? Compare it with birds that you know. Is it as big as a pigeon, or smaller than a sparrow?

SHAPE. Is its body long and slender, or short and chunky? Are its wings pointed or rounded? Is the bill long or short, thick or thin? Does the head have a crest? Is the tail long or short; rounded, square, or forked? Experts can identify many birds by their silhouettes alone.

MOVEMENTS. Does the bird fly straight or in a weaving, up-and-down pattern? Does it walk or hop?

HABITS. Is the bird climbing a tree, swimming and diving underwater, or soaring high in the sky? Does it flit about in the tops of trees, or stay near the ground?

How many of these bird silhouettes can you identify by size and shape alone? Notice how their bodies, wings, tails, and bills differ in shape. The birds above are (1) grackle, (2) Barn Swallow, (3) Chimney Swift, (4) Blue Jay, (5) Song Sparrow, (6) robin, (7) meadowlark, and (8) crow.

MARKINGS, COLOR, and SONG. Does the bird have a plain, spotted, or streaked breast? Is there a stripe over its eye, or a ring around it? Is the bird red with black wings, or black with red shoulders? Is its song like the carol of a robin or the jeer of a Blue Jay? Surprisingly, these three characteristics are often not as important as others in bird identification. Some birds imitate the songs of others, and even experts can be fooled by tricky lighting that seems to change a bird's color.

A few years ago, two ornithologists spotted a strange bird in a New Jersey marsh. It seemed to have a green back and stripes on its throat. "A European species," they whispered, "or at least one from the Northwest." With growing excitement they looked for some other markings. At last, they saw the bird clearly. It was a robin. The "green back" was imaginary.

One quick way to learn many birds is to go afield with an expert. There are probably several birdwatchers in your area, and they may belong to a club which you can join. Many clubs have special censuses or "big days," when the members roam far and wide trying to find as many kinds of birds as possible in one day. These "big days" are usually held in early May, during the peak of spring migration, and near Christmas, to census the wintering birds.

Bird-finding is much simpler if you know where to look. As you read about birds in field guides and other books, you will find many clues about their habits that will help you track down new kinds.

How To Study Birds

Some birdwatchers are content to simply identify birds, trying to see as many as possible in a day, year, or lifetime. This is great sport—like hunting for trophies—and a test for your eyes, ears, and legs. However, birdwatching can be much more than that. You can discover how birds live, and perhaps make a real contribution to science.

Begin with common birds that live in your own yard, garden, or along city streets. Each day, millions of people who live in cities see birds such as pigeons, starlings, and English sparrows. Yet, few of these people know how these birds live—their food, nests, territories, and so on.

Here are some questions you might try to answer about the birds in your area. Take the subject of migration. What kind of bird returns first in the spring? If you say, "the robin," many birdwatchers will disagree. Try to find out this coming spring. Also, when birds return from the south, do both males and females arrive at the same time?

Keep notes on the arrival dates of different kinds of birds. Also note the weather. By keeping notes like these for a few years, you can predict when certain birds will arrive. You may also discover that some migrating birds are slowed by bad weather, but others are not. Try to figure out why. Might it have something to do with the kind of food they eat?

There are many other parts of a bird's life for you to investigate—nest building, egg laying, the care and feeding of nestlings. You can easily spend all of your time studying just one pair of nesting birds. Or you might study all of the birds in one area, such as a nearby park or forest. Take a census of the birds in the area. Notice the numbers and kinds of birds that nest there. How do the birds' numbers change from season to season and from year to year? Try to figure out why bird numbers rise or drop.

By keeping careful notes on your observations, you may discover something new to science. You might even become an expert on the Yellow-bellied Sapsucker.

(Continued on the next page)

STUDY BIRDS FROM YOUR WINDOW

You can study the birds that spend the winter in your area by feeding them. Sometimes an ice storm coats trees, bushes, and the ground so that birds cannot find berries, insect eggs, and other foods. However, these conditions do not last long, and birds usually do not need to be fed to survive the winter. The best reason for feeding birds is simply to attract them so you can study them.

A feeder can be as simple or complex, as expensive or as cheap as you want it to be. You can buy bird feeders from garden stores and pet shops or make them from scrap lumber and other household items. The diagrams on this page may give you an idea of the kind you would like.

The kinds and numbers of birds that a feeder attracts depend on its location and the kinds of food offered. A feeder set in the middle of a lawn may not attract birds, because there is no nearby shelter for them. If you have no shrubs where birds can hide, drape or hang some pine boughs near the feeder for shelter.

To attract seed-eating birds, such as sparrows, cardinals, and juncos, offer sunflower, hemp, and millet seeds, and grains such as corn and wheat. These are available from garden and seed stores. Insect-eating birds, such as woodpeckers and chickadees, are attracted by peanut butter, suet, and fat trimmings (from a meat market). You can experiment with other kinds of food, such as fruit and table scraps. Begin putting out food in the autumn. Then the birds will discover the feeder and will begin using it as soon as winter arrives.

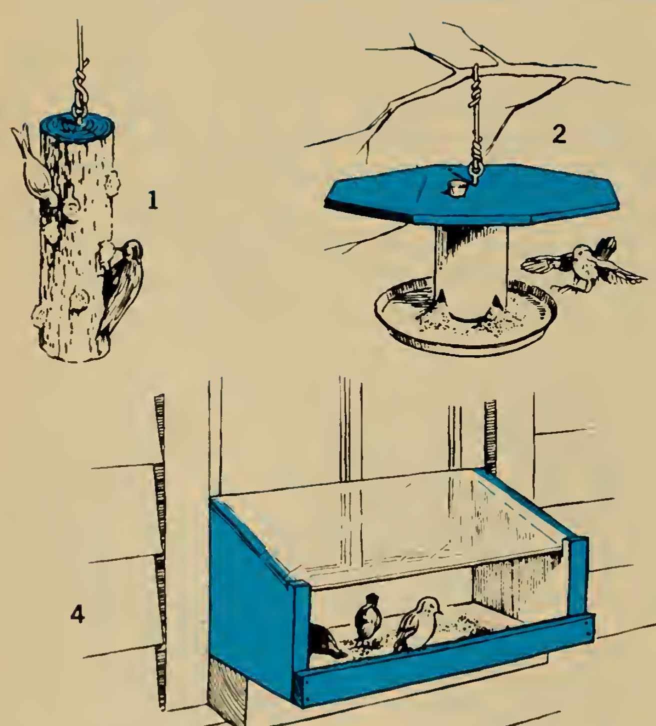
Some Things To Watch For

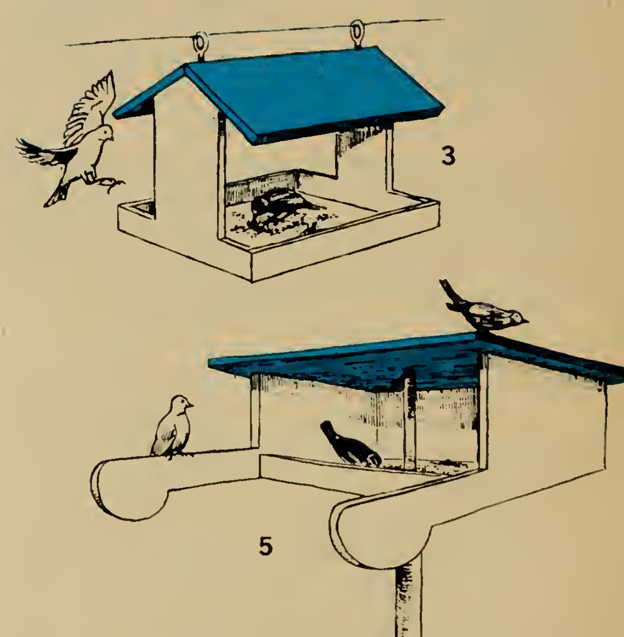
Take notes on what kinds of birds visit the feeder. When and how often do they visit? How long does a single bird or flock of birds stay at one time? Note the weather and see how it affects bird feeding.

Try to discover where else the birds roam in your neighborhood. What is the size of their winter territory? Is it bigger or smaller than their summer territory? Why?

You can learn a lot about bird behavior at a feeder. Do the birds feed one at a time, or in groups? How close will a bird allow another bird to get to it? Do some kinds of birds chase others away from the food? Do birds eat at the feeder or carry food away? What do birds do while waiting to get to the feeder?

Color some sunflower seeds with food coloring. Then put equal numbers of the different colors and of normal seeds in the feeder. Do the birds avoid any particular color? If so, can you figure out why?





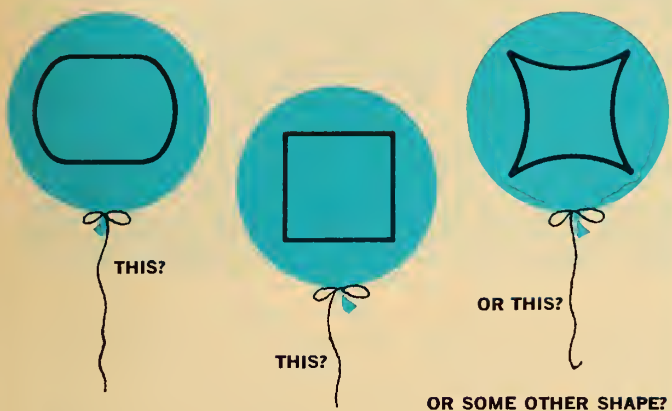
You can build or buy bird feeders like these. Hanging feeders (1, 2, 3) help protect birds from their enemies. Make a suet stick (1) by drilling holes in a piece of wood and filling holes with suet. A window feeder (4) allows you to study birds at close range. A weathervane feeder (5) keeps its back turned toward the wind.

■ Here are some books that will help you identify and study birds: A good beginning book is **Birds**, by Herbert Zim and Ira Gabrielson, Golden Press, 1956, $1 (paperbound). The best books for identification are **Field Guide to the Birds** (for eastern United States), 1947, and **Field Guide to Western Birds**, 1961, by Roger Tory Peterson, Houghton Mifflin Co., each $4.95. Good indentification books that also include information about bird nests and habits are **Audubon Land Bird Guide**, 1949, **Audubon Water Bird Guide**, 1951, each $4.50, and **Audubon Western Bird Guide**, 1957, $4.95, all by Richard Pough, Doubleday & Company, Inc.

prepared by DAVID WEBSTER

What Do You Think Would Happen...

...if you drew a square with a ball-point pen on a balloon and then blew the balloon up? What would the square look like? *Now try it.* What happens? You can also make a square on the balloon when it is blown up, then let the air out. What happens to the square?



Answers to Brain-Boosters appearing in the last issue

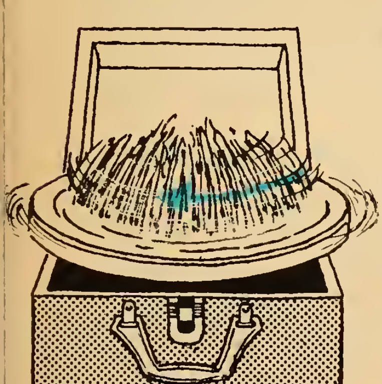
Can You Do It? One way to make the egg float is to add salt to the water. What else could you put into the water to get the egg to float?

What Do You Think Would Happen if you left milk out for a few weeks? Usually it separates with thick, white curd at the top, and watery, clear whey at the bottom.

Fun with Numbers and Shapes: 1 dime, 1 nickel, and 3 pennies make 18 cents. 2 dimes, 8 nickels, and 40 pennies equal a dollar.

For Science Experts Only: The iron and aluminum would still balance under water. What would happen up in space?

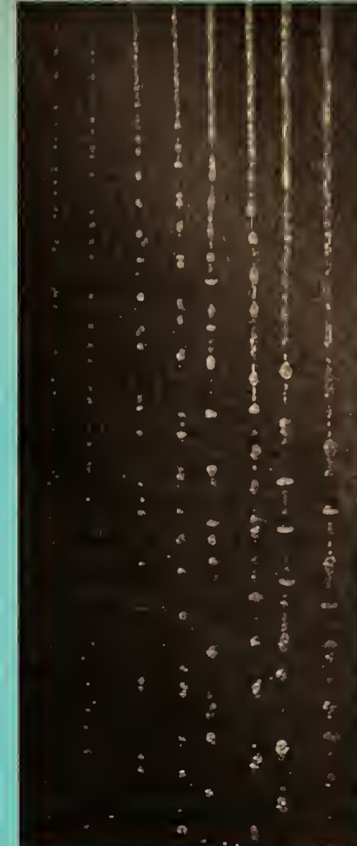
MYSTERY PHOTO



To make the plants grow in toward the center, they were grown on a spinning phonograph *(see drawing)*. Usually plants grow up, away from the pull of gravity. But when they are spinning around, there is another force pulling toward the outside. This makes the plants grow sideways as well as up. It is the same force that makes you lean in when you go around a corner on your bicycle.

Would the plants have grown the same way if they were not spinning and a light had been placed just above the center of the plants?

MYSTERY PHOTO

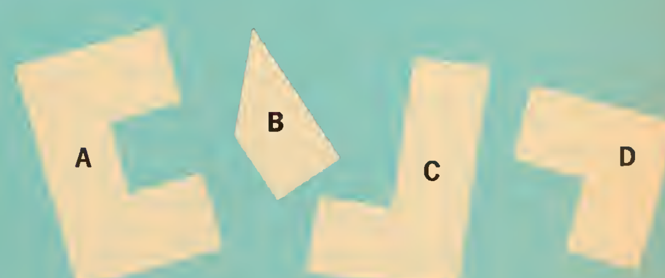


Does each stream of water break up into drops at the same place? What do you notice that is different about each stream?

Fun with Numbers and Shapes

You can take four squares like this and fit them together to make a big square, like this. Can you fit some triangles together to make a bigger triangle? Cut out four, five, or six triangles and try.

Cut out several shapes A, B, C, and D. Can you fit several shapes C together to make a bigger shape C? Try the same thing with shapes B, D, and A.



For Science Experts Only

Can you dissolve more sugar in hot water or cold water?

TELLING TIME BY THE SUN

With simple materials, you can make a sundial and measure the time where you live.

■ Without watches or clocks, how would you tell time? Until about 200 years ago, there were few reliable clocks. People used a variety of "timepieces"—marked candles, hourglasses, water clocks, and most commonly of all, sundials.

You can make a very simple sundial with a pencil and a piece of cardboard about 1 by 2 feet in size. Push a thumbtack through the cardboard near the edge and at the center of one of the long sides. Push the eraser end of a three- or four-inch pencil over the point of the tack so that the pencil stands straight up. The pencil—or whatever object is used to cast a shadow—is called the *gnomon* of the sundial.

Put the sundial on a flat surface where the Sun will fall on it throughout the day, and turn it so the gnomon is on the south side of the cardboard. Fasten the cardboard down flat with sticky tape or by pushing some nails through it into the ground.

Six or seven times throughout the day make a dot where the tip of the gnomon's shadow falls on the cardboard. When you think it is nearing noon, make one dot about every 15 minutes. Try to make four such dots spread over an hour. You won't have a watch to help you tell when the 15-minute periods are up, so you'll have to guess. Don't look at a watch.

At the end of the day draw a line connecting all the dots. What kind of pattern do you see?

You know from experience that shadows are long early in the morning and late in the afternoon, when the Sun is low in the sky. Would you expect the shadows to be long or short at noontime? Look again at the curve connecting the dots. Can you figure out which dot comes closest to Sun time noon?

Leave your sundial outside overnight. The next day see if you can tell a friend, who is standing by with a watch, about when it is noon by the Sun. Perhaps it was closer to 1 p.m. than noon. If so, this is probably because you are on *daylight saving time* in your area, not *standard time*. If you are on daylight saving time, your watch will be one hour ahead of the noon mark shown by the Sun on your sundial.

Probably you have cousins or friends who live farther west or farther east than you do. Suppose one of them also made a sundial. Suppose also that the two of you were talking by radio as you watched the shadows of your gnomons grow shorter and shorter as they approached noon. Then when the shadow became the very shortest you said "Noon!" into your radio. Would your cousin say "Noon!" at the same time you did? When it is noon in New York is it also noon in San Francisco?

It is not difficult to figure out that noon, Sun time, for a New Yorker is not noon, Sun time, for someone living only a few miles—or even a few feet—farther west.

Keeping Time by Zones

What if everyone kept his own personal time by the Sun? People living only a few miles east or west of you would be using time slightly different from yours. In the 1800's, this was the way people kept time, and towns in the United States used hundreds of different times.

To avoid such confusion, the Earth has been divided into 24 *standard time zones* so that everyone living in the same zone keeps the same time. The standard time is always one hour earlier in your time zone than in the time zone to the east of you. Which time zone do you live in—the Eastern, Central, Mountain, or Pacific Standard Time zone?

Many towns, cities, and states set their clocks by standard time all year around. During spring and summer, though, some areas use *daylight saving time*. This means that they set their clocks ahead one hour in the spring and back one hour—to standard time—in the fall. The purpose of this is to "shift" one hour of sunlight from early morning to evening, by the clock, during spring and summer. It permits us to work and play an hour longer before the Sun sets ■

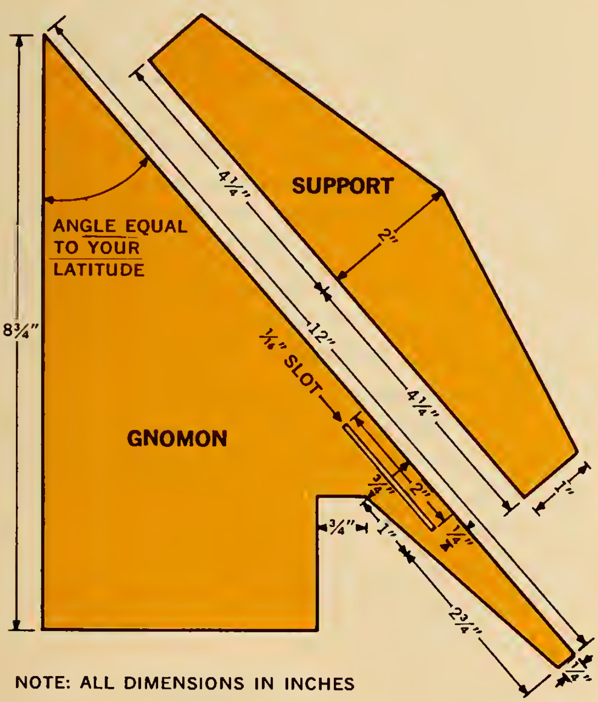
How To Make and Use a Sundial

First get some cardboard, such as the mounting board used by artists and photographers, about 1/16-inch thick and about 12 inches square. Cut out the gnomon and support, using the measurements shown in the diagrams. The angle of the gnomon should be the same as your *latitude*, which you can find on a map. Use a protractor to measure this angle for the gnomon.

To make the equatorial ring, use a strip of lighter cardboard that will bend easily into a circle. Mark off one inch at one end for the overlap. Make a line in the center of the remaining 24 inches and label it "12." Draw the other hour lines and label each, as shown. Cut three slots in the ring.

Bend the strip into a circle and cement the ends together with one inch at the overlap. Make sure the numbers are on the *inside* of the ring. Slide the support into the slot in the gnomon. Then set the ring in place with slots over the edges of the gnomon and support. Cement these joints.

Finally set the sundial in a slotted wooden base (the size of the base is not important). The slot can be made with a hand saw.



NOTE: ALL DIMENSIONS IN INCHES

To use the sundial, set it on a level surface with the gnomon pointing directly north. At night you can aim the gnomon at the North Star (Polaris). You can also line it up with a compass if you know how to find *true north*. (In some places, a compass needle pointing to the north *magnetic* pole points some degrees away from the true North Pole.)

If you wish to leave your sundial outside, you can make it more weatherproof by spraying it with clear lacquer. Read the time on your sundial from the part of the shadow cast by the top edge of the gnomon.

Can you figure out what time of the year the gnomon's shadow will be longest? Would you still be able to use your sundial if you moved into another time zone?

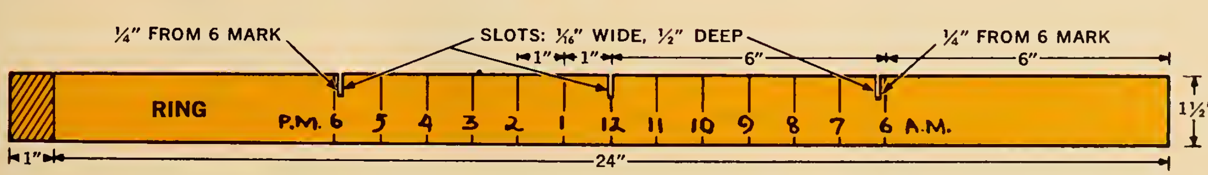
Changing Sun Time to Standard Time

Each time zone is roughly centered on a *meridian*, or line, of longitude. The farther east or west you live from the standard meridian in your zone, the more the Sun time by your sundial will vary from standard time by your clock.

You can easily correct your sundial reading to get standard time instead of Sun time. Look on a map and find the meridian of longitude where you live, to the nearest whole number of degrees. Compare it with the standard longitude for your time zone (see *table*) and figure out how many degrees your meridian is from it. Multiply this number by four minutes and subtract the answer from your sundial reading if you live east of the standard longitude for your time zone. If you live west of the standard longitude, add the same number of minutes to your sundial reading. For example, Omaha, Nebraska, is located at 96° west longitude. The standard longitude for the Central Time Zone is 90°. If you lived in Omaha, you would multiply 4 minutes times 6° of longitude difference and add the 24 minutes to the reading on your sundial.

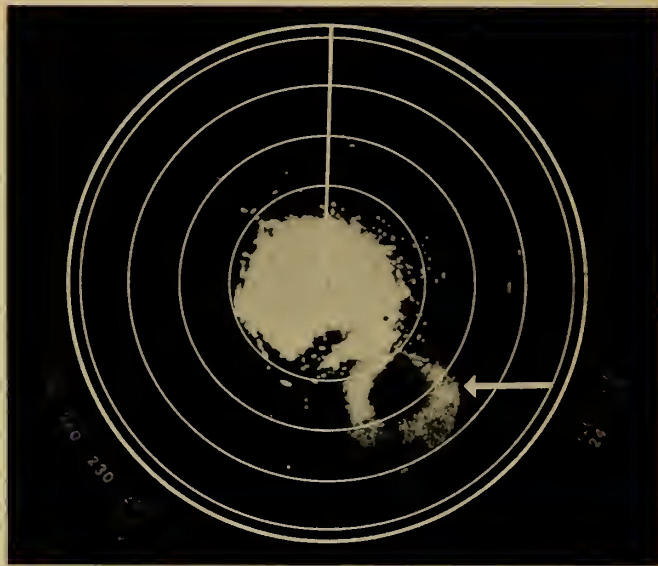
Standard Time Zone Meridians

Eastern Zone	Central Zone	Mountain Zone	Pacific Zone
75°	90°	105°	120°



HOW IT WORKS

Radar



A large flight of birds settling down to feed near Tampa, Florida, shows up as a large "doughnut" on a radar screen.

■ If you have ever heard an echo, you already know something about radar. You can sometimes hear the sound of your voice bouncing back from a hill, a cliff, a building, or the far end of a cave. You may also have seen a giant searchlight sending a beam of light into the sky. When the searchlight's beam strikes a cloud, you see the cloud because light is reflected from it back to your eyes.

You can use echoes to figure out the distance to a cliff by the length of time it takes sound to travel to the cliff and return. Sound travels through the air about 1,100 feet each second. Suppose it took one second (half a second to the cliff and another half second back) to hear your echo after you shouted. In half a second the sound would have traveled 550 feet, which would be the distance to the cliff.

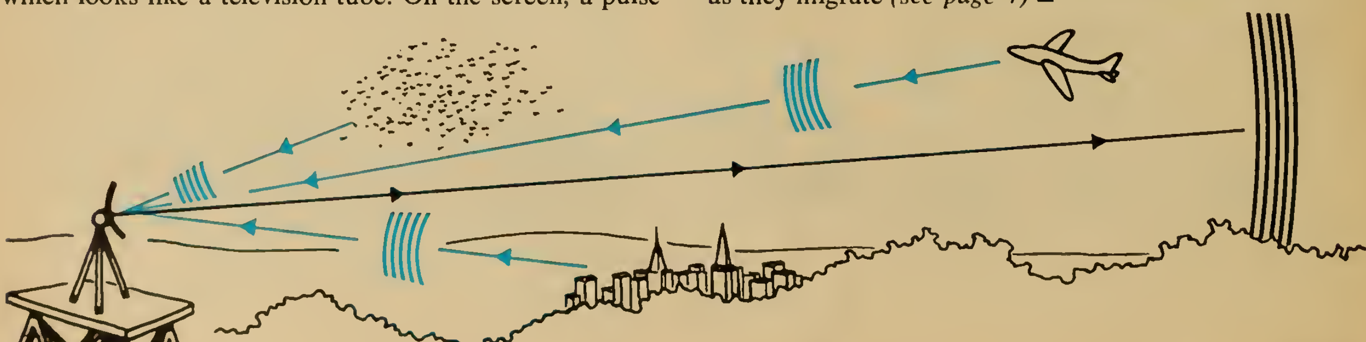
In much the same way, we can use radar waves to find the distance to objects. But instead of sound waves, radar uses radio waves. Radio waves travel at the speed of light —186,000 miles each second. Radar takes its name from "RAdio Detection And Ranging."

Radar waves are sent out in *pulses,* or short bursts, with pauses between pulses. Each pulse from the transmitter may last only five or ten *microseconds,* or millionths of a second. Most radar antennas turn around, sending pulses in each direction as they turn. When a pulse strikes an object, the object reflects the pulse back to the radar antenna *(see diagram).*

The reflected pulse goes to the radar receiver, where it is *amplified,* or strengthened, then sent to the *indicator,* or screen. The screen is the flat end of an electronic tube, which looks like a television tube. On the screen, a pulse reflected back from a ship or airplane, for example, shows up as a bright spot of light, called a *blip.* Blips on the operator's screen make up a miniature map of the surrounding area, with the center of the screen representing the radar set's position.

The distance to a blip from the center of the screen is set by the time it takes a pulse to go from the antenna to the object and back again. By measuring on the screen, the operator can learn, for example, that an airplane is 10 miles north of his position or a city is 25 miles southwest. He can also figure out the speed of moving objects. Other objects that show up well are large buildings, groups of buildings, railroad yards, and bridges.

Radar is used at airports to control air traffic and in airplanes for navigating and for avoiding storm clouds. Ships carry radar so they can detect other ships in fog. Special kinds of radar sets have bounced pulses off the Moon to measure its distance from the Earth. Scientists who study birds have also used radar to study the flight paths of birds as they migrate *(see page 4)* ■



nature and science
TEACHER'S EDITION

VOL. 2 NO. 3 / OCTOBER 19, 1964 / SECTION 1 OF TWO SECTIONS

Who Will Win the "Bird Contest?"

By Patricia P. Sturges

■ A "bird contest" is a powerful motivator that rapidly becomes a self-propelling activity. It will spark your lowest to highest achievers to work at their individual capacities. Unlike most school contests that require special learning or physical skills, this contest is based on the more common denominators of curiosity, interest, patience and the ability to observe. I could never predict which of my fourth graders would be the winner.

The object of the contest was to determine who would identify the largest number of different species of birds. I mimeographed sheets *(see sample on page 4T)* to guide the pupils in observing and recording the information that helps identify a bird. Simultaneously these record sheets served as a list for judging the winner and as a check that an actual observation had been made. Pupils recorded the common name of the species, observation date, and any of the following items which were adequately seen: color and markings, size, beak shape, type of feet, where the bird was observed, what it was doing, and any special features observed (such as song, nest, and so on).

In the first few weeks of school I prepared myself and then the class for the contest. You can get a checklist of the birds found in your area from a local bird club or state university. Often these lists will be keyed: resident, winter visitor, summer visitor, migrant.

Mrs. Patricia P. Sturges taught in an elementary school in Corvallis, Oregon, from 1953-57. This article is based on her experiences there.

"I had no idea bird watching was so exciting."
Courtesy of National Wildlife

A field guide by Roger Tory Peterson *(see list of books on page 12)* is a must. The children will often recognize a bird they've seen by looking at the colored plates. *How To Know the Birds,* by R. T. Peterson (Mentor, 1949, 60¢) will help you and your students discover where to look and how to observe. Also helpful are the Cornell Science Leaflets entitled *Birds* (Vol. 52, No. 4) and *Inviting Bird Neighbors* (Vol. 46, No. 4). These may be obtained for 10 cents each from *Cornell Science Leaflets,* Stone Hall, Cornell University, Ithaca, New York.

Look for other books about birds in your school or city library. Some colleges lend teaching collections of identified birds in celluloid containers. The National Audubon Society (1130 Fifth Ave., N. Y., N. Y. 10028) publishes *Audubon Magazine* and has available many education aids and materials on birds and conservation, including a "Bird Program for Audubon Juniors."

Beginning the Contest

After gathering my source materials, I sketched an outline of a bird resembling a robin, and mimeographed it and the recording sheet. I explained the rules and procedures of the contest during a science period. Showing a live bird, picture, or bird model, I announced, "We're going to have a contest to see who can find the most different kinds of birds. Watch the birds in their natural surroundings and then fill in this observation sheet. You can use any books or people to help you discover the names of the birds you see." Then I passed out the observation and bird outline sheets and asked, "What kind of bird is this?"

"A robin," someone answered.

"How do you know it's a robin and not a blackbird or Blue Jay?" I asked.

"Well, it looks like one," came a prompt answer.

"Let's discover what makes it look like one." Together we used the sheets to describe the robin.

Then we found, and labeled on the

(Continued on page 4T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

IN THE NEXT ISSUE

How scientists track animals by radio . . . Botanists get ready for an expedition into a rain forest . . . Changing plants with light . . . Patterns you can make with a swinging pendulum . . . The ways seeds travel.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Bird Travels

This article on bird migration describes some of the exciting discoveries about how birds navigate. The point made in the next-to-last paragraph of the article—that star and Sun navigation is still a theory—is an important one. Your pupils should know that there are differences between *hypotheses* (ideas), *theories* (ideas supported by some evidence), and *facts* (proven ideas).

Suggestions for Class Discussion

Your pupils may wonder about some facets of bird migration that are not discussed in the article. For example:

• *Why do birds migrate?* Scientists can only guess at the reasons for the beginnings of bird migration. One guess is that migration began when northern birds were forced southward during glacial periods. They returned to the north when the glaciers retreated. From then on, they flew south when winter arrived. Regardless of the original cause or causes of migration, many kinds of birds now inherit the ability to migrate the moment they are conceived.

Unfavorable living conditions, such as a lack of food and cover, were the original stimuli for migration, but most migrants now begin their southward flights while food and shelter are still plentiful. Exactly what triggers this flight is still unknown. Perhaps the shortening day-length during the northern summer is the stimulus for birds to fly south. However, there is only a slight difference in the tropic day-length through the year, and some other factor must prompt birds to start north in the spring.

• *Do all birds migrate?* No, few birds living in the southern hemisphere migrate during the changes of seasons there. Also, there are a few birds—such as chickadees and horned owls—that are permanent residents. However there are some birds that your pupils may consider to be permanent residents that are actually migrants. Crows and Blue Jays may be in your area year round, but these birds migrate; the ones you see during winter may be from areas farther north.

• *Can I band birds?* Banding is illegal without a permit from the United States Fish and Wildlife Service and one from your state conservation department. Before anyone is granted these permits they must be experienced at bird identification, have a specific problem to study, and be recommended by a reputable ornithologist. There are a few teen-age banders, but most are adults.

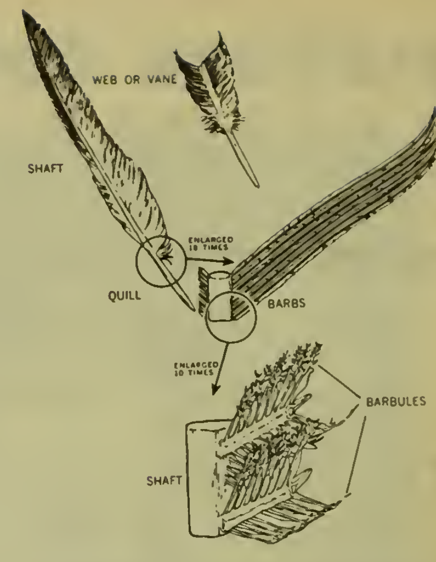
If one of your pupils finds a banded bird, the band should be sent to the Fish and Wildlife Service, Washington 25, D.C., along with information about where the bird was found. In return, you will be told where the bird was banded.

PAGE 8 Bird Flight

Adaptation to environment is a major theme of this WALL CHART. Only recently have scientists discovered some of the truly marvelous features of these feathered animals.

Suggestions for Class Discussion

• *What are the four forces acting on a bird or airplane in flight?* The WALL CHART describes *lift*, the force that causes an object to rise in the air, and *thrust*, the force that propels it forward. Another force, *gravity*, pulls downward in opposition to lift. The fourth, *drag*, opposes thrust, and is caused chiefly by air deflection and air friction. When an airplane or bird is flying at a constant speed and height, lift equals gravity, and thrust equals drag. (It might seem that thrust would be greater than drag if a bird or airplane were moving ahead. But when thrust exceeds drag, it causes the object to *accelerate*, or speed up. When drag exceeds thrust, the object *decelerates*.) Perhaps some of your pupils could bring model airplanes to class for a demonstration of the four forces.



The barbules of a feather lock together, forming an unbroken web. When the hooks are separated by wind or some object, the bird relocks them by preening itself.

• *How are birds different from other animals?* They have such features as feathers, highly modified "front legs" (wings), lightweight bones, bills, complex breathing apparatus, a higher *normal* body temperature than that of any other animal group, and a "song-box" (*syrinx*) for producing sounds.

• *Are bats birds?* No, bats are mammals. They have no feathers, only skin membranes stretched over their wing bones. Their skin is covered with hair, and they bear live young rather than hatching eggs.

• *Do all birds fly?* No. A number of contemporary birds are flightless, and so were some birds that are now extinct. The ostrich and kiwi have only small vestigial wings and spend their time on the ground. The penguin "flies" only in water, using its wings as flippers. Domesticated "meat" birds—such as chickens—have a very limited ability to fly.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using this issue...
(Continued from page 2T)

• *How do we know that birds are descended from reptiles? Archaeopteryx,* the earliest known bird, has been found in fossil form with bird-like feathers but with other features—teeth for example—relating it to the reptiles. Birds also lay eggs and retain some scales on their feet, legs, and heads.

Activities

• Let your pupils collect and examine bird feathers of different kinds and colors. Some of your pupils may wish to identify, mount, and label them. Have your pupils examine the structure of a large flight feather through a magnifying lens or microscope. Branching off from the shaft are *barbs,* which are held together by rows of hooked *barbules (see diagram on page 2T)*. By stroking the feather with a finger, your pupils can see that the barbs cling together to form an unbroken surface, necessary for flying. If two barbs are separated with a pencil, they can be rejoined by stroking the feathers. This is what the bird does as it preens itself with its bill.

• Arrange for someone to bring a large bird, like a chicken or domestic pigeon, to class. You can point out the structure of its wing by gently extending the wing. Emphasize the similarities between the wing and a human arm and hand, and then between the bird wing and an airplane wing. Find the *alula,* or group of thumb feathers. Point out the powerful pectoral (chest) muscles which pull the wing up and down and which are attached to the sternum (breastbone). (If the bird is a chicken, you can explain that these large muscles provide the white meat of the breast.)

• If you have flocks of pigeons nearby, take your pupils on a field trip to observe them. The pigeons' actions in flying, gliding, landing, and taking off will give new stimulus to the study of bird flight.

References

• *Biology of Birds,* by Wesley E. Lanyon, The Natural History Press, Garden City, N.Y., 1963, $1.25

• *The Birds* (Life Nature Library), by Roger Tory Peterson, Time Incorporated, New York, 1963, $3.95

PAGE 14 Telling Time

This SCIENCE WORKSHOP on sundials introduces many concepts that may be new to your pupils: Sun time (as opposed to clock time), worldwide time zones, standard time, and daylight saving time.

Suggestions for Classroom Use

Shine a bright light at the classroom globe. The illuminated half of the globe represents the sunlit side of the Earth. Rotate the globe from west to east (counter-clockwise as seen from above the North Pole). Emphasize that the Earth turns about 15° (or about one time zone) each hour. This suggests the practicality of everyone's setting his watch to the same hour in the same time zone. Standardizing time avoids the problems of hundreds of different Sun times—each based on a noon when the Sun is highest in a particular place.

Most time zones are centered as nearly as possible on a standard meridian of longitude (0°, 15°, 30°, 45°, etc., at 15° intervals). This provides 24 time zones around the world. However, one time zone is centered on the International Date Line. People in the eastern half read the same clock time as those in the western half, but they are separated by one full calendar day. (Few people live near the International Date Line.)

Activities

• Have your pupils convert time in one part of the U.S. to that of another. For example, *If you were in New York City at 3 p.m. E.S.T. and telephoned someone in San Francisco, what time would it be there?* (12 noon Pacific Standard Time.) Time zones are usually not indicated on globes, but you can select major cities that obviously lie in one time zone or another *(see map).*

• Have your pupils make the sundial described in the article. If you find large errors, check the following items:

1. Make sure that all parts are in proper alignment: gnomon perpendicular to base; support perpendicular to gnomon; and ring circular—not bent out of shape.

2. If your pupils have difficulty reading between the hour marks on the ring, divide the spaces into 15-minute or 5-minute intervals.

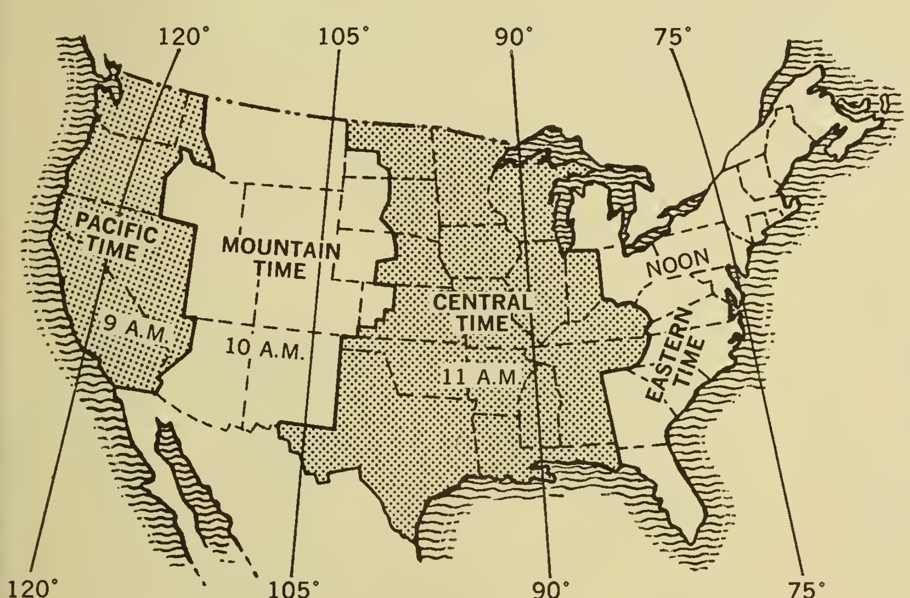
3. Be certain that the gnomon is pointed to *true north.* An ordinary compass points to magnetic north, which may be quite a few degrees different from true north in your area. To correct the compass reading, consult a *Boy Scout Handbook.* Or you can point the gnomon toward the North Star at night and draw an outline of the sundial base so that you can set the base in the same position the next day.

References

• *Sundials,* by Roy K. Marshall, Macmillan, New York, 1963, $3.50

• *Sundials,* by R. Newton and Margaret L. Mayall, Branford, 1938, $3.95

• *Time and the Stars (Astronomy Highlights),* by Joseph Chamberlain, Natural History Press, Garden City, New York, 1964, 50 cents



The United States extends over seven standard time zones, four of which are shown on this map. The next three zones to the west cover Alaska, and Hawaii is in the second of these three zones. The time in each zone is one hour earlier than in the zone to the east.

Who Will Win . . .

(Continued from page 1T)

board and bird outline sheets, the crown, hood, beak, throat, breast, belly, side, tail, outer-tail feathers, rump, and back.

Find a Judge

A qualified, impartial judge is an important feature of the contest. You can find one by making inquiries in your community. The local scout troop frequently has a nature or bird advisor. Your state Fish and Game or Conservation Department may be able to recommend someone. Perhaps a local or nearby newspaper has a bird-watchers' column and you can contact the author. Most bird watchers will be happy to help you, and may even offer their services for a discussion or field trip with your pupils.

After the sheets had been judged, the winner (or winners) received a prize during the last week of school. The National Audubon Society and National Wildlife Federation (1412 16th St., N.W., Washington 6, D. C.) sell bird kits (like airplane models), books, bird pins, plaques, and pictures that can be given as prizes.

My pupils were enthusiastic about the contest. "How many do you have?" was a frequent question. They would often come to the desk in the morning asking for help in identifying some bird. We would look through Peterson's guide and usually find it. Sometimes we weren't successful because the observations were inadequate. The child would have to observe the bird again.

During the four years I've had such contests, about one third to half the class turned in records of 10 to 25 species. The rest had fewer recordings, usually from five to 10.

There was no perceptible listing of unobserved birds or copying from one another or from books. This was partly due to the voluntary nature of the contest, and to the details about a bird that were needed before a pupil won a point for a species sighting. The more capable pupils made detailed observations. The less capable pupils had more simple observations. This is where individual differences showed; but this was not the measure the judge used.

One mother was amazed by her boy's interest. He'd been getting up at five o'clock to watch for birds in their yard. A conscientious, average student, his interest and effort earned him recognition when he won the award ■

A SPRINGBOARD TO MANY OTHER ACTIVITIES

You'll find yourself using the interest created by the contest to motivate other learning activities *(see "How To Spy on Birds," page 10)*. Here are some ideas that will start you on your way—in art, English, social studies, and mathematics, as well as in science!

- Study John J. Audubon's life and examine his prints.
- Draw pictures of birds in their typical habitats.
- Black silhouettes of birds (found on the end papers of Peterson's field guides) can be enlarged with the opaque projector, traced, and cut out for part of your bulletin board display. Guessing games can be played with these.
- Discover and study your state bird and other state birds.
- Study different ecological communities—grassland, forest, edges of forest, desert—and the birds found in the areas. How are birds adapted to live in certain areas or climates?
- Map migration flyways and the birds that use them; assign reports about migration.
- Have a representative of your state Fish and Game or Conservation Department come and discuss the laws on killing, capturing, and keeping wild birds. He can tell some of the things his department does to promote the conservation of bird life.
- Discover a wildlife refuge, nature center, or park near you that might be a good site for a class field trip or a weekend excursion for your pupils and their families.
- Science becomes a listening experience when you play bird calls. There are many recordings of bird songs available (see advertisements in *Audubon Magazine*), and some have a side of unidentified songs which can be used as a quiz.
- Mathematics is used when building feeders and bird houses. Your pupils can gain experience with quantitative measurement by making graphs of their observations of birds at a feeder. How do bird visits vary with the weather? What is the frequency of visits for different species? How many seeds are consumed each day?
- The article "How To Spy on Birds" suggests many questions about bird life your class can study. A rich source of ideas for further investigation is *A Guide to Bird Watching*, by Joseph J. Hickey, The Natural History Library, Doubleday & Co., Inc., Garden City, N.Y., 1963, $1.25 (paperbound).

Record Sheet #1 Your name Pat Sturges

Number the birds you see and draw a line between each recording.

Name	When	Where	Size	Feet	Beaks	Color	Special features
	Date: month, day Time of day: morning, afternoon evening, night	ground grass post tree (etc.)	head to tail in inches or compare to another bird	grasping climbing webbed perching	seed cracking insect chisel spear prober strainer	patterns markings description	eating? food? behavior flight pattern
1. Robin	May 10, 1963 morning	grass	8"	perching	Prober - flattish narrow long	yellow legs and feet white eye ring rusty red breast grey-brown back	erect posture poking into grass; caught a worm

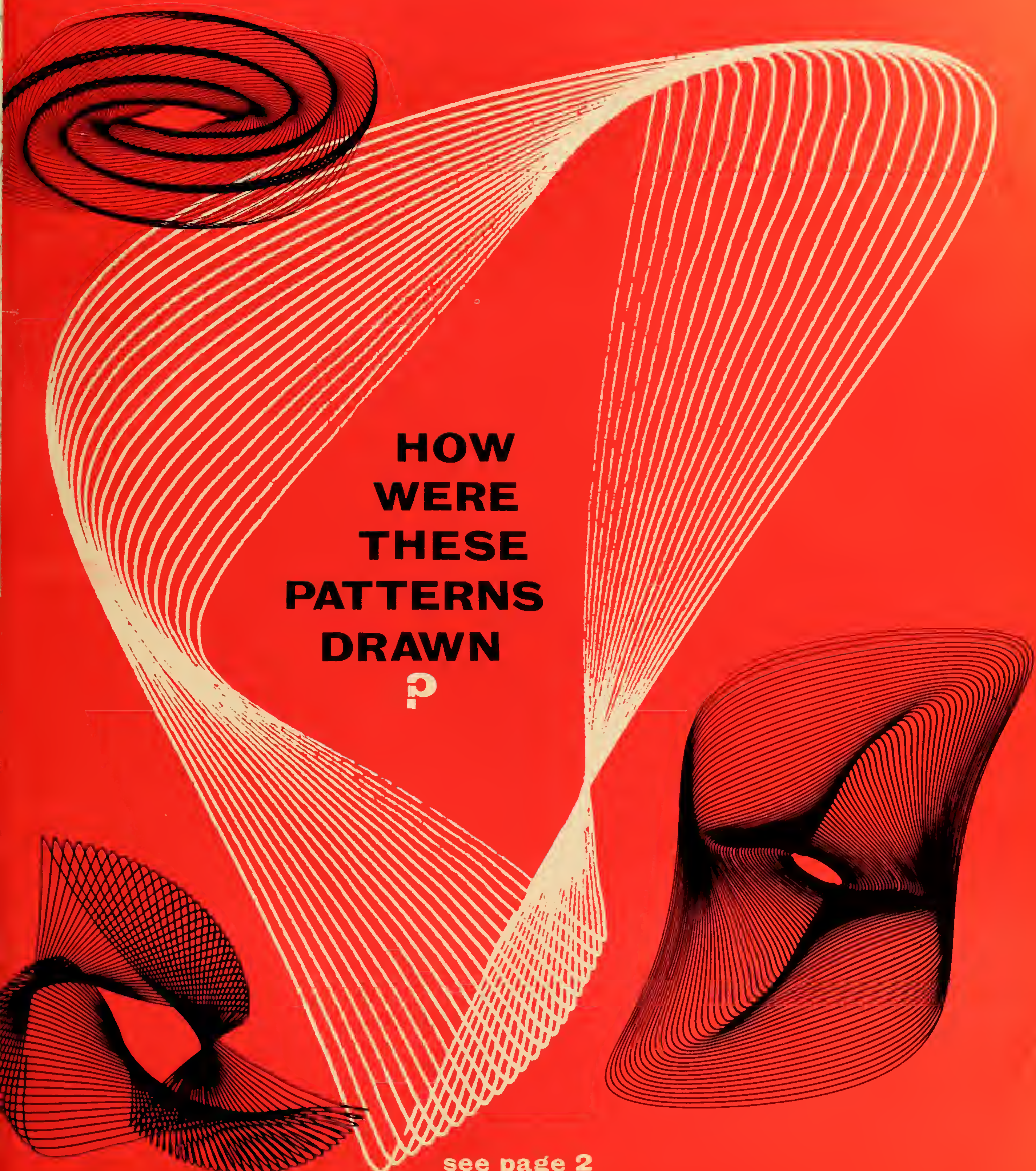
nature and science

VOL. 2 NO. 4 / NOVEMBER 2, 1964

"DEER 54, WHERE ARE YOU?"

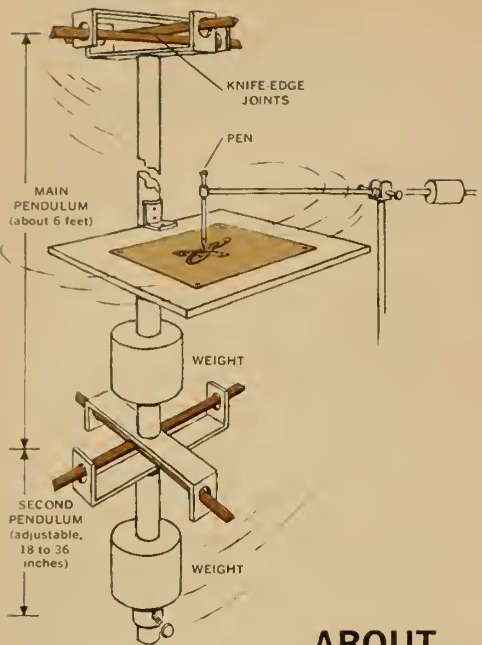
How much do animals move around? Scientists are using tiny radios to find out.

see page 4



HOW WERE THESE PATTERNS DRAWN ?

see page 2



ABOUT THE COVER

The strange patterns of curved lines shown on the cover were drawn by an instrument called a *harmonograph (see diagram above),* which is a special kind of pendulum. A simple pendulum is a weight suspended on a string or bar so that it swings freely to and fro. The harmonograph is a *double* pendulum, with two parts that can be set swinging in different directions at the same time. By changing the direction and amount of swing of each part, you can make the harmonograph swing in an endless number of different patterns.

A shelf with a sheet of paper on it is attached to the pendulum, and the point of a pen rests on the paper. The pen is held by an arm that lets it move up and down, but not in any other direction. As the paper swings with the pendulum, the pen draws a picture of its path. Because the swing of each part of the pendulum affects the swing of the other part, the pattern changes slightly with each swing.

These patterns are called Lissajous figures, and you can draw your own with some easy-to-make pendulums described in "Making Shapes by Swings," beginning on page 13.

nature and science

VOL. 2 NO. 4 / NOVEMBER 2, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

CONTENTS

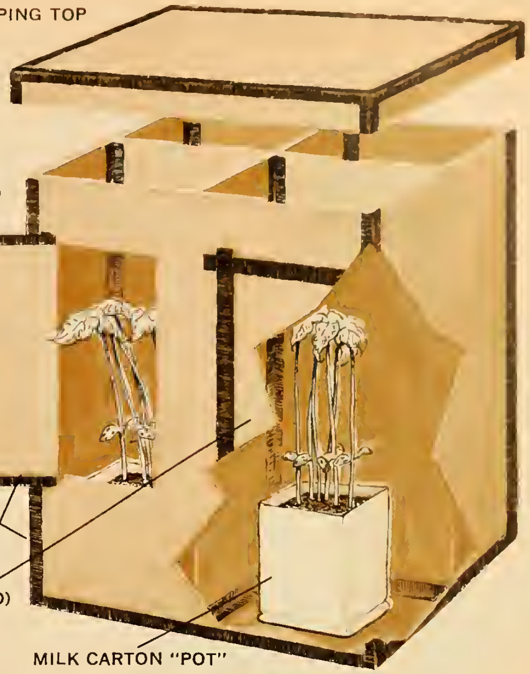
CREDITS: Cover, Lissajous figures by John A. McKinven; pp. 2, 6, 7, 11, 13, 14, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, R. G. Bryant; p. 4, deer photo by John Kupa, radio operator photo by Dave Mech; p. 5, radio photo by Dave Mech, collaring photo by J. R. Tester; p. 6, photo from University of Rhode Island; p. 7, photos by George Cope of Educational Services Incorporated; pp. 8-9, drawings by R. G. Bryant and Gaetano di Palma; p. 10, Charles McVicker; p. 12, bottom photos by Laurence Pringle, top photo from Howard S. Irwin; p. 13, Lissajous figure from Photo Lettering, Inc.; pp. 14, 15, photos from Ronan Picture Library.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3. two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

SHAPING PLANTS WITH LIGHT

by Richard M. Klein



■ Picture a young bean plant as it grows. Its stem straightens out, reaching toward the Sun. Its leaves grow and begin to make food for the young plant.

Everyone knows that the growth of green plants, such as beans, depends on light. Scientists call this control of plant growth by light *photomorphogenesis.* They have discovered that certain amounts of light are needed by plants in order for them to grow properly. By giving different amounts of sunlight to some bean plants, you can discover how light affects their early growth.

First, buy some fresh seeds of Black Valentine, Red Kidney, or Stringless beans from a hardware or garden store, or from a seed company. Soak the seeds overnight in tap water. Then plant about five to eight seeds in soil in each of five "pots." You can use one-quart wax-coated milk containers. Cut off the top part so that you have pots about three inches high. Punch several small holes in the bottom of each container to allow for drainage.

Find a cardboard box big enough to cover four of the pots. Use some other cardboard to make walls within the box so that it has four compartments, one for each of the pots of bean seeds *(see diagram).* Leave the fifth container of seeds in sunlight so you can compare the seeds in it with those grown in the darkness of the box.

Now cut out a section, or "porthole," in each compartment of the box. Make a cover for each porthole so it can be sealed shut while the plants are growing. Label the covers 1, 2, 3, and 4. In my own laboratory, we seal all outside edges and inside compartments of the cardboard box with black Mystic Tape to make sure that no light enters the boxes. Make a cover for the box so that it overlaps the sides *(see diagram),* but does not keep air from the plants.

Let the five containers of seeds grow at room temperature for five days. Be sure to water the pots at the time of planting. You can also water them again two days after planting, before the plants have grown above the soil. Then cover the box so that no light reaches the four pots.

On the fifth day after planting, the experiments with light can be started with the plants. Leave the porthole on compartment #1 closed and sealed so that you will be able to see what bean plants look like when they grow in darkness. Then open the porthole on compartment #2. Expose the plants inside to exactly one minute of light from a 25-watt incandescent lamp held 12 inches away from the porthole. Quickly shut the porthole and re-seal it. Open porthole #3 and expose the plants for 30 minutes to light from the same lamp held at the same distance. Shut and re-seal this porthole. Finally, open the porthole of compartment #4 and leave the lamp turned on until the next day, giving the plants 24 hours of light.

On the next day, take the four containers out of the box and examine the plants. Compare the bean plants with those from compartment #1, which were grown in complete darkness, and with those in the fifth container.

Are there differences in color of the plants exposed to different amounts of light? Which are the tallest and which the shortest plants? Are all of the stems growing straight up or are some of them hooked? If some are not straight, is the angle of the hook the same in plants from different treatments? Which plants have opened their leaves and which have not? Are all the leaves open the same amount? Are the leaves all the same color? ■

(Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.)

"DEER 54, Where Are You?"

by Dave Mech

Scientists are tracking the travels of deer, bears, skunks, and other animals by fitting them with tiny radio transmitters.

■ Imagine that you're hiking in the woods. Suddenly a twig snaps, and a big buck deer bounds out of the brush. To your great astonishment, you notice that the deer is wearing a collar! And that isn't all. Sticking out of the top of the collar is a two-foot piece of stiff wire. If you didn't know better, you'd swear it was an antenna.

Should this ever happen to you—and it might—don't run to the nearest doctor. The deer probably *is* wearing an antenna, and what's more, the antenna probably is hooked to a small radio on the deer's collar.

No, the deer hasn't been caught up in the transistor radio craze. He's not listening to the Beatles. In fact, he's not listening to anything at all. Instead, his radio is sending a signal, and on the other end of the signal is a scientist.

Today scientists are putting radios on all sorts of animals, from toads to Grizzly Bears. By listening to signals from one of these radios, scientists can tell where the animal is, and in some cases, what it's doing. This new game started several years ago. People studying animal movements got fed up with the old-fashioned methods. They used to put an identity tag on an animal, release it, and try to recatch it to learn how far it moved. Most of these tagged animals were never caught again. Even when someone did catch one, he still didn't know where it had roamed between the times it was let go and found again.

Dr. David Mech lives in Minneapolis, Minnesota, with his wife and four children. From 1958 until 1962, he studied moose and timber wolves on Isle Royale National Park.

"If only we could put a radio on an animal," the biologists thought, "then we could tell where it is all the time." But the biologists had no idea how to build a radio small enough to fasten to an animal, or even if it could be done. So they turned to engineers to help solve the problem.

One of the pioneers in making a radio for use on animals was a bright young engineer from Illinois, named William C. Cochran. Bill had been designing and building transmitting equipment to send information back to Earth from satellites. When a biologist friend of his asked about getting a tiny radio built for tracking animals, Bill surprised him. "Sure it can be done; hasn't anyone tried it yet?" Bill has been building such radios ever since.

That day started the disappearance of privacy from many animals' lives. Biologists all over the United States have begun using radios to study animal wanderings. The usual radio-tracking system consists of: (1) a transmitter (the device that makes a signal), (2) batteries to power it, (3) an antenna (or aerial) which sends the signal through the air, and (4) a receiver with antenna to pick up the signal.

The transmitter weighs about 1/10 of an ounce *(see photo)*. The signal it sends is heard at the other end as a high-pitched whistling sound or a click-click-click. Batteries weighing from 1/5 ounce to several ounces give the transmitter its power. The antenna may be either a "loop" (a circle of wire) or a "whip" (like a car radio aerial). The wider the loop or the longer the whip, the stronger the signal.

Fastening the batteries, transmitter, and antenna to an animal has been a challenge. Even such a docile animal as the cottontail rabbit is a problem. One day at the University of Minnesota's radio-tracking lab, we put a one-ounce collar with a radio onto a rabbit and turned him loose. For the next couple of days the signal sounded very strange: waaaaaw-waaaw-waaw. Then it stopped. We caught the animal and found the trouble. With his strong hind legs, the rabbit had scratched through the collar and broken the loop antenna inside. Since then, we have been putting hard coatings on the collars.

Collars have been used successfully on deer, foxes, skunks, Snowshoe Hares, and cottontail rabbits. But animals with necks larger than their heads, such as badgers and raccoons in certain seasons, present other problems. They can pull the collar off, so harnesses fitting behind their front legs must be used. Another way biologists hope to solve this problem is to make a small slit in the skin, push the radio in, sew it up, and turn the animal loose.

Case of the Sleeping Skunk

The equipment used to receive the signal varies. Some scientists use a receiver built into a car or truck with a large loop antenna on top. This is useful where there are plenty of roads. Where there are few roads, the biologists use a small portable receiver. It weighs only a few pounds and can pick up a signal from as far away as half a mile.

To learn where an animal is, the biologist turns the antenna toward the strongest signal. When a biologist gets the strongest signal from an animal, he finds the compass direction of that point and draws a line in that direction on a map. Next he drives on a few hundred yards, takes another compass reading, and plots it on the map *(see photo and diagram on the next page)*.

The animal's location is where these lines cross. This process is known as *triangulation*, and the point where the lines cross is a "fix." Often biologists using walkie-talkie radios work in pairs so they can take bearings from two points at once. By getting a fix on an animal every few minutes, they can trace its travels.

If an animal sleeps in a den during the day, a biologist can use a portable receiver to find the animal's hideout. I was trying this on a skunk one day when I got quite a surprise. Until that day, the skunk had spent most of its days sleeping under old buildings, or in holes in the ground. But this time the signal came from the middle of a swamp, where I knew there couldn't be a hole. I walked in the direction of the signal. The signal was very strong, so I knew the radio was within 10 feet.

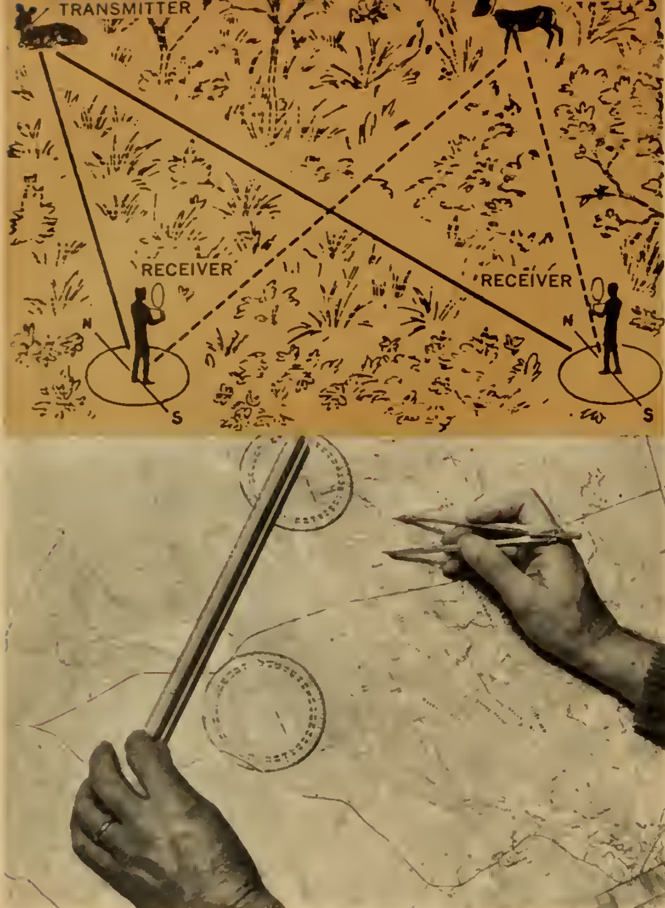
This seemed like an unlikely spot for a skunk to spend its day. I decided that the skunk had scratched itself free of its collar, and left it in the swamp. I started to pick through the tall grass to find the collar. Suddenly I spied the skunk—just four feet away! Luckily, he was all curled up, sleeping in the grass. I left him exactly that way.

What the Radios Reveal

By attaching radios to animals, scientists can learn all kinds of new things about the home range, movements, and even the foods of animals. For instance, Dr. William H. Marshall and others from the University of Minnesota fol-

(Continued on the next page)

This tiny transmitter (compared with a penny) and batteries to power it are put into a collar that is fastened around an animal's neck (right). Signals from the transmitter are sent from an aerial that is attached to the collar. Biologists can track animals such as this deer by detecting the signals with a radio receiving set.



The diagram above shows how biologists use radio-tracking to locate a deer. Each man uses a portable receiver to find the compass direction (dotted lines) of signals from the deer's transmitter. Then protractors and a ruler are used to draw the lines of the compass directions on a map. (see photo). The deer is located where the two lines cross. As the deer moves, the biologists trace its travels by taking new compass readings (solid lines).

"Deer 54, Where Are You?" (continued)

lowed two adult porcupines periodically for over a month. Each animal remained in an area of 30 to 35 acres during that period. Often the porkies had spent the entire day in one tree. They were fussy about the kind of trees they chose. One preferred White Spruce, aspen, or White Pine; the other liked Red Maple, White Pine, and Jack Pine.

Wildlife biologists in Rhode Island, New York, Illinois, South Dakota, and other states are using radios to study the movements of deer. In South Dakota two biologists played a joke on some deer hunters. They sat on a hill with a radio receiver and watched several men stalking through an open area where there was a radio-tagged buck. The men passed close to the animal a couple of times without knowing it—once coming within 40 yards. They decided that no deer were in the area, and headed up the hill. The hunters met the biologists, who told them about some hunters who had just passed a big buck without seeing it. The hunters laughed and went on hunting without ever knowing they were laughing at themselves.

In a few places, scientists have advanced beyond the stage of using portable receivers. They have built larger and more powerful antennas which they leave mounted in one spot near a trailer or field laboratory. Then they don't need to wander all around the woods to follow an animal. This is important, because the animals are undisturbed. The scientists can spend their time in comfort listening to changes in the signal that tell not only *where* the animal is, but *what it is doing*. Dr. Marshall, for example, who is now studying grouse, can tell when the radio-tagged birds are sitting, walking, flying, or eating. Each type of activity makes the whip antenna move differently and causes the signals to differ.

With such a system of permanent antennas, biologists can pick up signals from much longer distances and can study animals that travel widely. Montana State University biologists are studying Grizzly Bears this way. Using a special gun that shoots darts with drugs in them, these men knock out the big bears. Then they fit them with a collar and a two-pound radio. From their laboratory in Yellowstone National Park, the biologists can trace these animals as far as 10 miles away.

Radio-Tracking in the Future

The next advance in radio tracking is a permanent system that will follow animals constantly and record their movements automatically. Such a system is now being developed by Bill Cochran at the University of Minnesota's Museum of Natural History, under the direction of Drs. Dwain Warner and John Tester. When this is completed, biologists expect that they will be able to radio-tag several animals, turn them loose, and wait for the information to pour in. To answer a specific question such as "What time do foxes begin moving at night?", they hope just to ask an electronic "brain," or computer. The answer will be printed by an automatic typewriter!

Hard to believe? Well, try this one. Dr. Warner plans to use a satellite to study the movements of "gooney birds," or albatrosses, that nest on Midway Island, in the Pacific Ocean. They fly hundreds of miles over the ocean, and nobody knows where they go. Dr. Warner plans to attach radios to them and put a receiver in a satellite. As the satellite circled the Earth, it could send a signal telling just where the birds are.

But let's get back to Earth. This satellite project is for the future. There are still many "bugs" to be worked out of the tracking systems now in use. For example, the accuracy of triangulation becomes less and less at long distances. To locate an animal exactly, sometimes scientists must get so close that they scare it. They hope to improve radio-tracking methods so that an animal's location can be pin-pointed at long distances ■

prepared by DAVID WEBSTER

Can You Do It?
Can you make a round ice cube? How about one shaped like a donut? Try to make some. Maybe you can also make a funny shape of your own.

What Do You Think Would Happen...
if you poured some cooking oil into some water? Would it float or sink? What would it look like? Suppose some water was poured into cooking oil. Would the same thing happen? Try it and see what happens.

Fun with Numbers and Shapes

• Here are four 3's arranged to make 12.

$$3 + 3 + 3 + 3 = 12$$

Four 3's can also be arranged to make 66.

$$33 + 33 = 66$$

• Now arrange four 3's to make 330. • Arrange eight 8's to make 1,000. • Arrange four 9's to make 100.

Mystery Photo
What is the large skull?
The little skull is a cat. Why is it in the picture with the big one?

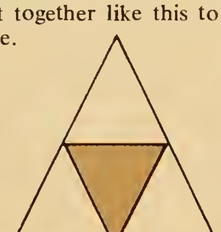
For Science Experts Only
Can you see a word here? It is an easy word and has only three letters. But it is hard to find.

Answers to Brain-Boosters appearing in the last issue.

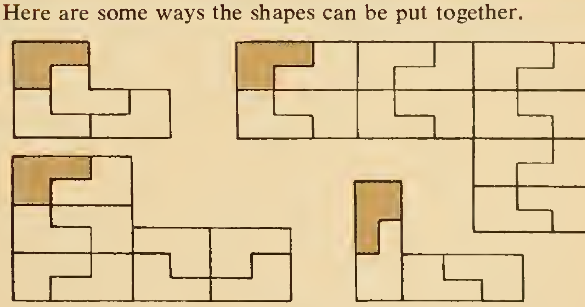
Mystery Photo: Now can you see why the streams of water are different? How does the size of the tubes affect them?

What Do You Think Would Happen? When the balloon is blown up, the square becomes larger, but stays about the same shape. The lines also get wider. When you draw a square on a blown-up balloon, then let most of the air out, the square becomes smaller.

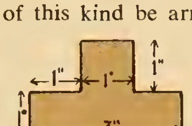
Fun with Numbers and Shapes: Four triangles can fit together like this to make a bigger triangle.



• Here are some ways the shapes can be put together.



• How could some of this kind be arranged to make the same shape?



For Science Experts Only: More sugar dissolves in hot water than in cold. But what about salt?

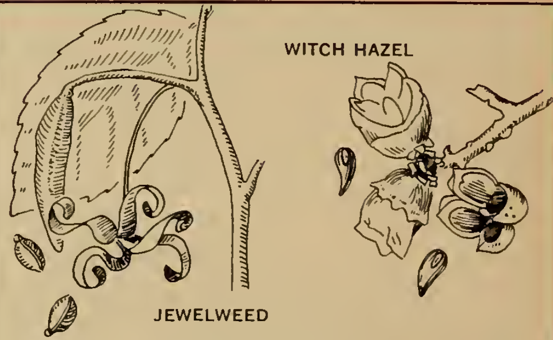
How Seeds Get Around

■ In the past few weeks, you may have seen bits of fluff from plants like milkweed *(above)* gliding on the breeze. Such bits of fluff have an important job—to scatter seeds. Each of these miniature "parachutes" has a seed attached to it, and the wind carries the parachutes away from the plants that produced them. Once on the ground, the seeds may lie almost lifeless for months. But when sunlight, moisture, and other conditions are right, some of the seeds will sprout and grow.

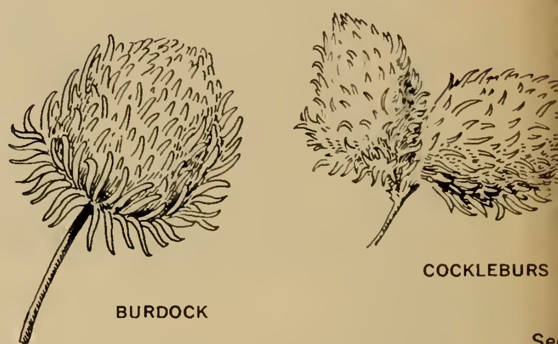
You may have noticed that some plants produce thousands of seeds. Many of these seeds never sprout, or do not grow for long. Often this is because the seeds fall beneath already growing plants where they don't get enough light or moisture. Over the ages, some *species*, or kinds, of plants have thrived because their seeds changed in such a way that they tend to travel away from the parent plant. Once in a new spot, their chances of sprouting may be better.

Seeds of plants are scattered in many different ways. The drawings on this chart show some of the ways that seeds get around ■

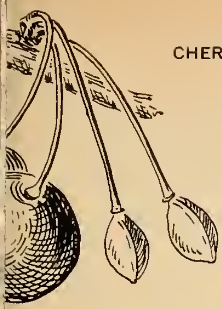
Squirrels and chipmunks often forget where they hide their nuts and acorns. These seeds may later sprout and grow.



After drying up, some seed containers suddenly pop open and shoot seeds in many directions. Witch hazel seeds may fly as far as 10 feet.

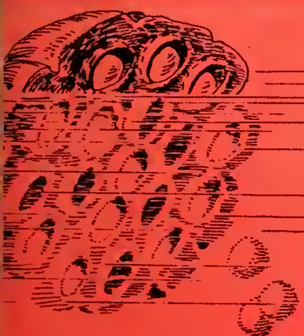


Some kinds of pines have changed over the ages so that their seeds can survive forest fires. During intense heat, the cones open to release the seeds, which survive and sprout.

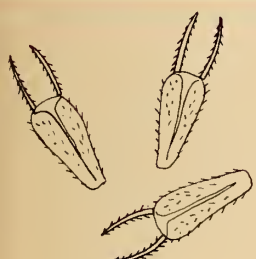


CHERRIES

are eaten together by birds
uch seeds have tough, indi-
'ts, and are later eliminated



otus, a water plant, releases
container. Round seeds drop
tainer as it is carried along



BEGGAR'S-TICKS

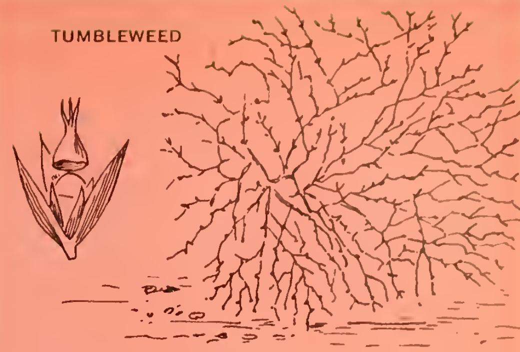
ks catch onto animal fur and
They may travel miles be-
ne ground.

DANDELION

Many familiar plants release seeds with "parachutes," which may drift with the wind for miles from the parent plant.

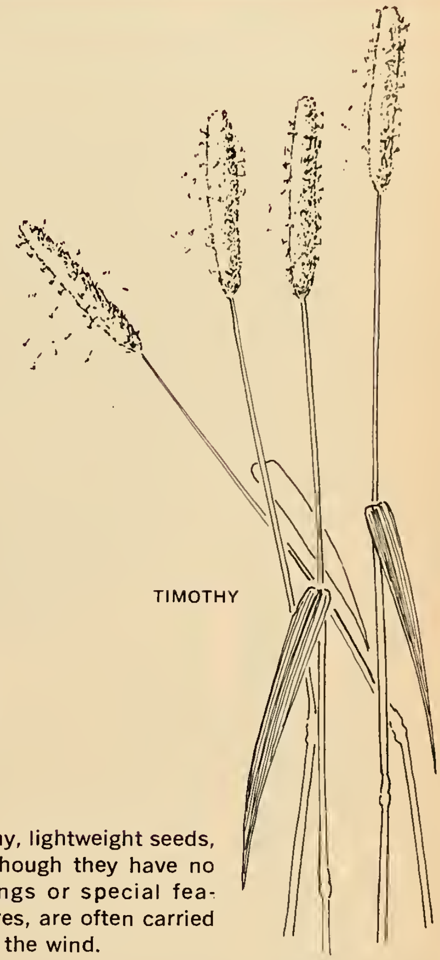
PEARLWORT

Rain drops splash seeds out of the seed containers of plants such as pearlwort.



TUMBLEWEED

Tumbleweeds dry up and break off at their stems. The seeds scatter as the wind rolls the dry plants over the ground.

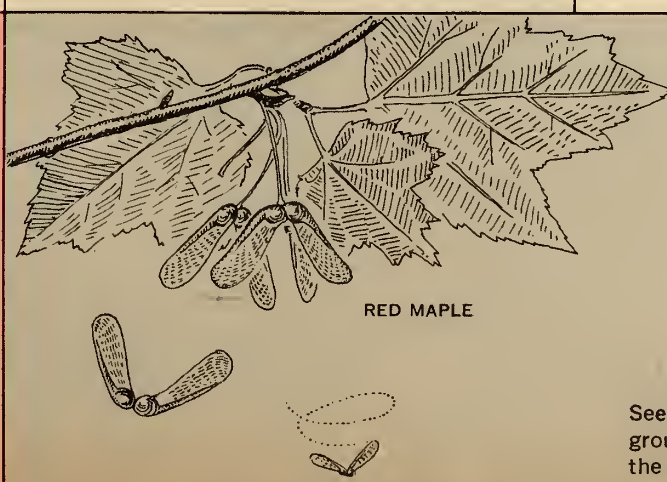


TIMOTHY

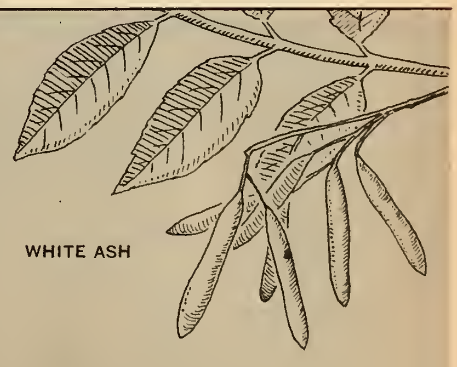
Tiny, lightweight seeds, although they have no wings or special features, are often carried by the wind.

COCONUT

eed is enclosed in a light,
. If it falls into the ocean, it
ndreds of miles, then be
where it sprouts and grows.



RED MAPLE



WHITE ASH

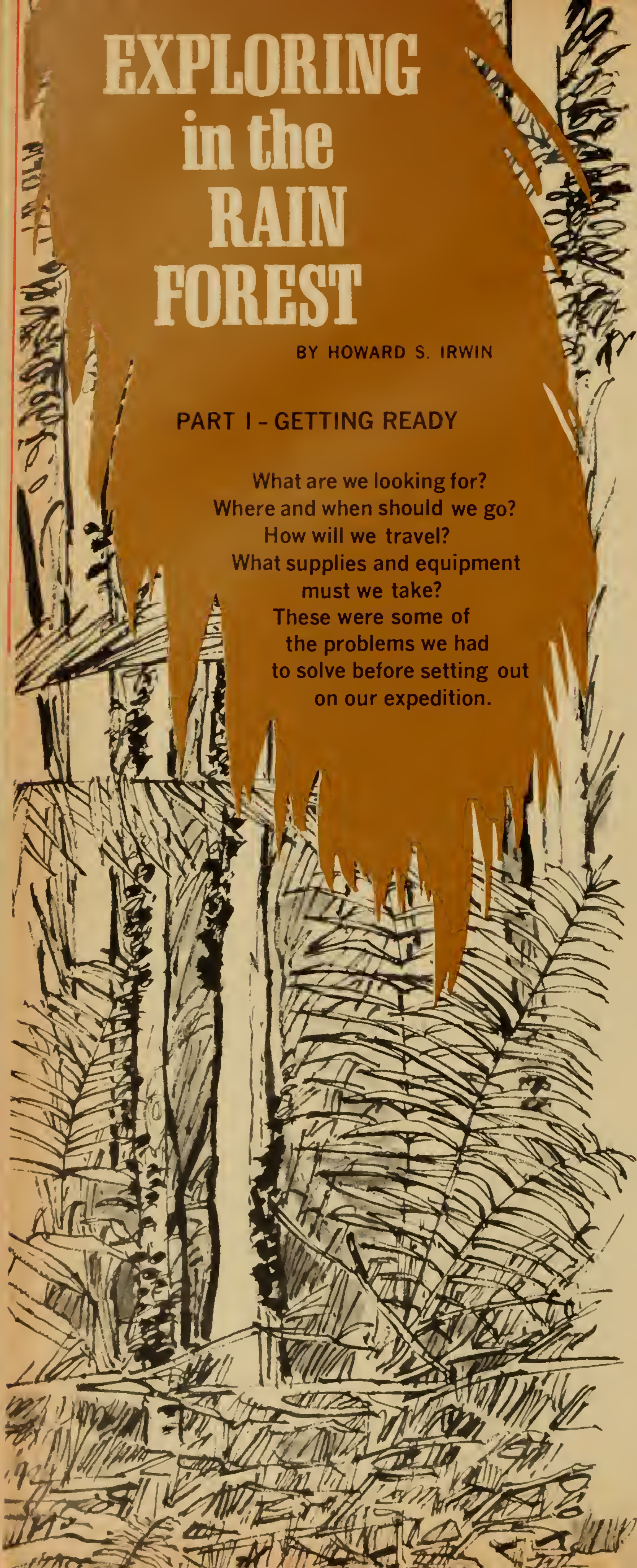
Seeds with wings do not fall directly to the ground but follow a spiral path away from the tree where they grew.

EXPLORING in the RAIN FOREST

BY HOWARD S. IRWIN

PART I - GETTING READY

What are we looking for? Where and when should we go? How will we travel? What supplies and equipment must we take? These were some of the problems we had to solve before setting out on our expedition.



■ As our jet dropped down below the billowing clouds my pulse quickened a little. We were about to land at Zanderij Airport in Surinam (a self-governing Dutch territory in northeastern South America) to begin an expedition to a little-known mountain range.

As the plane circled the field, my thoughts wandered. I recalled the feverish preparations during the past few months back in New York, and the adventure that lay before us. The plane trip from New York seemed somewhat like the "eye" of a hurricane—a brief calm between two periods of fast-paced activity. Basic questions came to mind: What brought us to Surinam? What were we going to do? Who would benefit?

Unlocking the Forest's Secrets

If you stop a moment and think of what has happened to our North American forests in the last 200 years, you will have one answer to the first question. As settlers spread westward and the population grew, the needs for living space and forest products increased rapidly. In time it became necessary to buy pulpwood and certain timbers from other countries. The demand for wood still increases and now eyes are turned southward, to the great tropical forests in Central and South America.

The leaders of the countries of the Guiana-Amazon area *(see map)* hope that this story will not be repeated in their forests. But before they can manage their forests wisely there are some big questions to be answered. For example, what kinds of trees make up this largest unbroken forested area in the world? Which kinds of trees are useful, or likely to be useful? The only practical way to answer these questions is to spot-check the forest in certain places, collect specimens from the trees, and take the specimens back to laboratories for study. Some of the trees may even be new to science.

This is one reason for our trip to Surinam. There are several others. As botanists we want to learn more about the kinds of plants and the places in which they grow. The only way to satisfy these interests is to go to the forests and observe, take specimens, and study.

Also, drug companies are interested in bulk collections of leaves, bark, seeds, and soil as sources of new medicines. Seed companies are always looking for new ornamental plants. Biochemists need leaves and flowers to study the types and makeup of plant colors, or *pigments*. Finally, wood specialists want blocks of wood to examine the structure and find possible uses.

In the Surinam rain forest, palms, small shrubs, ferns, and young trees grow in the shade of slender trees that tower 100 feet or more above the ground.

Several years ago I had interested Dr. Thomas Soderstrom in going on one of these trips. He is a grass specialist at the Smithsonian Institution in Washington, D.C. Now, at last, Tom was able to get away. To prepare for our expedition, careful plans had to be laid and many details worked out. One thought haunted us throughout this period: Despite radio contact with Paramaribo, the capital of Surinam *(see map)*, we would be on our own in the forest. Anything forgotten or overlooked we would have to do without.

To choose an area for our field work, we looked over specimen collections and read what scientists on other expeditions had written. At the New York Botanical Garden we have the world's largest collection of plant specimens from tropical America—a collection that numbers in the millions. Such a collection is called an *herbarium*. Each specimen in the herbarium is mounted on a large card which also bears a label that gives the botanical name, country of origin, date, collector's name, and so on. After working with these specimens for several years, I began to make a mental list of the places that were not represented in the collection.

Also, many botanists have published accounts of their own and others' expeditions, as well as of the new plant species that have been discovered on these trips. By plotting the paths of these past expeditions on a map, we got an idea of where the blanks were. This is how we were first led to the Wilhelmina Mountains of west-central Surinam. We were also attracted to the Wilhelminas because another New York Botanical Garden expedition went to a nearby Surinam mountain—called Tafelberg—20 years ago, and returned with some very unusual plants.

Our Man in Surinam

Our first step was to write to someone in Surinam who knew the history of field work in that country. Such a man was Dr. D. C. Geijskes, director of the Surinam Natural History Museum. Dr. Geijskes was born in the Netherlands, but has lived and worked in Surinam for about 25 years. He replied that Dr. Gerold Stahel, a Dutch botanist, had climbed the Wilhelminas from the north in 1924. He reached the summit of Juliana Top, the highest point in Surinam. However, Dr. Stahel had lost nearly all of his specimens in a boat accident on his return trip. He had also abandoned a lot of equipment at his camp on Juliana Top. Dr. Geijskes hoped that we might find some trace of Dr. Stahel's expedition, something that could be brought back to the Surinam Museum.

This was valuable information. It told us that the Wilhelminas could be approached from the north. It also told us that someone had been able to reach this difficult area 40 years ago, without the mechanical and medicinal aids we have today. We decided to go ahead with our plans.

Our next step was to get in touch with someone in Surinam who would want to join the expedition and who could, in the early stages, act as our agent for buying food and other supplies. He would also hire the field men who would cut trails and carry supplies and equipment during the three-month trip. We wrote to Dr. Jop Schulz of the Surinam Forest Department. He said that he and another scientist from the Geology Department would be glad to work with us. He suggested that we set July 1 as a target date because the dry season would begin at the end of that month. The beginning of the dry season is best for collecting plants. First, the weather is good, but more important, most of the trees come into flower then. The flowers are important for the identification of most plants.

Choosing Equipment for the Trip

Before going further we had to consider how our supplies and equipment would be carried from the port of Paramaribo to the Wilhelminas. There are no roads into that part of Surinam, and to ferry everything by river, as Stahel had, would take too much time. Dr. Schulz wrote that the Surinam government had recently built an airstrip on the Zuid River. The Zuid is a tributary of the Lucie River, and the Lucie flows through the Wilhelminas. We had our answer. We would fly everything in from Paramaribo to the airstrip, then use dugout canoes to reach the Wilhelminas.

(Continued on the next page)

Choice of expedition equipment is never easy. We always have to ask ourselves: Is it really needed? Is it portable? In this case another question would have to be asked: Can it be shipped by air? Often the answers are not simple. For example, since we cut many trees on these expeditions I have often thought of buying a motor-driven chain saw to replace axes. However, our Surinam field men know no such machine, and a chain saw in unfamiliar hands can be dangerous.

Our expedition gear was divided into eight categories:
1. Motors and canoe equipment—outboard motors and parts, gasoline, oil, cans, funnels, caulking, rope, nails, tools.
2. Camping equipment—tarps, hammocks, kerosene lamps, shovels, rope.
3. Collecting equipment—plant presses, straps, pruning shears, duffel bags, plastic sheeting, newspapers, kerosene stoves and parts, boxes, burlap bags.
4. Cooking equipment—pots, pans, utensils, soap.
5. Food—rice, beans, dried fruit, crackers, sugar, coffee, powdered milk, cereals, salt.
6. Medical equipment—snake bite kits, insect repellents, penicillin, local anesthetic, sutures, bandages.
7. Hunting and fishing gear—shotguns, shells, fishing lines, hooks, nets.
8. Personal equipment—clothing, blankets, mosquito nets, toiletries.

We had to decide where to buy each item—in the United States or in Surinam? We decided that categories 1, 2, 3, and 6 would come almost entirely from the United States. Cooking equipment (4), food (5), and hunting and fishing gear (7) could be purchased inexpensively in Surinam.

We began looking over our old orders from previous expeditions, leafing through new catalogs, and window shopping in search of new and improved equipment, lower prices, or, hopefully, both. We placed our purchase orders about January 1, 1963 in the hope that everything would be on hand by February 15 and ready for shipment to Paramaribo by March 15. It may sound strange to work so far ahead, but in expedition work one day's delay in the arrival of vital equipment paralyzes everyone. As things were received in New York they were crated and addressed.

Meanwhile, arrangements were made with a shipping line with service to Paramaribo. We were told that because the ships have many ports of call in the West Indies, we should allow six to eight weeks for delivery.

As you read this article, Dr. Irwin is on another plant-collecting expedition, this time to Brazil. In December he will rejoin his wife and two daughters (ages 9 and 12) at his home in Oscawana, New York. Dr. Irwin is Associate Curator of Taxonomy at the New York Botanical Garden.

By mid-March everything was packed. Our two tons of equipment were ready to go. In Paramaribo, Dr. Schulz had arranged for everything to enter Surinam without customs duties. As the truck pulled away from the New York Botanical Garden and left for the docks, I felt relieved. However, I knew that we could not relax. There was still much to do before leaving in July.

In another letter to Dr. Schulz we enclosed our final food lists, based on a party of four botanists and 15 field men. We had already arranged for passport renewals, but now had to get entry permits, or visas, to Surinam from the Dutch Consulate. Air reservations were made. We had physical examinations and dental check-ups.

Gradually we got our clothes together—ordinary lightweight cotton work clothes, about four sets in all, with a mixture of long trousers and shorts, long-sleeved and short-sleeved shirts. For footwear we chose basketball shoes. Leather, once wet, dries very slowly in the humid atmosphere of Surinam and often turns green with mold.

Finally the day came for Tom and me to clean off our desks, say goodbye, and board the plane. No two expeditions are ever alike; an entirely new experience lay ahead ■

(In the next issue of Nature and Science, *Dr. Irwin describes the expedition's exciting canoe trip into the Wilhelmina Mountains, and tells what surprises awaited them.)*

To prepare for the expedition, Dr. Irwin studied the plant collection to find unexplored areas (1), plotted his route on a map (2), and packed axes, twine, and one and a half tons of other equipment (3).

MAKING SHAPES BY SWINGS

by Colin A. Ronan

By making different kinds of pendulums, you can create some fascinating patterns. The patterns are often beautiful; they can also be very useful.

■ When you pluck the string of a violin or guitar, it vibrates back and forth, and makes the surrounding particles of air vibrate the same number of times per second as the string. These vibrations are called *waves,* and when the waves of vibrating air particles reach your ear drum, they set it vibrating at the same speed, or *frequency.* Your brain changes the signals it receives from your ear drums into the sensation we call sound.

About 100 years ago, a French scientist named Jules Antoine Lissajous *(pronounced lee-suh-ju)* found a way to draw patterns representing sound waves by using a swinging pendulum. Since his time, these patterns have come to be called *Lissajous figures* and have been used to study many different kinds of waves, including those that carry sound and pictures to your television set.

With some string, a piece of sticky tape, a paper cup filled with salt, and a sheet of black construction paper, you can make lots of Lissajous figures, each one different.

Setting Up Your Equipment

Try making a single pendulum first, and start with simple figures. With a sharp pencil, punch a hole in the bottom of your cup, from the inside. Next punch two holes, one in each side of the cup, and thread a piece of string through them *(see diagram).* Tie the ends of the string together, and loop the string over a floor lamp, or hang it from something else. The distance from the cup to where you hook the string can be 3½ or so feet; the distance from the bottom of the cup to the floor, about 6 inches. Fasten the two strands of string together just above the cup with tape.

Now cut out a disk of paper, make one cut to the center and fold it into a cone *(see diagram).* Cut the point off the cone, so that you make a small hole, and fit the cone into the cup, pointed end downward. The tip of the cone should just be sticking through the hole in the bottom of the cup.

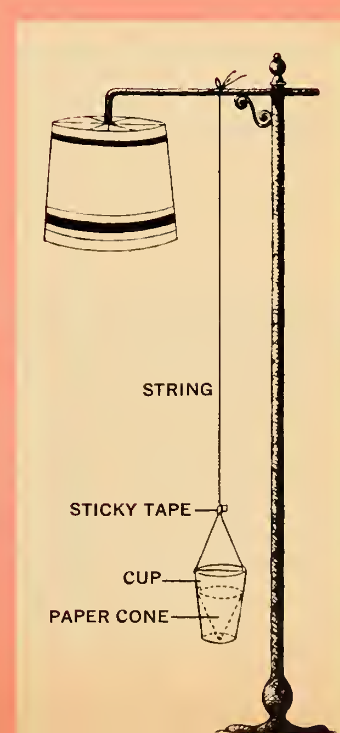
Now put a large sheet of black construction paper (about 22 x 28 inches) on the floor, and pour some salt or sugar into the cup until it is half full. Keep your finger on the hole so that the salt doesn't run out. You are now ready.

Hold the pendulum off to one side (the string is the pendulum "rod," and the cup of salt is the pendulum weight). Remove your finger from the bottom of the cup and let the pendulum go. It will swing back and forth in front of you, and salt will pour out, tracing a line across the paper. (You don't want too much salt to come out—just enough to make a solid line.) As the pendulum swings back and forth, it will trace a straight line if you held it in the right position before releasing it. If you hold it a little bit toward you or away from you while you are holding it to one side, it will trace a long oval figure.

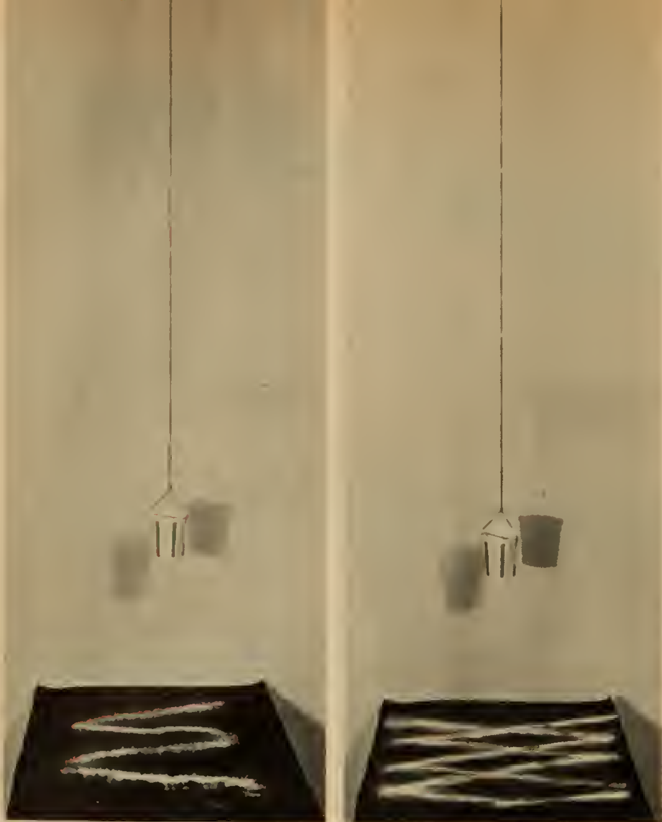
Making Waves with Your Pendulum

For the next experiment, make the pendulum swing from side to side in front of you, as you did before. But this time, pull the paper *slowly* toward you. Try to keep the

(Continued on the next page)



Make this simple pendulum as shown, and hang it from a floor lamp or hook so that the bucket swings freely.



The pattern made by pulling the paper in one direction as the pendulum swings across it (left) is called a sine wave. If you change from pulling the paper to pushing it when the pendulum is at the middle of its swing, two sine waves are drawn (right). They are exactly out of step—or out of phase—with each other.

Making Shapes with Swings (continued)

paper moving at an even speed, and make sure you pull it directly across the pendulum's line of swing. (The pendulum should not be swinging so hard that the salt line spills off the paper.) You will now find that the salt traces out a wiggly curve, or *waves,* as shown in the photograph.

Look at the waves and you will see that they are quite regular—if you pulled the paper smoothly. Maybe you have six or seven waves. Do they remind you of ocean waves? With a ruler, measure the distance from the top of one wave to the top of the next wave, and so on along the sheet. If you pulled the paper evenly, the distance between each pair of wave tops should be about the same.

The distance from the top of one wave to the top of the next wave is called the *wavelength.* Now that you have had some practice, make another set of waves, measure their wavelength, and write it down in box number 1 under "wavelength." Also, find out how fast the pendulum is swinging. By watching the sweep second hand of a watch, you can time your pendulum's swings. If it makes one complete back-and-forth swing in two seconds, then we can say that the *frequency,* or rate of swing, of your pendulum is two seconds. Write down the frequency you just measured in box number 2 under "frequency."

Can You Speed Up Your Pendulum?

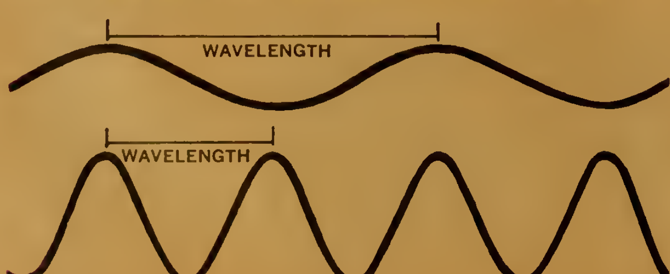
So far, you have measured the wavelength of salt waves made by a pendulum swinging at a certain frequency. If you could think of a way to speed up the pendulum's swing, what do you think would happen to the wavelength? Would it get bigger or smaller? In other words, would the waves be bunched up closer, or would they be stretched out more? Try to find out by making the pendulum swing faster. Does it swing faster if you give it a longer swing, or a harder push? Try it and find out.

Next, shorten your pendulum so that it is only half as long as before. This time you'll have to put your sheet of construction paper up on a small table, so that the paper is just about the same distance from the cup as before. Set the pendulum swinging. Does it swing slower or faster than before? Now make another set of waves, pulling the paper toward you at the same even speed. When you have made several waves, measure their wavelength and write it in box number 3 under "wavelength." Also write the frequency of your short pendulum in box number 4 under "frequency." What do your figures tell you about the length of waves made by two pendulums of different length? Which length pendulum makes shorter waves?

Making Double Waves

There is still something else you can do. You can push your paper forward, as well as pull it back. To try this, use your long pendulum, then fill the cup with salt again

The length of a wave is measured from the highest point on one curve to the highest point on the curve next to it. (The bottom wave has twice the frequency of the top wave.)



	WAVELENGTH	FREQUENCY
LONG PENDULUM	1	2
SHORT PENDULUM	3	4

and set it swinging. Pull the paper as you did before, and then push it back again. What do you see? You have made two sets of waves.

The kind of linking pattern you see depends on where the pendulum had swung to when you began pushing the paper the other way. If you changed from pulling to pushing when the pendulum was at the end of its swing, you would find that the second set of waves was traced right on top of the first set. And the second set would be exactly in step—or *in phase*—with the first set.

Maybe you began pushing the paper back on its return trip before the pendulum was at the end of its swing. If so, what happened? Try pushing the paper when the pendulum has only reached the *middle* of its swing. You will find that the second set of waves crosses over the old one *(photo-page 14)*. The waves are exactly out of step—or *out of phase*—with each other. Make more waves. Try to keep some in phase, and others exactly out of phase. See how many different and interesting patterns you can make. Shorten and lengthen your pendulum, letting long waves mix with short waves.

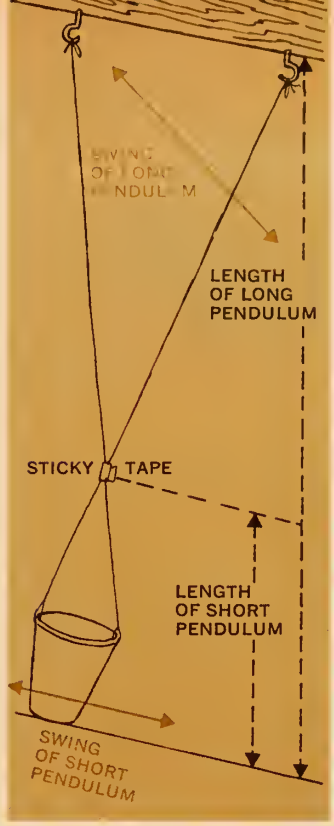
A Two-in-One Pendulum

Now try making a double pendulum. It's easy, and you will get more interesting patterns. Just separate your strings and tie one to one hook and the other to a second, as the diagram shows. Wrap a new piece of sticky tape around the string so that it divides the pendulum into two parts, the top part four times as long as the bottom part.

You now have two pendulums. One stretches from the hooks to the bottom of the cup. It swings forward and backward. The second pendulum goes from the sticky tape down to the bottom of the cup. It swings from side to side. Because it is only one-fourth as long as the long pendulum, the short pendulum swings twice as quickly.

Fill your cup with salt and put a piece of black paper underneath it. You are ready to see what kinds of patterns you can get. Begin by pulling the pendulum toward you, holding one hand on the sticky tape. With the other hand, swing the cup out far to one side. Now, let go. The cup will swing back and forth, also from side to side. It will move side to side with twice the frequency that it moves forward and back. You will find that it makes a curve like a bent V. This is because both pendulums swing in phase.

What do you suppose happens when the two pendulums are exactly out of phase? To find out, hold the long pendulum at the sticky tape and pull it toward you with the cup hanging straight down. Then, as you let go, give the cup a small push sideways. The figure you will get is rather like an 8 on its side *(see photograph)*. If you watch the shorter pendulum swinging in relation to the longer one, you will see how this happens.



This diagram shows how to make and hang a double pendulum. Swinging the double pendulum back and forth as the short part swung from side to side produced this pattern (right).

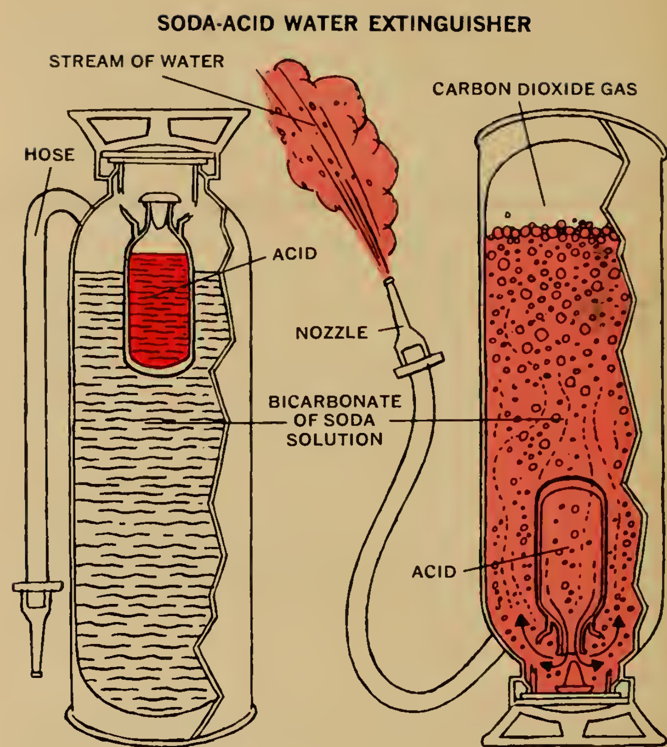
You can make all kinds of figures, ranging from the V to the figure 8, by getting the two pendulums just a little out of phase. Try it. Also, try moving the construction paper very slowly, first one way, then another. You will make some fascinating patterns.

Make a Pendulum as Long as You Can

The greater the difference in frequency between the two pendulums, the more complicated the Lissajous patterns become. If you use a really long string so that you can make the long pendulum nine times as long as the short one, when the pendulums are in phase, you will get something like an S instead of the simpler V. When they are exactly out of phase you will find that they give you a kind of double figure 8. The patterns also become more complicated when the shorter pendulum does not swing a precise number of times to every swing of the long one. Try the sticky tape at different positions and see the wonderful patterns you can make.

On an instrument called an *oscilloscope,* scientists can get the most beautiful Lissajous figures of all. They use the figures to compare the frequencies of all kinds of things—from radio transmitters on space probes to different notes of electronic organs, or even the squeaks of animals. If Jules Lissajous could have known how his figures are used today, he would no doubt be very surprised ■

Fire Extinguishers



■ One of the most common types of fire-fighting equipment is the *soda-acid extinguisher,* which uses water to put out a fire. Here is a way to find out how it works. Mix as much bicarbonate of soda as you can in a glass of lukewarm water. As you keep adding more and more of the white powder, there will come a time when no more will dissolve. When this happens, pour in one or two teaspoonfuls of vinegar (which is a weak acid). What happens? The gas that forms is carbon dioxide.

The tank of a soda-acid extinguisher is nearly full of water containing bicarbonate of soda. At the top of the tank is a small bottle of sulfuric acid. When the extinguisher is turned upside down, the acid mixes with the soda in the water and forms carbon dioxide gas. As this gas expands, or spreads out, it forces the water out through a hose to wet the fire.

A *pressurized water extinguisher* contains water and compressed air. When you squeeze the handles, a valve opens and the compressed air forces the water out. These water extinguishers work best on small fires of paper, cloth, wood, and trash.

A *foam extinguisher* works like a soda-acid extinguisher, but along with water, it sprays liquid foam that looks something like shaving cream from a spray can. This foam covers the burning surface and keeps air from reaching it. Without getting oxygen from the air, a fire cannot burn.

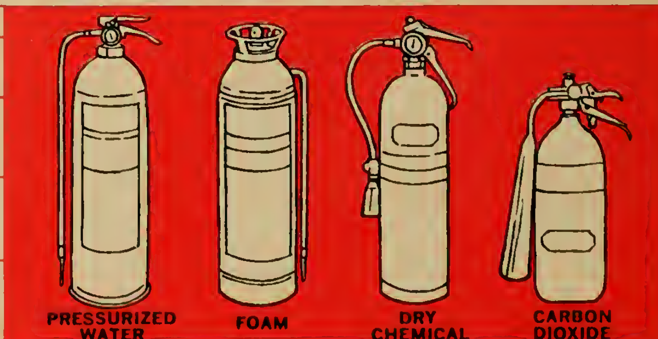
A *carbon dioxide extinguisher* uses the gas itself to smother the fire. Carbon dioxide gas is stored under pressure inside this extinguisher. When you press the handles together, a valve opens and sprays the gas through a horn-shaped tube onto the fire.

A new kind of fire extinguisher can be used on nearly all kinds of fires. It is called a *dry-chemical extinguisher.* Air under pressure inside the extinguisher forces a fine powder through the hose onto the fire. The powder is mostly bicarbonate of soda, which smothers the fire.

There are three main classes of fires *(see table).* Can you guess why water-filled extinguishers should not be used on burning liquids? Why wouldn't carbon-dioxide extinguishers be used on large Class A fires?

Fire extinguishers should be used only in emergencies. If the chemicals are released, an extinguisher will be useless in case of fire, and the chemicals may injure someone ■

TYPE OF EXTINGUISHER TO USE				
TYPE OF FIRE	WATER (soda-acid or pressurized)	FOAM	CARBON DIOXIDE	DRY CHEMICAL
CLASS A FIRE (wood, paper, cloth, trash)	YES	YES	YES (if fire is small)	YES (if fire is small)
CLASS B FIRE (burning liquids—gasoline, oil, paint, cooking fat)	NO	YES	YES	YES
CLASS C FIRE (electrical equipment—motors, appliances, switches)	NO	NO	YES	YES



nature and science
TEACHER'S EDITION

VOL. 2 NO. 4 / NOVEMBER 2, 1964 / SECTION 1 OF TWO SECTIONS

Centers of "Land for Learning"

by Joseph J. Shomon

■ Teachers in a number of communities are getting valuable new facilities for teaching natural science. These facilities are community nature centers—centers of "land for learning" now being set up in many urbanized places throughout the United States and Canada.

The modern community nature center has been variously described. Some have called them merely outdoor classrooms. Others think of them as special outdoor areas where strong emphasis is placed on nature study and the teaching of basic principles and concepts of conservation. Still others think of them as special outdoor centers set up to serve the entire community.

So far as the classroom teacher is concerned, the nature center is really an extension of the indoor classroom into the outdoors. The basic purpose of the nature center is to enrich the learning process of pupils by taking them outdoors for rich, direct experiences.

Fine, you say. But where are these centers, how are they being developed, who runs them, and how does the classroom teacher make use of them?

Joseph J. Shomon is Director of the Nature Centers Division, National Audubon Society.

The nature centers movement began about 20 years ago. Bill Carr, a far-sighted naturalist, established in the '30's the famous Trailside Museum at Bear Mountain, New York. It was so popular as an outdoor interpretation center and was so widely acclaimed that the Pack Foundation asked him to set up a similar center in the Arizona desert. The result was the now-famous Arizona-Sonora Desert Museum, in the heart of the saguaro cactus country near Tucson.

One of the first private nature centers was the Stamford Museum and Nature Center at Stamford, Conn. Later other junior museums and nature centers developed in the east and west. The National Park Service, under the able leadership of Dan Beard, began developing interpretive centers, in some cases called "visitor's centers," on park lands.

Then a number of Audubon nature centers were developed by the National Audubon Society, at Greenwich, Conn.; El Monte, Calif.; Dayton, Ohio; and Sharon, Conn. The first farm center, known as the Aullwood Children's Farm, adjoining the Aullwood Audubon Center, was opened to the public in Ohio.

In 1961 Nature Centers for Young America, Inc., merged with the National Audubon Society to become the nature

(Continued on page 4T)

PHOTO BY J. J. SHOMON FROM NATIONAL AUDUBON SOCIETY

A teacher-naturalist explains plant-animal relations to a class visiting the Audubon Nature Center at El Monte, Calif. Pupils can make first-hand observations at these centers.

IN THIS ISSUE

(For classroom use of articles preceded by ● see pages 2T and 3T.)

● **Shaping Plants with Light**
With a few bean sprouts, your pupils can investigate *photomorphogenesis*—the effect of light on the shape of growing plants.

● **"Deer 54, Where Are You?"**
How much do animals move around? Biologists are finding out by attaching tiny radio transmitters to animals and plotting their positions from radio signals.

● **How Seeds Get Around**
A species of plant has a better chance to survive if its seeds are widely scattered. This WALL CHART shows some of the ways seeds are carried away from parent plants.

● **Exploring in the Rain Forest**
The problems of planning an expedition into a South American rain forest are described in the first part of this two-part article.

● **Making Shapes by Swings**
The fascinating patterns your pupils can create with a swinging pendulum demonstrate the concepts of *wavelength* and *frequency*.

● **How It Works—
Fire Extinguishers**
Five common types are explained. A table shows which type to use on a specific kind of fire.

IN THE NEXT ISSUE

The building of a great suspension bridge... Botanists go into the mountains of Surinam by canoe... Proving the case against a germ that infects tropical fish... Valves as mechanical and biological "traffic cops."

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Shaping Plants

This article is one of a series prepared by Dr. Richard M. Klein, Caspary Curator of Plant Physiology at the New York Botanical Garden and botanical consultant for *Nature and Science*. Past articles by Dr. Klein include: "Make Flowers Bloom When You Want Them" (N&S, *July, 1964*) and "Guinea Pig Seedlings" (*May 15, 1964*). More botanical investigations with common plants will appear in future issues.

Topics for Class Discussion

• *Have your pupils discuss the effect of sunlight on the shape of the plants in their homes or gardens.* How does light affect the direction in which plants grow? Have they ever seen a houseplant appear to be leaning toward the nearest window? What happens to such a plant when it is turned 180 degrees? The tendency for a plant to turn toward light is called *phototropism*, which means "turn to light."

• *Have someone describe a greenhouse.* How would the uniform light of a greenhouse affect the shape of plants grown there?

• *What shape does a tree take in an open field? How do trees in a dense forest look?* Trees in the open usually have bushy crowns (like the "lollypop" trees that children often draw). When trees grow side by side, they have fewer side branches *(see diagram).*

The amount of sunlight reaching the lower parts of trees affects their shape.

Activities

• *Take a nature walk to observe the effect of sunlight on the shape of plants.* Observe plants in shaded situations and crowded situations. Visit a number of spots before letting your pupils draw conclusions. Remind them that water, soil, and pruning also affect the appearance of plants.

PAGE 4 "Deer 54..."

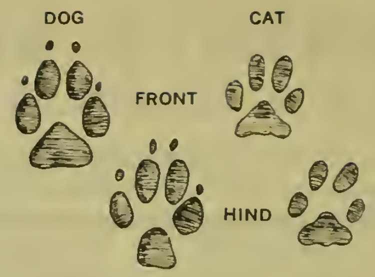
The tracking of animals by radio is a good example of technology coming to the aid of biology. This new field of animal observation was not possible until the invention of the transistor and the miniaturization of radio equipment brought on by the space age. Radio-tracking is in its infancy and much of the research being done now is aimed at improving techniques.

Topics for Class Discussion

• *Why are scientists interested in the whereabouts and activities of wild animals?* The reasons vary with the animal. The Grizzly Bear is being studied in hope that knowledge about its habits may save it from extinction. Deer, grouse, and rabbits are studied so that biologists can manage these game animals more wisely. Knowledge about the travels of deer and porcupines also interests foresters, since these plant-eaters can do considerable damage to trees.

• *What are some of the time-honored methods of following animals?* They include observing footprints, droppings, feeding signs, and evidence of bedding-down. Also, listening for characteristic sounds or calls.

• *What advantage has radio-tracking over these methods?* Footprints must be made in mud, snow, or sand to be easily followed, or even identified. In radio-tracking, biologists know the sex of the animal, perhaps even its age and the exact time it is in a certain location. Usually, once a transmitter is attached to an animal, radio-tracking can be done without disturbing it.



The presence or absence of toenail marks, and the size and shape of toe pads are clues to track identification.

Activities

• *Until electronic tracking kits appear on the market, your pupils will have to follow animals by their signs.* Winter is a good time to encourage this. Even a city offers opportunities—vacant lots, parks, garbage dumps, and swampy areas. A good time to look is in the morning after rain or light snow.

Begin with common animals. Dogs and cats leave characteristic pawprints *(see diagram).* Cats retract their claws when walking, and so do not leave claw marks as dogs do. Children may corroborate this by observing that cats tread soundlessly, whereas dogs' feet click on hard surfaces.

The author of this article, Dave Mech, has also written a SCIENCE WORKSHOP on animal tracking that will be accompanied by a WALL CHART guide to tracks in a winter issue.

PAGE 8 Seeds Get Around

The dispersal of plants and animals is often essential to their continued existence. Point out to your pupils that dispersal among animals is generally *active*, while in plants it is most often *passive*. That is, it is usually effected by external agents such as wind, water, animals, and man. Exceptions are those plants that actually shoot their seeds from pods (the range of spread in these cases, however, is never very great). The great seed-spreaders are birds and man.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition wth single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE & SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . .
(Continued from page 2T)

Topics for Class Discussion

• *Have your pupils consider the many seeds produced by a single plant.* Do they see a relationship between the number of young that a species of living thing produces and the chances that the species will survive? Mice and rabbits are good examples of animals that produce many young and have a high rate of mortality.

• *Of the seeds that are spread by man, what kinds are apt to be carried on purpose and what kinds by accident?* Food plants are spread deliberately, weeds accidentally. The Russian thistle entered this country in a bag of flax seed and quickly became a pest to farmers. Many other common weeds in the United States were brought accidentally from Europe.

• *Will seeds collected in the fall sprout if planted indoors?* Some will, but many seeds need a period of cold temperatures (such as they would be exposed to outdoors) before they will sprout. Florists often keep seeds refrigerated for a time to simulate cold winter temperatures.

Activities

• *Fall is an excellent time to gather seeds.* Let the class arrive at a way of sorting and arranging them for display. Very likely they will choose to organize seeds by the way they travel, as shown in the WALL CHART. Seeds may be glued in place on construction paper or displayed in small plastic bags.

Keep mystery seeds to one side and encourage identification by letting the pupil who solves the mystery add the seed in question to the regular display.

• *Someone might read and report on John Chapman, better known as "Johnny Appleseed."*

References

• *The Wonders of Seeds,* by Alfred Stefferud, Harcourt, Brace and World, Inc., New York, N.Y., 1956, $2.75.

• *Play With Seeds,* by Millicent E. Selsam, William Morrow and Co., Inc., New York, N.Y., 1957, $2.88.

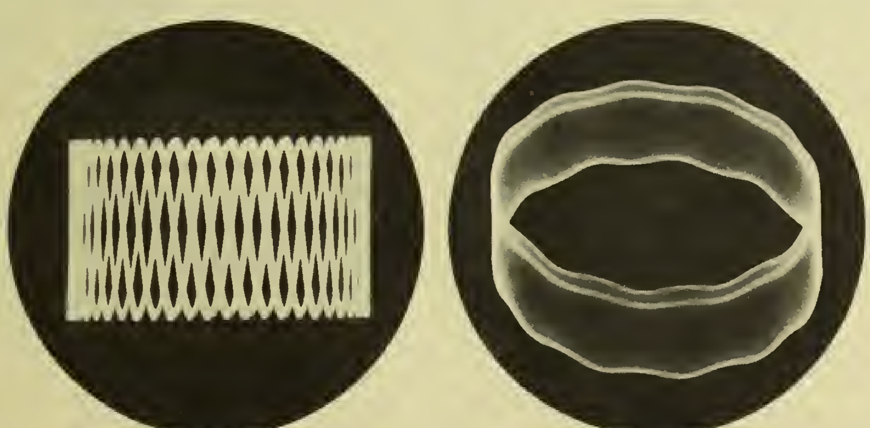
PAGE 10 Exploring

Part One of this fascinating account provides insight into the extensive preparations necessary for scientific investigation. Your pupils will come to see that an expedition is a thoroughly human activity, full of mistakes, surprises, successes, and failures.

Topics for Class Discussion

• *What were the main purposes of the expedition?* (See page 10.)

• *How is preparing for an expedition similar to preparing for a camping trip?* Have the class list the parallels that exist between the author's experience and their own. (For example, planning to take such things as lightweight, compact gear; high-calorie concentrated food; only appropriate and essential clothing; and first-aid supplies.)



These Lissajous patterns (see *page 13, "Making Shapes by Swings"*) were produced on an oscilloscope screen by comparing two waves of different frequencies. The pattern at the left was made by two waves, one of six times the frequency of the other. The pattern at the right was made by a high frequency radio wave and a wave with a frequency of 50 cycles per second.

• *What is a "rain forest?"* As the name implies, these forests have lots of rain—often more than 100 inches a year. The plants that grow there are those kinds that thrive in a wet, humid climate. There are rain forests on the northwest coast of the United States, but the plants that grow there are quite different from those in Surinam.

In the next issue of *N&S,* Dr. Irwin points out that a rain forest is *not* a jungle of tangled plants. Actually, there is little underbrush growing in the shade beneath the canopy of trees, and it is easy to walk through a rain forest.

Activities

• *Your school library is sure to have many exciting stories of expeditions for your pupils to read.* Magic names are Thor Heyerdahl, Howard Carter, Roy Chapman Andrews, Admiral Byrd, Edmund Hillary, Ernest Shackleton, and Jacques-Yves Cousteau.

• *In preparation for the second part of this article, have some children look in an encyclopedia and other references for information about Surinam.*

PAGE 16 Fire Extinguishers

To stimulate interest in fire extinguishers, you might take your pupils on a "field trip" around your building to learn the locations and kinds of extinguishers available. Be sure to caution your pupils never to tamper with them. You can set an example by leaving the extinguishers in place while talking about them. Tell your pupils that if they know where extinguishers are located they can direct adults to them in case of emergency.

Point out that playing with fire extinguishers can be dangerous for anyone, but especially for a child. If an extinguisher fell on a child or if he spilled the chemical contents on himself, the results could be tragic.

You can take advantage of interest in fire extinguishers to discuss the chemistry of fire. For example, there are three essentials for any fire: fuel, heat, and oxygen (air). An extinguisher must deprive the fire of one of these essentials in order to put it out.

Your local fire department would probably be willing to send a representative to your classroom to explain fire equipment and fire-fighting techniques. He might also arrange for your class to visit a fire station.

Centers of Land...
(Continued from page 1T)

centers planning division. Today the division provides valuable professional and technical help to local governing bodies and private groups who seek to establish nature centers in their own local communities. The help comes mostly in the form of advice and guidance to local leadership groups. In addition, the division prepares and distributes informative material on all aspects of nature centers. It also provides valuable technical field planning services which are available to any organization which requests them. These services are offered on a cost-share basis.

A conservative estimate now discloses that there are some 200 nature centers in the United States and Canada. About half of these are public facilities administered by city, county, state, or federal recreation, park, or conservation agencies. The other half consists of private or semi-private nature centers run by private organizations or administered jointly by private groups and government agencies.

Today the visitor will find well-established nature centers in the Washington, D.C., area; Chicago; Cleveland; Los Angeles; Richmond, Va.; Kalamazoo, Mich.; and in many other cities. In a good many instances nature centers are operational only in the summer months. This is especially true of those set up in many state and county parks.

In countless communities, however, the community nature center idea is only now getting established. But if all goes well there should be 1,000 nature centers in the United States by 1985 and 2,000 in America by the year 2000. Because nature centers are developing rapidly and personnel and situations are changing frequently, no accurate and really complete directory of nature centers is available at the present time.

Using a Nature Center

The best way for a teacher to use a nature center is to visit such a facility, become acquainted with its personnel, and learn what resources and services are available to the school. One or two visits to a nature center will soon familiarize the teacher with what is available.

Most nature centers are specially geared to serve the schools, but the manner in which these services are offered often varies. Some centers specialize in guided tours. Others feature self-guidance nature walks. Still others feature a variety of educational programs.

At the Aullwood Audubon Center near Dayton, for example, school groups come to the center by appointment. The classroom teacher writes or telephones the director, makes an appointment for a class visit, usually well in advance, and then appears with her class on the scheduled day. Transportation is usually by school bus. Sometimes P.-T.A. groups will provide private transportation.

When the class arrives, it proceeds promptly into the interpretive building for a brief orientation by a teacher-naturalist. The class is then taken outdoors for an hour's guided field trip. The teacher-naturalist stresses natural science concepts and conservation principles. The young people learn about natural resources, about soil, water, forests, wildlife. They learn by seeing, feeling, touching, smelling, listening, asking questions. They learn about plant and animal interrelationships including man's role in them.

Following the field trip, a delightful quarter hour is spent in the educational building, viewing exhibits and displays and manipulating electric quiz boards and educational charts and games.

When the class leaves, the teacher is handed a packet of helpful instructions outlining ways in which the nature center experience can be followed up in the classroom and at home. Many pupils get so excited about the nature center that they persuade their parents or community leaders to bring them to the center on afternoons or weekends.

Although all school groups from kindergarten through the 12th grade and even college are encouraged to visit and use the nature center, especially effective work is being done with grades 5, 6, and 7. At some nature centers special programs are offered gifted groups. Some provide special educational programs for the handicapped groups, the crippled, blind. Much good work is done with teenage groups who are given opportunities to develop outdoor skills or to further their interest in natural science.

An important aspect of nature center programming is the training of teachers and community leaders in outdoor education techniques. At the El Monte, Calif., nature center, considerable time is spent training teachers on how to use the nature center. Frequent one-, two-, and three-day workshops are held. Paul Howard, the center's director, believes that "if we can train sufficient teachers to be good outdoor interpreters and field leaders, then we will have the multipliers we need in outdoor conservation education." He considers teacher and leadership training to be one of the big jobs of the effective nature center.

An important aspect of outdoor education today is that nature centers now have day camp areas. After teachers have been trained to use the outdoors, they are encouraged to use day camp areas on their own. Thus it is possible for classes to go out for a whole day or several days of field instruction without having to depend upon the center's teacher-naturalist for fulltime help.

The typical nature center nowadays is located within the city limits or within easy reach of schools in urbanized areas. It features a special area of land, usually at least 50 acres, together with a planned educational building and land educational facilities specially developed to interpret natural resources. More than likely a well-trained staff of teacher-naturalists is on hand to help with a full program of interpretation and with administration.

A Film Shows How To Start a Center

Teachers interested in the natural sciences as well as nature study and conservation would do well to make maximum use of the nature center in their community. Where no such centers exist, they can often supply the leadership necessary to get one started. A new motion picture, "A Green Island of Nature," was cooperatively produced by the National Audubon Society and the U.S. Forest Service. This film is now available through each of these organizations. It is especially designed to show what a nature center is and how the local community can go about developing one.

One of the great needs in American education today is to teach young people an appreciation of nature, natural laws, and the importance of our natural environment to a free, vigorous, and happy people. Man is, after all, a biological being, tied by endless strings to an environment which, over the millennia of time, has been essentially natural. He can sever his contact with nature only at his own peril.

There is much talk today of the importance of a strong land-ethic in America, of developing a natural resource conservation philosophy among people. Perhaps 2,000 nature centers, serving this nation as land-for-learning centers, may be just the thing to bring this about ■

HELP WANTED

Do you have a science teaching technique or suggestion that you would like to pass on to others? *N&S* welcomes suggestions and articles for the Teacher's Edition that will lead to more effective science teaching in the elementary grades, as well as articles for the student's edition. Articles are paid for on acceptance. All manuscripts should be accompanied by a self-addressed envelope and return postage.

IS THERE A NATURE CENTER near your school? To find out, ask your school superintendent or call any local county or state conservation office, Audubon Society, or conservation club.

nature and science

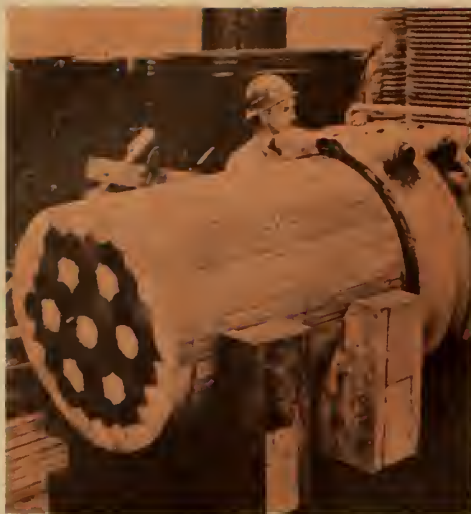
VOL. 2 NO. 5 / NOVEMBER 16, 1964

Could a bridge be built to carry men and trains across the treacherous East River?

BUILDING THE GREAT BRIDGE see page 3

THE LONGEST SPAN IN THE WORLD

SEE PAGE 2



ABOUT THE COVER

Since 1937, the Golden Gate Bridge has been the longest suspension bridge in the world. Its main span stretches 4,200 feet across San Francisco Bay. However, on November 21, 1964, the bridge on our cover will set a new record—4,260 feet. It is the Verrazano-Narrows Bridge, linking Brooklyn and Staten Island, New York.

The bridge is named after Giovanni de Verrazano, the Italian explorer who discovered the New York harbor in 1524. The "Narrows" is the stretch of water between Brooklyn and Staten Island.

Construction of the bridge began in August 1959. Its foundations rest over 100 feet below the water surface, and its twin towers rise 690 feet above the water.

One interesting thing about the bridge is that its basic design and some of the building methods used are almost the same as those used to build the famous Brooklyn Bridge—begun nearly 100 years ago *(see article beginning on page 3)*. The method of spinning cables is almost the same as that used on the Brooklyn Bridge.

The photo above shows a test section of one cable, made up of 26,108 wires. Four cables, containing 143,000 miles of wire, will support the roadway of the Verrazano-Narrows Bridge.

nature and science

VOL. 2 NO. 5 / NOVEMBER 16, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez
CONSULTING EDITOR Roy A. Gallant

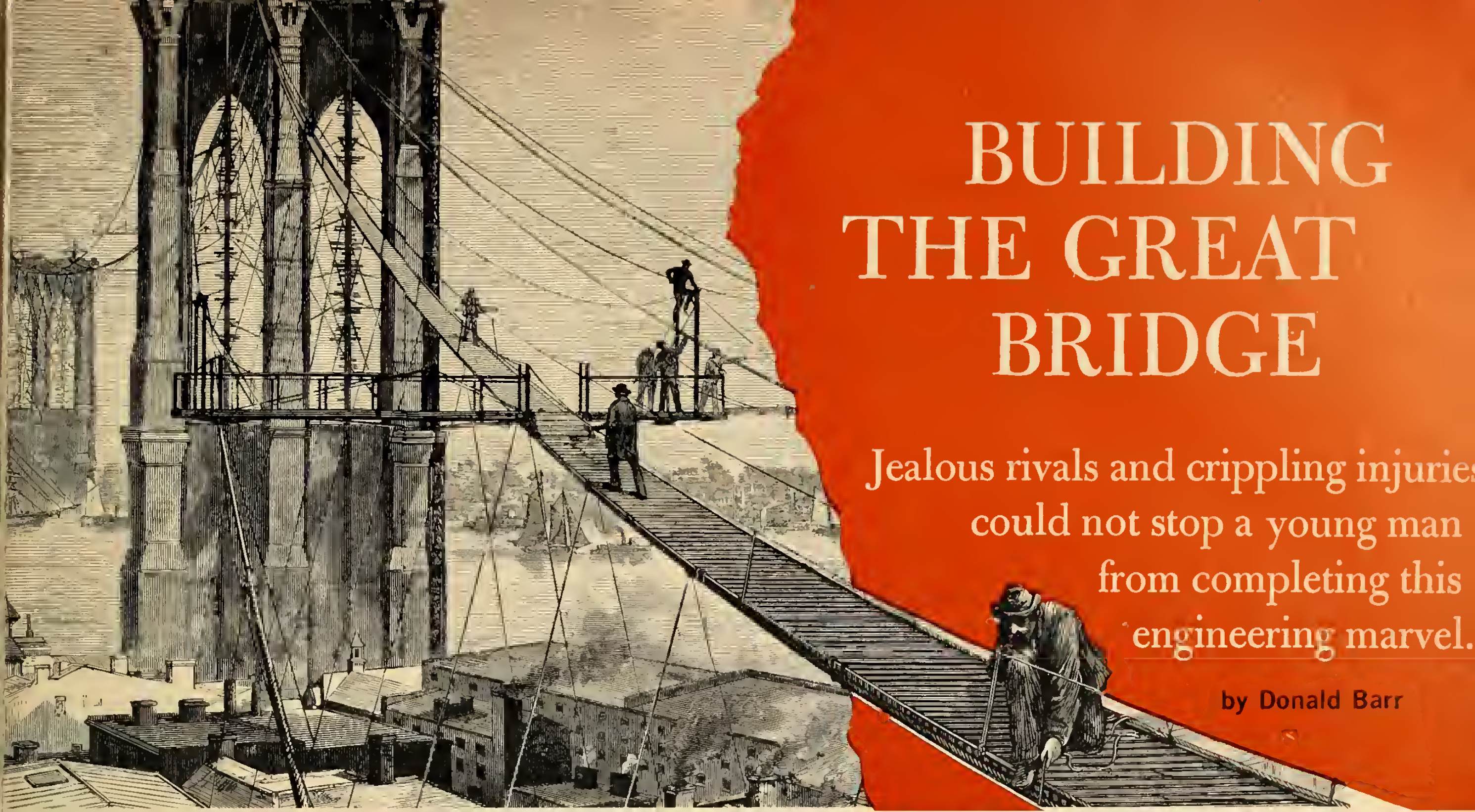
PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

CONTENTS

CREDITS: Cover photo by Richard Jacobson; pp. 2, 5, cable-spinning photos from Triborough Bridge and Tunnel Authority; p. 3, Culver Pictures, Inc.; pp. 4, 7, 10, 12, 13, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, "Galloping Gertie" photos from Wide World Photos; p. 6, photo by Dick Hanley from Photo Researchers, Inc.; p. 7, photo by Berenice Abbott from Educational Services Incorporated; pp. 8, 9, drawings by R. G. Bryant; pp. 11, 13, 14, photos from Howard S. Irwin; p. 15, photo by Gerard J. M. Timmerman from T.F.H. Publications, Inc.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.



BUILDING THE GREAT BRIDGE

Jealous rivals and crippling injuries could not stop a young man from completing this engineering marvel.

by Donald Barr

When the 266-foot-high towers of the Brooklyn Bridge were complete, the spinning of the giant cables began.

■ The story of New York's famous Brooklyn Bridge began about 1830 when a German engineering student named John Roebling traveled to Bavaria to watch an unusual bridge being built. The bridge was held up by iron chains hung from towers at each end, and Roebling thought to himself, "*This* is the way to build a bridge over wide deep water where tall ships must sail!"

It was the cables for these "suspension bridges" that worried him, for he knew that iron chains could not be made strong enough. But what could he use instead of chains? He was still thinking about this problem when he came to America as a young man of 25. He married, became an American citizen, and worked as a surveyor.

One day, while surveying in the Allegheny Mountains, he saw an accident. In those times, canal boats were an important way of traveling, and the heavy craft were hauled from canal to canal on tracks over the mountains. A rope broke, and the boat it was pulling plunged down a mountainside, killing two men. Roebling asked himself, "Couldn't they make ropes out of something stronger than hemp fiber?" And suddenly he saw that he had solved the problem of bridge cables. He would weave ropes out of iron wire.

Roebling built a rope-twisting machine in his backyard. He bought some iron wire and went into business, selling his new wire-rope to canal-boat companies. His business was a success. Then he moved to New Jersey and built a factory that used machinery that he designed himself.

The oldest of John A. Roebling's sons was named Washington Augustus Roebling and, like his father, he became an engineering student. He, too, loved bridges, and hoped to join his father in building them. For John Roebling's dream had at last come true. After building some small bridges and showing that his wire cable could make suspension bridges strong and steady, he tried to get the job of building the railroad bridge across the Niagara River near Niagara Falls. Another engineer got the job but could not do it. Roebling was called in.

His plan was a daring one, for suspension bridges bend and swing much more than other kinds. Most engineers were sure that the rough northern winds and rushing locomotives would wrench the structure apart. However, by cleverly using his cables to steady the 822-foot span, he built a bridge out of wood and wire that was one of the marvels of its time. Soon other engineers began building suspension bridges that followed John Roebling's designs.

Planning the Great Bridge

In 1867, John Roebling was asked to build a bridge from Manhattan Island to Brooklyn. Washington Roebling moved to Brooklyn with his bride Emily, and father and

(Continued on the next page)

This article is adapted from The How and Why Wonder Book of Building, *by Donald Barr. © 1964, Wonder Books, Inc. Reprinted by permission of the publishers.*

son began to study the problem of spanning the East River with a mighty bridge.

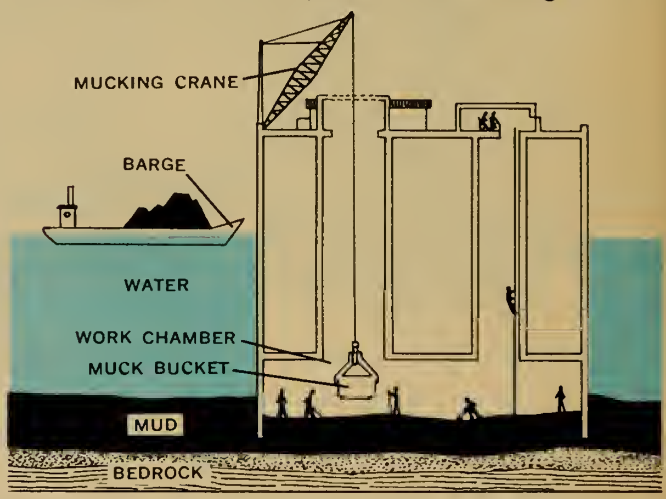
Ocean-going ships with tall masts passed along the East River day and night, and the river was wide and deep. The Roeblings saw that their Brooklyn Bridge would have to have one high, long span, nearly twice as long as the Niagara span, and far longer than any span anyone had ever tried to build. The great towers would have to be built on the hard rock that lay under the muddy banks of the river—so Washington Roebling and his wife spent a year in Europe looking at suspension bridges. Then they returned and boarded a train for St. Louis to see how an engineer named James Eads was building underwater foundations for a bridge across the Mississippi River. John Roebling stayed in New York, surveying, designing, planning, talking to politicians and bankers, preparing to build his masterpiece.

Just as work was about to start, John Roebling went down to the docks to check the surveyors' measurements once more. He did not notice a ferry coming in to its dock. As the boat bumped into its berth, a heavy timber was knocked over, crushing John Roebling's foot. The terrible disease of lockjaw set in, and two weeks later John Augustus Roebling was dead.

Washington Roebling, only 32 years old, became chief engineer of the great bridge that his father had designed. He was determined to show the world what an engineer his father had been.

He decided that the best way to build solid foundations for the huge granite towers was to use a device called the *pneumatic caisson*. This was a kind of huge box stiffened with iron and concrete, and open at the bottom (*see diagram*). It was set down in the mud, and the granite blocks

Roebling used a "pneumatic caisson" to help build the foundation of the bridge. Mud was dug out, lifted from the caisson, and loaded onto barges. The high air pressure inside the caisson kept water from rushing in.



GALLOPING GERTIE

■ The problem of designing a bridge is like the problem of designing a doorway in a wall or a roof over a room. It is the problem of carrying a load over an open space. The load on a bridge is more than the *dead* weight of the structure itself. It is also the *live load*—the push of people and trains and cars moving across the bridge, and of winds blowing against it.

The *rhythm* of the pushing is also important. If you have ever pushed someone in a swing, you know how a series of very gentle pushes at the right moment will make the swing go back and forth in wild swoops. This is because the swing has a "natural" rhythm of its own (which depends on how long its ropes or chains are). If the rhythm of the pushes matches this natural rhythm, the pushes will keep adding to the movement of the swing.

Many bridges are "tuned" to one rhythm of movement. Every army has a rule that when soldiers are crossing a bridge, they must march *out of step,* because the rhythm of the marching might just happen to be the natural rhythm of the bridge and the bridge might shake apart.

One of the most famous bridge disasters in modern times took place at Puget Sound, Washington. The Tacoma Narrows Bridge was completed there on July 1, 1940. It was a long suspension bridge, but its designers had forgotten some of John Roebling's ideas. The very first people to drive across the bridge noticed a strange waving motion, as if they were driving along the deck of a big ship in a stormy sea. This motion was very violent in high winds. People came to drive across "Galloping Gertie" just for the thrill.

of the foundation were built on top of it layer by layer, leaving a shaft down the middle. Down this shaft went the workmen called "sand hogs," with picks and shovels to scoop away the earth under the edge of thc box, so that it sank lower and lower. And up thc shaft camc the sand and clay, pulled up by powerful machines and taken away.

But there was one big difficulty—how to keep water from flowing in under the edge, filling the caisson, and drowning the men. This was done by pumping compressed air into the caisson, so that the push of the air was greater than the push of the water. That meant, of course, that the deeper down in water and mud the caisson had to go, the greater the air pressure inside had to be.

If the pressure grew too high, men would be crippled or die horribly of what is called "the bends" or "caisson disease." It wasn't known then that a quick move from high air pressure to normal air pressure would cause cramps and paralysis—"the bends." Washington Roebling knew that the caissons on the Manhattan side of the river would have to go down more than 70 feet. But he had to take the risk.

Early in 1872 the Brooklyn caisson caught fire. From ten at night to five in the morning, Washington Roebling stayed in the compressed air, leading the desperate efforts to save the structure, and it was saved. But in May of that year, he was carried out of the Manhattan caisson, uncon-

A wheel carried wire back and forth between Brooklyn and Manhattan for a year and a half, forming the cables that hold up the Brooklyn Bridge. This photo shows cable spinning on the Verrazano-Narrows Bridge (see page 2).

scious from "the bends," and for a night his life seemed to be flickering out. A few days later, he said he felt perfectly all right and went down again. Again he was carried out—this time crippled for life at the age of 35.

But Roebling was still chief engineer. Every movement of his twisted body cost him a terrific effort, but he was determined to finish his father's masterpiece. Sitting in a chair at a window in his house, he watched the work through fieldglasses. He made drawings and wrote orders, and his wife Emily took them to the workers on the bridge.

(Continued on the next page)

A 42-mile-an-hour wind caused the Tacoma Narrows Bridge to sway wildly.

Then the roadway tore loose and plunged into Puget Sound.

On November 7, 1940, only four months after the bridge was built, there was a very high wind. The bridge's bucking grew more and more violent. All traffic on it was stopped. The roadway started to twist around. First one side would tilt up until it was 28 feet higher than the other, then it would fall and the other side would tilt up. Then the span tore loose and plunged into the foaming water below. No one was killed, except a dog.

The bridge had accidentally been "tuned" to a rhythm that happened to be the rhythm of the shaking caused by the wind when it blew at certain speeds against the steel girders and the edge of the roadway ■

She studied books on civil engineering and took lessons from her husband so that she could help him.

Testing New Ideas

The Brooklyn caisson came to rest 44 feet under the river. The Manhattan caisson, the largest ever built up to that time, had to work its way through quicksand and finally settled on a ledge 78 feet down. The towers began to rise. They rose 266 feet above the water, and then the stringing of the wire began. This wire was made of steel. At that time, using steel for building was a new idea. But new ideas were what made life worth living for the crippled engineer.

A slender footbridge was hung between the towers, and in May 1877, a five-foot wheel began traveling back and forth between Manhattan and Brooklyn, unrolling wire. The wheel made a trip every ten minutes for a year and a half. Each length of wire went back and forth 278 times—from the ground up to the tower, then down and up in a great curve across the river, then down to the ground, and up to the tower, across the river, down to the ground. When the whole length of wire was hung in place and looped around iron anchor-bars at each end, the 278 thicknesses were wrapped into a tight bundle. When 19 bundles were in place, they were wrapped into a cable. There were four cables, which together had a strength of 18,000,000 pounds. Two highways, two railways, and a wide walk were hung from these cables.

In 1882, jealous rivals and politicians tried to have Washington Roebling fired as chief engineer. Emily Roebling went to a meeting of the American Society of Civil Engineers to make a speech. She told the engineers all that her husband had done and all that he had lost, and the engineers rallied to him. He remained chief engineer.

On May 24, 1883, Washington Roebling sat waiting at his window in Brooklyn with his wife beside him. They watched the great bridge, completed but deserted. From across the river came the faint sounds of bands and cheering. Then a great procession moved along Broadway and swung onto the beautiful long span. Emily helped her husband focus the field glasses. "There they are, Emily, there they are!" said the engineer.

Three men in silk hats and frock coats stepped proudly side by side at the head of the parade—the Mayor of New York City, the Governor of the State of New York, and the President of the United States. On the river below them, the sirens of the boats bellowed their applause. Cannons boomed. Church bells jangled. Factory whistles screeched. Thousands of people cheered. Nearer and nearer came the marchers, until they were out of sight below the window where Washington Roebling sat. A moment later, there was a knock on the door of the room.

Tribute to a Brave Builder

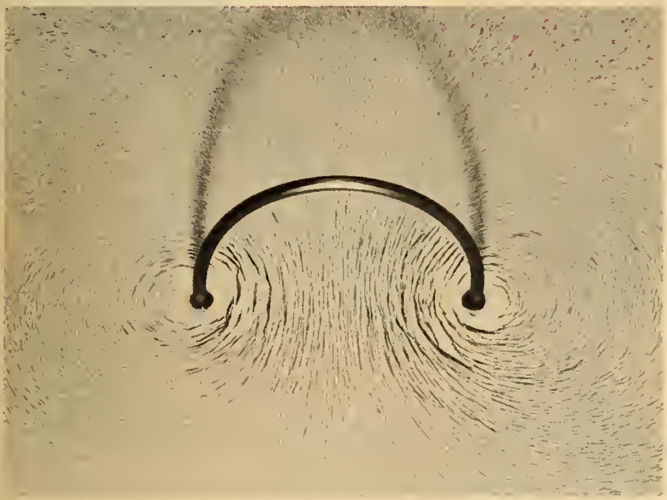
Three men stepped into the room—the Mayor, the Governor, and the President—while a dozen others crowded the doorway and watched. "Mr. President," said the Mayor, "may I introduce Colonel Roebling?" The President took the crippled man's trembling hand in both his own. "It is a privilege to meet a brave leader and a brave builder," he said. Outside, the fireworks were starting and happy crowds were swarming over the bridge.

On July 2, 1964, New York's Brooklyn Bridge was named a National Historic Monument by the United States National Park Service. Crowds still swarm across this famous bridge, thousands upon thousands, every day, and John Roebling's ideas can be seen in thousands of other suspension bridges all over the world ■

This photograph of the Brooklyn Bridge shows its 1,595-foot span and the tower on the Manhattan side of the East River. Even though the bridge is 81 years old, each year it carries nearly 30 million automobiles between Manhattan and Brooklyn.

prepared by **DAVID WEBSTER**

MYSTERY PHOTO



The little specks are iron filings which were sprinkled on a sheet of paper. What made them form the pattern around the wire?

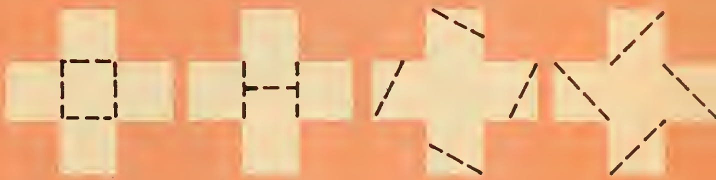
Can You Do It?

The three drawings show shadows made by something held in different positions in front of a light. Can you make something that would make the same shadows?

Fun with Numbers and Shapes

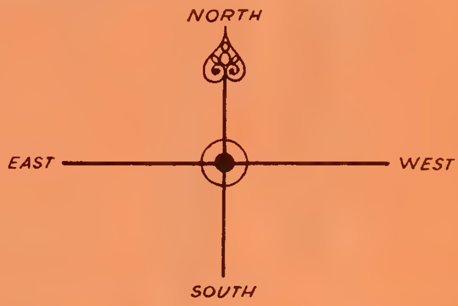
How can you cut the cross into pieces that can be fitted together to make a square? Trace the cross on paper, cut it out, and then cut it up into pieces.

Here are some ways you could try. Only one of these four ways works. There are other ways also.



For Science Experts Only

Compass directions like these were printed on something. Notice anything wrong with them? East is usually to the right of north and west is to the left. When the thing was used, the compass directions were the proper way. What was the thing the compass was on?



Answers to Brain-Boosters in the last issue.

Mystery Photo: The large skull is a giraffe. The cat skull helps to show the size of the big skull.

Can You Do It? One way to make a round ice cube is to freeze a balloon filled with water. A donut-shaped ice cube can be formed by a bowl of water with a small can in the center to make the hole.

What Do You Think Would Happen? Cooking oil floats on water no matter which is put in last. Did you notice how the oil formed drops when it hit the water?

Fun with Numbers and Shapes:

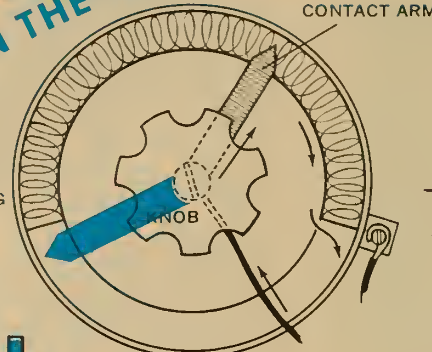
$$\begin{array}{r} 333 \\ -3 \\ \hline 330 \end{array} \qquad \begin{array}{r} 888 \\ 88 \\ 8 \\ 8 \\ 8 \\ \hline 1{,}000 \end{array} \qquad 99+9/9=100$$

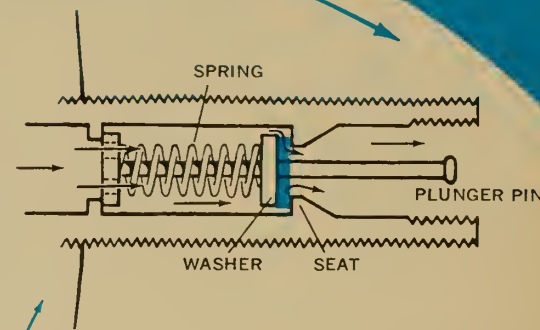
For Science Experts Only: The word is FLY. The letters are the spaces between the dark shapes. If you draw a dark line across the tops and bottoms of the shapes, you should be able to see the word better. Once you see it, it is hard not to see it.

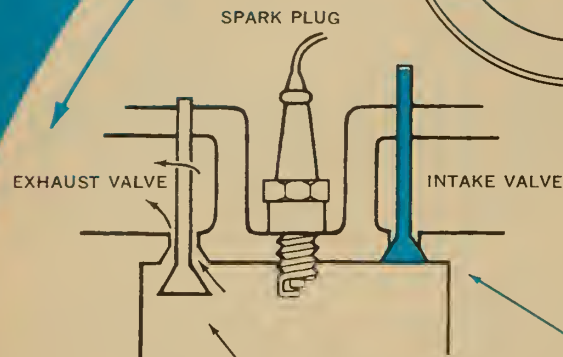
VAL

ALL A

IN THE GARAGE





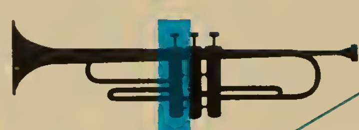


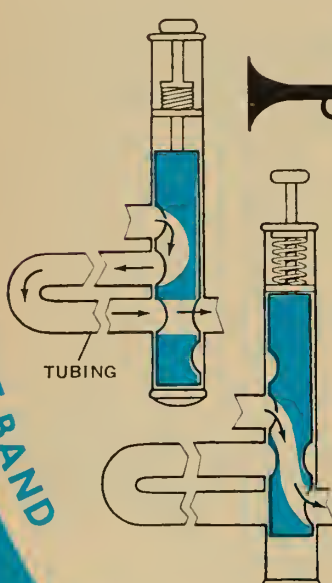
A *tire valve* is held shut by a spring. If you press down on the valve pin, the valve opens to let compressed air out or in.

A *rheostat* is an electrical "valve" used with automobile instrument panel lights and theater lights. Turning a rheostat knob dims or brightens a light by changing the amount of electricity flowing to it.

Automobile *engine valves* are made entirely of metal. An *intake* valve opens to let gasoline vapor and air into a cylinder, and an *exhaust* valve opens to let hot waste gases escape from the cylinder.

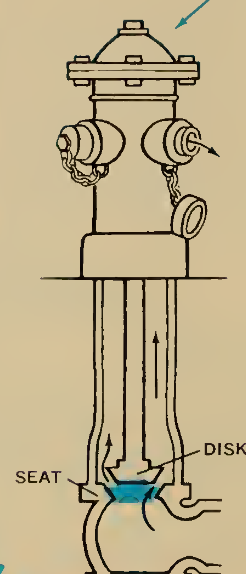
IN THE BAND





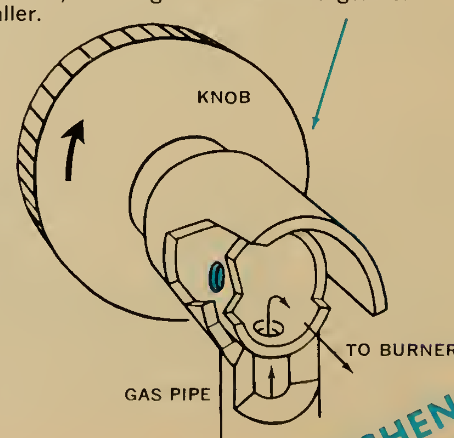
A trumpeter forces air from his mouth through metal tubing as he plays. When he pushes down on a *trumpet valve*, it opens up an additional length of the tubing. This lengthens the path of the air and produces a lower-pitched sound.

ON THE STREET



Hydrants provide water for fighting fires. A fireman fits a special wrench over the top of the hydrant and turns it to open a valve below the ground. Water flows up through the hydrant and out a side opening.

IN THE KITCHEN



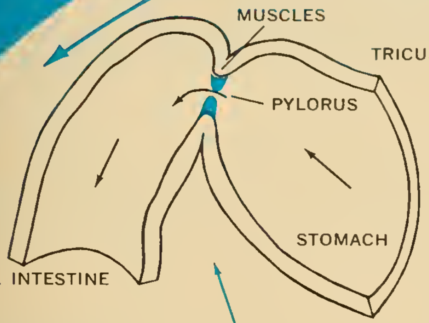
Cooking stoves have a *gas valve* for each burner and one for the oven. Turning a valve knob changes the amount of gas flowing to a burner, making the flame larger or smaller.

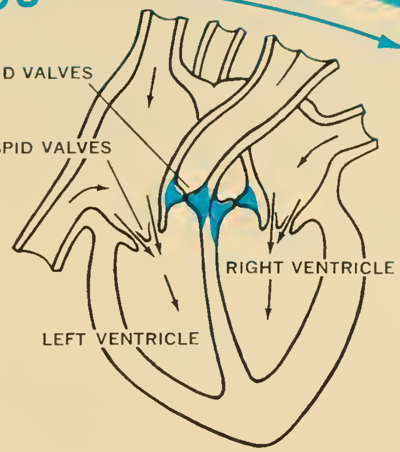
■ How many di
you used today?
you would first g
A valve is a
closed, opened pa
Such gates contr
solid particles, o
even say that thi
lips, canal lock
"valves," becaus
of people, air,
valves, however,
of such common
blood, air, steam
One type of va
—opens to let a
rection but close
from the opposit
tire valve, for e
flow in either di
open. Valves lik
stove have a ha
change the size o
less fluid flows t
Some example
of valves around
think of some o

VES

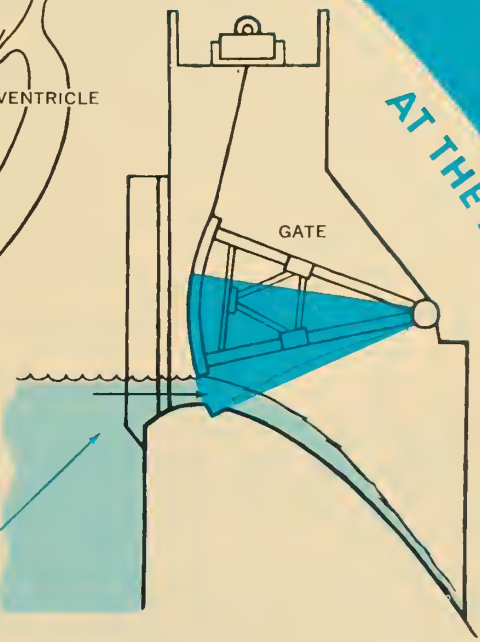
UND

IN YOU





AT THE DAM



ıls of valves have
many more than

ate" that can be
pened all the way.
of liquids, gases,
ricity. You might
rs, windows, your
era shutters are
ol the movement
and light. Most
control the flow
ater, gasoline, oil,
r stoves.
ıose in your heart
hrough in one di-
lock fluid flowing
Another type—a
s a gas or liquid
ng as the valve is
a faucet or a gas
you can turn to
g so that more or
valve.
ny different kinds
wn here. Can you
■

The *pylorus* is an opening at the lower end of your stomach. Circular muscles in the pyloric valve change the size of the opening and control the flow of food into the small intestine.

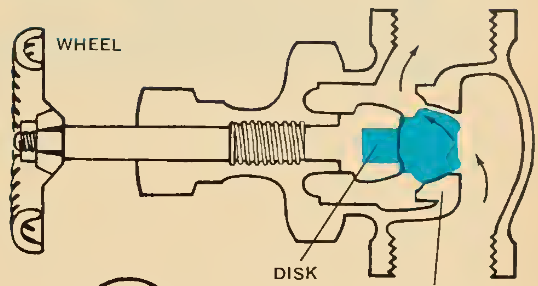
Bicuspid (two-pointed) and *tricuspid* (three-pointed) valves control the direction of blood flow through the hearts of mammals, including man. The hinged points fold back to let blood pass one way but close to prevent flow the opposite way.

Some dams have *spillway gates*, which hold back water at the top of a dam. When the gate is lifted, water flows over the spillway and into the river valley below the dam.

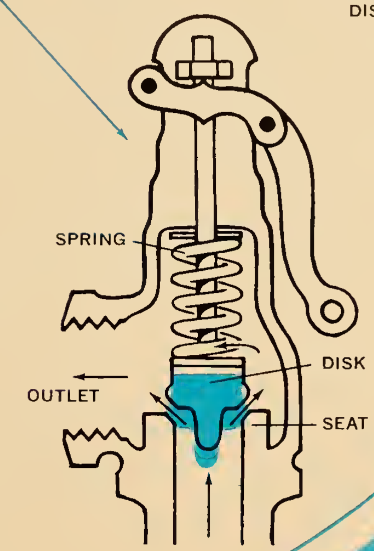
A *globe valve* is commonly used to control the flow of steam, water, and other liquids. Turning the wheel lifts a disk away from an opening to permit flow. Turning the wheel in the opposite direction closes the opening.

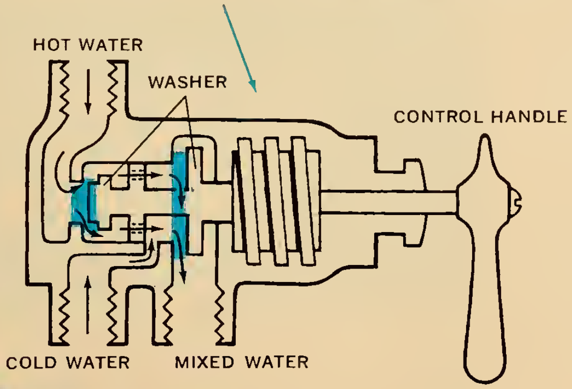
A steam *safety valve* goes into action only when steam pressure gets so strong that it may explode a boiler. Before this happens, the steam pushes against a spring, opens the valve, and escapes into the air.

A shower *mixing valve* is connected to both the hot and cold water pipes. By turning the handle, you can open the valve to get cold water, hot water, or a mixture of both.



IN THE BASEMENT





IN THE BATHROOM

Why Is the Sky Blue?

by Harry Milgrom

■ To an astronaut in orbit above the Earth's atmosphere, the sky is black at all times, both day and night. From the ground, however, the daytime sky is bright, and often blue. Why do we see a blue sky from the ground when an astronaut sees a black sky from space? Here's how you can find out.

Seeing Colors in Soapy Water

Fill a clear plastic dish with water and set it in front of a sheet of black paper. Then darken the room and shine a flashlight through one end of the dish *(see diagram)*. Look at the beam of light from the side as it passes through the water. What color do you see?

Next, dip a bar of soap (*not* detergent) into the water, and swish it around several times. Look at the beam of the flashlight from the side. What color or colors do you see in the beam of light now? Add some more soap and see whether the colors change.

The colors you see in the soapy water give some clues to the color that we see in the sky. Like the Sun, a flashlight gives off white light that is a mixture of colors including red, orange, yellow, green, blue, and violet. The specks of soap mixed with the water stop some colors and scatter them. These scattered colors are what you see when you look at the light beam from the side.

This article was adapted from Further Explorations in Science: A Second Book of Basic Experiments. *Copyright © 1963 by Harry Milgrom. Reprinted by permission of the publishers, E. P. Dutton & Co., Inc.*

The same thing happens when we view the sky from the Earth. The atmosphere around the Earth contains tiny particles of dust, water, smoke, and other things. These particles act like the particles of soap in the dish of water. Some colors of sunlight are scattered in the atmosphere, and others are not. From what you noticed about the colors in the soapy water, can you name the colors that seem to be scattered in the atmosphere?

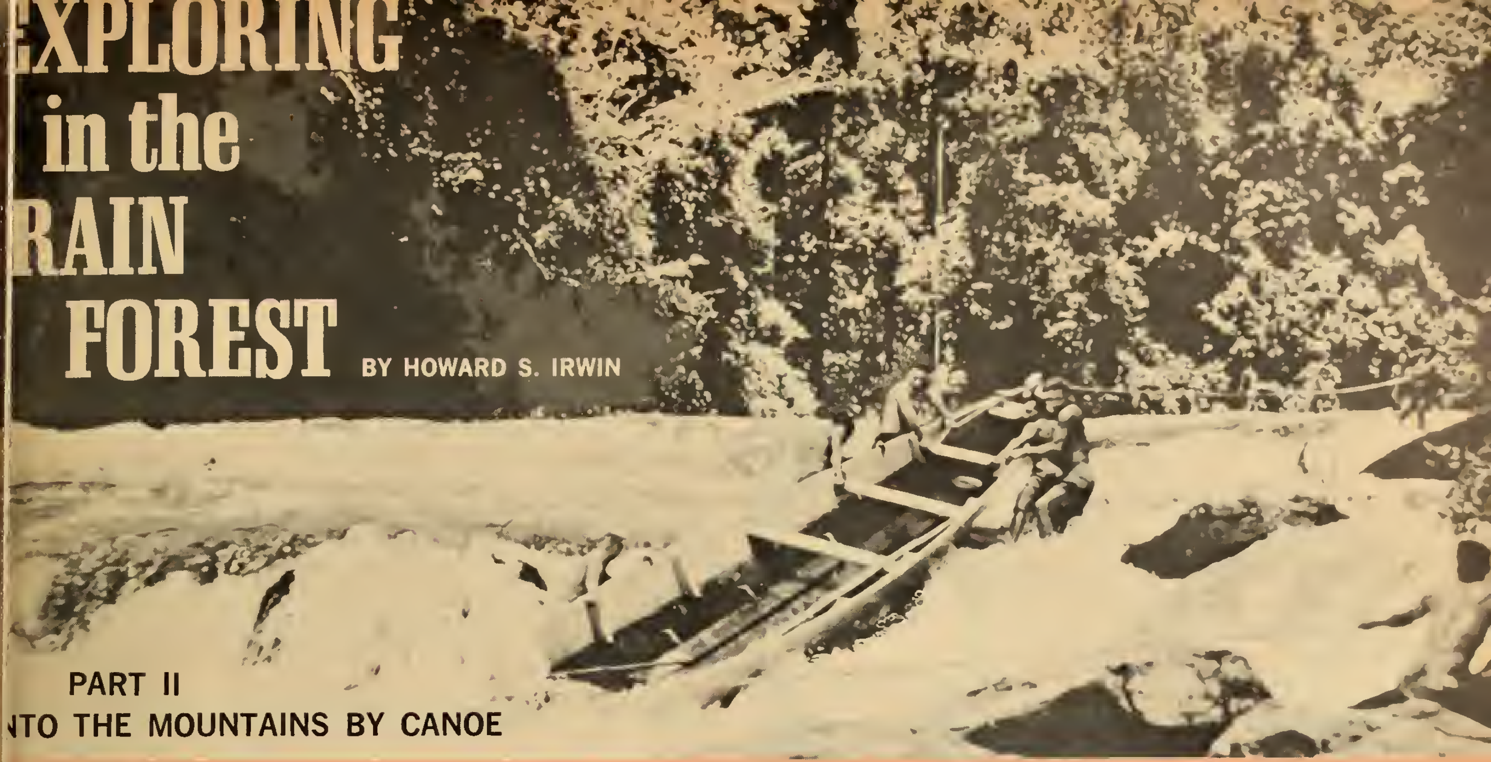
An astronaut in orbit is above nearly all of the Earth's atmosphere. He is in a region where there are very few tiny particles. This means that there is nothing to scatter the Sun's light, so the sky appears black.

Why Does the Sun Change Color?

Most of the time the Sun appears as a brilliant white disk in the sky. However, at sunrise and sunset it often looks yellow, orange, or red. To find out why, repeat the above experiment with the plastic dish, water, soap, and flashlight. This time, however, look directly at the beam of light, instead of observing it from the side *(see diagram below)*.

You will see the color of the light change as you add more and more soap. Notice what colors appear as you add the soap. In what way are these colors like the colors of the Sun?

The specks of soap in the water affect the light from the flashlight in the same way that particles in the atmosphere affect sunlight. Can you figure out why the Sun sometimes appears yellow, sometimes orange, and sometimes red? The greater the thickness of atmosphere that the Sun's light passes through, the redder its light will seem to us ■



EXPLORING in the RAIN FOREST

BY HOWARD S. IRWIN

PART II
INTO THE MOUNTAINS BY CANOE

Arriving in Surinam, scientists from the New York Botanical Garden set out by canoe to collect thousands of plant specimens in the wild Wilhelmina Mountains. (In Part I, Dr. Irwin told how the expedition was planned, and how the scientists arranged for the tons of equipment they would need.)

■ We were met at Zanderij Airport by Dr. Schulz and Gerard Wessels-Boer. Gerard, an expert on palms, looked a little embarrassed at our efforts at pronouncing his first name in Dutch. "My last name is no better," he explained. "It means weasel-farmer. Why don't you just call me W.B.?"

Dr. Schulz and W.B. drove Tom and me into Paramaribo. Bicycles and motor scooters darted among the cars and buses. Masses of bicycles were parked under airy new school buildings. Soon we pulled up in front of the Surinam Museum and were met by Dr. Geijskes. "Your things from New York are all here," he smiled. "I've arranged for a couple of planes to take you and all the men to the interior tomorrow. The equipment will follow the next day."

Flying to the Zuid River

That afternoon we met John Nunes. Dr. Schulz had asked him to be the field foreman. Usually we like to deal directly with our field men, but in Surinam that is a problem. Our men were Djukas, descendants of freed slaves who live in settlements along some of the rivers. John assured us they would be the best field men we would ever see. "They love the forest, the rivers, the wildlife. It's all they know."

The problem was that the Djukas spoke neither English nor Dutch, but *Taki-taki,* a mixture of English, Dutch, French, and African. We knew only a few Dutch words and no Taki-taki at all. John Nunes spoke both, and English as well.

At the airport the next morning we met the 15 Djukas. They were short, powerfully built, and gay in spirit and dress. They shook hands with Tom and me, then with arms folded across their barrel chests, looked at us as if to say, "Well, when do we start?"

In a few minutes two DC-3's taxied up. One plane would be for people, the other for the first load of our supplies. In five minutes we were in the air and began the bumpy one-hour trip to the Zuid River airstrip. The Djukas were right at home. John told us that they had flown several times before, mostly on his geological prospecting trips. Outside the window, 2,500 feet below, a magnificent unbroken forest spread before us. It was laced with meandering rivers and was interrupted here and there by a few grassy plains, or *savannas,* and palm-fringed Indian clearings. In the distance we could see mountains.

John nudged me and pointed. "That's Tafelberg Mountain. Beyond it are the Wilhelminas." Our plane began to lose altitude. The airstrip came into view, at right angles to the nearby Zuid River. As the tires squealed on the packed sand of the airstrip we all sensed that the expedition was really under way.

Here we were, in a remote backland area, about to embark on a three-month job for which we had been prepar-

(Continued on the next page)

Exploring in the Rain Forest (continued)

ing for over a year. What would it be like? What sort of place is the rain forest?

Inside the Rain Forest

Tropical rain forest is often called "jungle," a word I have never liked. It brings to mind pictures of trees seething with snakes, panthers crouching in the brush, centipedes crawling into boots, and explorers hacking their way through an endless tangle of greenery. This is an image given to us by many books and movies, radio and television programs. It is not the rain forest.

True rain forest is a very different sort of place. Most of the trees are slender, with mop-like crowns crowded together to form a dense canopy. Beneath the trees the forest floor is carpeted with the tans and browns of many different kinds of fallen leaves. Here and there the ground is sprinkled with the yellows, reds, and purples of wilted flowers. The carpet of leaves is thin, easily scuffed away to show the common soils—white or brown sands, or reddish clays. There is no thick leafmold, because decay is a very rapid process in the rain forest.

In the rain forest the annual rainfall is often over 100 inches and sometimes over 200 inches. It falls in brief torrential squalls. All-day drizzles are rare. The humidity on the forest floor is usually close to 100 per cent, while the temperature stays around 75 to 80° F. The light is dim beneath the leafy canopy of trees, 100 feet above.

Because of the dim light there is little underbrush. Tree seedlings grow here and there, while ferns, dwarf palms, and large-leaved creepers grow in small groups, mostly in the wetter spots. It is easy to walk through this kind of forest. A machete is needed only to cut an occasional vine or hanging branch. It is along the river banks that the bushes and vines form a curtain-like thicket down to the ground.

Canoeing into the Mountains

There are two ways to travel in the Surinam rain forest—by canoe or by foot. For long distances the round-bottomed, dugout canoe is best. Most of these canoes are built with one flat end, where an outboard motor can be attached. Our canoes were propelled by 18-horsepower motors. They weighed between 1 and 1½ tons when we finished loading them.

For two days, our eight canoes floated down the Zuid River and then pushed up the Lucie (*see map*). Although these rivers are broad, deep, and slow moving in most places, there are stretches where the water is shallow and rushes over rocks. Sometimes these rapids are too difficult or dangerous to pass. Then we had to unload the canoes and pull them over or around (*see photo on page 11*). We depended on the Djuka boatmen on this water highway, and their skill soon set us at ease. Hardly a rock was touched.

Toward the end of the second day John and I scanned our map, and pointing together to the mouth of a creek, shouted, "There's a good place." We tied up to a mass of vines hanging from the riverbank trees.

Then began the most remarkable display of teamwork that Tom and I had ever seen. John and the Djukas took up their machetes and axes and disappeared into the shadows. Amid the crackle of branches and crunch of leaves, the machetes began to ring as they cut through the vines and trees. Down tumbled the vines into the water. Trees began to topple. Within an hour a campsite was cleared. Within another, small trees were cut to various lengths and lashed together with tough vines to make frames for our 12 by 20-foot canvas sheets, or *tarpaulins*. The tarps were thrown over and tied. Meanwhile Tom and I unloaded the canoes and slung our hammocks and mosquito nets.

The next day two Djukas were left to finish the camp. The rest of us set off toward Juliana Top, the 3,600-foot peak of the range. We hiked quickly through the rain forest, slowing only when we waded across small streams and felled trees to bridge larger ones. At 3 p.m. we made another camp, smaller than the big river camp. Tom, W.B., Dr. Schulz, and I would stay in this area for the next few days while John and the rest went on to clear sites for other camps. It was time for us to begin our work in earnest.

Our job for the next three months was to collect specimens from as many different kinds of plants as we could find—trees, shrubs, vines, and low plants. We collected along rivers, on mountain slopes, around rock outcrops, and from mountain peaks.

Collecting Plants in the Rain Forest

Sometimes a Djuka had to climb to the top of a tree to collect some flowering branches. If the tree was too difficult to climb, we cut it down. Sometimes a cut tree did not fall, because its crown was tied to others by matted vines. Then as many as six or eight trunks had to be cut before the tree we wanted finally crashed down.

We looked up into the leafy patterns of the canopy, searching for the flowers and fruit that would help identify a tree. We also looked along the ground for tell-tale signs: a withered petal, a berry, a shiny seed. These were the clues. It was up to us to find them and know what they meant.

We collected 10 specimens of each plant. One set was for the New York Botanical Garden's herbarium, and one was for the collection of the Surinam Forest Department. The remaining eight would be used to trade for specimens of other plants from other museums.

We had to keep in mind that eventually, back at the Botanical Garden, each of the plants we collected would be mounted on a piece of white poster board, 11½ by 16½ inches. If the plant was the size of a dandelion, we collected a whole plant or even several plants. For larger plants, we selected a leafy branch with flowers or fruit, preferably both, together with some bark. If the leaves were very large—like those of the banana plant—one leaf was cut into pieces and mounted on a series of cards. Fruits that do not dry well were preserved in alcohol or formaldehyde.

As the fresh plants were collected, we wrapped them in plastic sheeting and stuffed them into duffel bags. We also took notes on flower color, height of the plant, soil type, and anything else that the collected specimen did not show. Finally, we cut wood blocks from the trunks, and filled burlap bags with leaves and bark from trees that might interest plant chemists. Usually we had all the specimens we could carry by mid-afternoon. Then we headed back to camp.

Life at the Camp

At camp we often took a dip in a nearby stream and changed into dry clothes. Then we began to put our specimens into drying presses while the Djukas set out with their shotguns and fishing tackle, hoping to bring in some game to brighten our rice-and-beans fare.

After we laid out the plastic-wrapped specimens and gave them collection numbers, we entered the same set of numbers in a field book, along with notes we had jotted down on paper while collecting the specimens. This information is important, since it will eventually go onto the specimen's label.

Each specimen was spread out on a half sheet of newspaper (*see photo*), which was then folded over and laid on top of a plant press. When the specimens piled up to about five feet high, we tied the press as tightly as possible and set it on a frame over a kerosene stove (*see diagram*). Hot air from the stove passed through the press, carrying away the moisture from the specimens. They dried in about six to eight hours. Leaving them in their newspapers, we dusted them with DDT or naphthalene to keep out insects, tied them into bundles, and then packed them into boxes.

While we pressed the plants, the Djukas came back with their catch. It might be deer, bush pig, agouti, capybara, tapir, bush fowl, even alligator, or any of 20 or more different kinds of fish. The cook had the fire ready and before long there was food bubbling and sizzling in half a dozen different pots and pans. The food was simple, but always appetizing.

After coffee the presses were checked, stoves pumped, and plans laid for the next day. Then, after some talk or quiet reading, we turned in, usually by 9 p.m. We worked seven days a week, 14 hours a day, but there was no com-

(Continued on the next page)

Each of the 20,000 plant specimens collected was spread on a half sheet of newspaper (left). Then the sheet was folded over and pressed together with other specimens. The pressed plants were then set on a frame over a stove to dry (far right).

plaining. We liked our work and, with our time limited, there was nothing to do but get on with the job.

So the days passed. We moved up to another camp every few days. As we moved farther away from the Lucie River camp, more Djukas had to serve as load bearers. They took dried specimens back to the river camp and returned with food. Within a month we had reached Juliana Top. We made three separate trips to the summit, but found no trace of the camp or equipment that was abandoned there by Dr. Gerold Stahel's 1924 expedition.

After working for a month on Juliana Top and nearby peaks, we began our slow retreat to the Lucie River camp. We cut wood blocks from many trees, and collected specimens from trees that had come into flower since we had first passed through.

Return to Paramaribo

By early October we had hiked out of the forest and were again in our river camp. The river, which nearly overflowed its banks in July, was now 15 feet lower. Many more rocks were exposed. The Djukas had to build a ladder down to the canoes. Within a few days we began taking our collections back to the airstrip. The radio operator at the airstrip alerted Dr. Geijskes in Paramaribo to send the planes. Tom and I were the last to leave the river camp. By now the water was so low that we had to jump into the river many times to help the canoes over rocks.

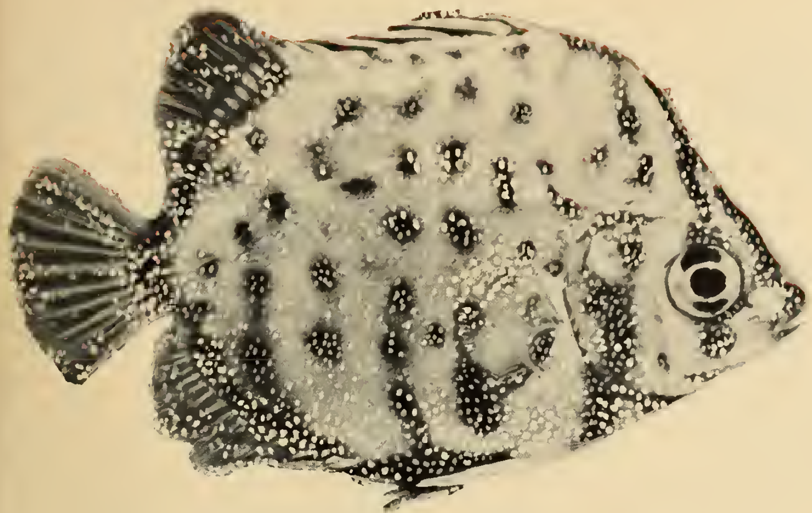
At the airstrip we said goodby to the Djukas. They were to return to Paramaribo first. By the time we arrived, they were off to join their families. In a few days Tom and I bid farewell to our Surinam friends and left for home. Another expedition had ended.

The end of an expedition marks the beginning of other work that may go on for many years. The blocks of wood that we collected are still being tested, and the test results may not be known for two or three years. Also, it is too early to know anything about the material that was collected for drug companies. Labels are still being prepared for the 20,000 specimens that we collected. Once the plants are labeled, some will be sent to botanists who are interested in studying these particular kinds of plants. They will send back their findings in about six months to two year's time.

Still other specimens will be exchanged with other botanical museums. After subtracting 2,000 specimens for the New York herbarium and 2,000 for the Surinam Forest Department, there will be 16,000 specimens left. These will be divided into 12 or 15 sets and sent to other botanical museums throughout the world.

In this way, we will send the specimens from Surinam to plant scientists all over the world, and 16,000 different specimens will be returned to us in exchange. Our original 2,000 kinds of plants will swell to as many as 20,000 different kinds for our collection ■

Camps like this one were set up as the expedition explored the dimly lit Surinam rain forest. The men slept in hammocks slung under canvas tents, and the Djuka field men caught fish and shot game for food.



HOW TO PROVE THE CASE AGAINST A GERM

by Victor Kirsch

With an aquarium as your laboratory and a famous doctor's rules as your guide, you can track down the cause of a common fish disease.

■ I don't think that there was ever a tropical fish aquarium that didn't at one time or another contain some sick fish. It seems that no matter how hard you try to keep a tank disease-free, sooner or later small white spots develop on the skin of some of the fish. These little spots are really colonies of a tiny organism called *Ichthyophthirius multifiliis.* This little animal is the cause of a disease commonly known as "Ich."

This disease first attacks the fins and body of the fish. The fish tries to rid itself of the irritating parasite by brushing against parts of the aquarium. Soon its gills become infected, and the fish has trouble breathing. The spots grow more numerous, and the fish stops eating. In the last stages of the disease, the fish's skin rubs off, leaving raw spots. Unless the fish is given some help, it will die.

Testing the Suspected Germs

Scientists for many years have been studying how disease is passed from one person to another. The scientists use laboratory animals to test out their ideas about disease before they experiment with human beings. Here is how you can act as a scientist, using fish as your laboratory animals. With these fish you can study the way disease is transmitted from one living thing to another. (Then you can cure the fish.)

In Germany, in 1882, a physician by the name of Robert Koch discovered a method for finding the cause of a disease. In his experiments, Dr. Koch made the rules for proving that a particular organism is the cause of a disease. These rules are called "Koch's Postulates."

To prove that a certain organism is the cause of a particular disease, a scientist must follow these steps:

1. The suspected organism must be found in every animal that has the disease.
2. The suspected organism must be taken from the sick animal, identified, and then grown all by itself in a *pure culture.*
3. The organism must be taken from the pure culture and introduced into healthy animals. These animals must

(Continued on the next page)

Setting Up Your Aquarium

If you don't have an aquarium, here are a few tips for setting one up. You can use any good-sized watertight container, but a rectangular glass aquarium is best. A rectangular aquarium has a large surface area for gases to enter and leave the water, and the oxygen gas that animals need enters the water from the air.

Cover the aquarium bottom with an inch or two of clean, fine gravel. Put the aquarium in a place out of direct sunlight and away from heat. Fill it to near the top with tap water and let the water stand for two days or so, to let chemicals in the water escape as gases. Plant some water plants in the gravel. You can buy them from an aquarium or pet shop.

Now you are ready to add some animals—tropical fish, native fish from a nearby pond, water insects, tadpoles, or crayfish. Feed the animals lightly, once a day or less often, with prepared fish foods, bits of ground beef, or lettuce (for snails and tadpoles). Clean out leftovers before they decay.

then get the particular disease that is being studied.

4. The organisms that the scientist finds in the newly diseased animals must be identified as the same kind that were taken from the originally infected animals.

Knowing these rules, you can now set out to investigate the disease that you may see on your fish in the aquarium. By doing the following things, you can find out if the white spots on your fish are made of disease-causing organisms. You can also find out if these organisms can infect other fish.

1. With a fish net carefully remove one of the fish with white spots, and place it on a dampened piece of cotton. Use a sterile cotton swab to scrape off some of the white spots from the infected fish. Now put the fish back in the tank. Place some of the material from the cotton swab on a clean microscope slide. Add one drop of water and inspect the slide through a hand lens or microscope that magnifies from 10 to 100 times. Save the cotton swab and the material on it. You are now ready for the next step: growing the organism in a *pure culture*. A pure culture is a colony of one kind of bacteria with no other kinds mixed in.

2. Wash the remainder of the colonies off the cotton swab by swishing it around in a previously boiled solution of powdered malted milk and water, which is the *culture medium*. (Three tablespoons of malted milk to about three glasses of water will do fine.) Cover this solution well and allow it to stand for approximately one week. What will happen is that many Ich organisms will grow in the malted milk culture. This is just what you want.

3. After a week has gone by, pour one-third of the culture medium (about one glassful) into a large glass container—a one-gallon mayonnaise or pickle jar is excellent—and add fresh water. From a batch of five or six *undiseased* fish, put two or three in this jar. To make sure that the fish in this batch are not already infected, put the remaining fish in a jar containing only fresh water and see whether they develop the disease.

4. After about two weeks, small white spots should appear on the fish in the tank that contains the Ich culture. Remove some of the spots as you did before, and examine them under a microscope. Are they the same kind of organisms that you took from the original animals?

If you do your work carefully, you will actually see the germ theory of disease as it occurs.

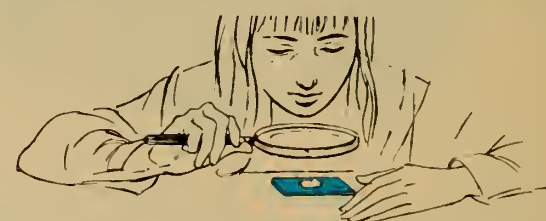
How To Cure Your Fish

You can save your fish from being destroyed by the Ich if you act in time. You can use any of a number of cures to save your fish. One way is to use a medicine you can buy in any pet shop. (One satisfactory medicine,

Follow these steps to prove the case against the Ich disease:

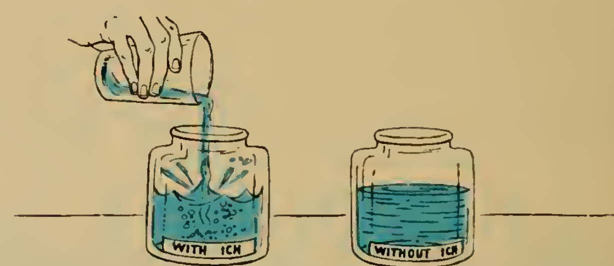
1

Take some of the white Ich spots from a diseased fish with a sterile piece of cotton.



2

Gently rub the white spots onto a microscope slide. Examine them with a hand lens or microscope. Then grow the organisms in a culture of malted milk (see text).



3

Pour some of the culture into a glass jar or other large container and add water. Put some undiseased fish in the jar. Also put some in another jar with only water.

4

Watch for white spots to appear on the fish. Remove some of the spots and examine them as you did before. Have you proved that Ich causes the white spots?

called Ich-Out, is manufactured by Longlife Fish Food Products, Denville, New Jersey.) Another way is to add four drops of Mercurochrome for every gallon of aquarium water in your tank and raise the temperature of the water to about 85° F. Either of these methods should work.

A fish tank can be your own private science laboratory. There are many experiments that you can perform with the animals and plants that live in it. You will find some mentioned in "*Winter Homes for Pond Animals*" (N&S, *September 21, 1964*) ■

nature and science
TEACHER'S EDITION

VOL. 2 NO. 5 / NOVEMBER 16, 1964 / SECTION 1 OF TWO SECTIONS

Encouraging Your Pupils To Think for Themselves

■ Anyone who believes modern science beyond the ken of the very young mind might drop in on a special course in elementary physics that meets at New York's Columbia University. For two hours every Saturday morning, Harry Milgrom, who heads the science program in New York City's elementary schools, teaches the fundamental laws of physics to a class of 16 children between the ages of 8 and 10. The youngsters love it.

Mr. Milgrom's manner is that of a benevolent guide, taking his charges on a hunt for scientific understanding in which he provides the clues but leaves them to follow paths of their own choosing. "You'll notice I do not give them any answers," he remarked following a recent session on applied mechanics. "My primary concern is to encourage the children to think for themselves."

The problem on this particular day was to discover, and duplicate, the inner mechanism which caused a pint-sized ice cream container, when placed on its side and given a push, to roll not only forward but back to its original position. (Mr. Milgrom snapped his finger in a "presto" gesture with each push, but the kids were too sophisticated to be so easily fooled.)

Reprinted by permission from THINK Magazine, Copyright 1964 by International Business Machines Corporation.

Search for the Truth

After several demonstrations, Milgrom set the container upright, gave it a twirl, and the children watched as it completed a neat little spin. As they had just observed the action of three previous containers — one filled simply with air, another containing a coin taped inside (it went uphill), and a third heavy with marbles — there was much enlightened speculation as to what this latest container might hold. The teacher then invited each amateur scientist to approach the table, select his materials—he had his choice of rubber bands, small and large weights, washers and masking tape —and apply his theories to his own cylinder. Then, individually or in pairs, on

(Continued on page 4T)

PHOTO BY THE NEW YORK TIMES

What makes this container roll forward when pushed, then stop and roll backward? Harry Milgrom believes youngsters learn to observe and reason by solving such problems.

IN THIS ISSUE

IN THE NEXT ISSUE

The hardy, adaptable, disease-carrying rat . . . How to track common animals . . . Exploring with the microscope . . . The mystery of mirages.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Brooklyn Bridge

The story of bridges is the story of man's conquest over nature's barriers. Down through the centuries bridgebuilding has reflected the progress of civilization. As this article illustrates, it is a romantic and adventurous undertaking.

Topics for Class Discussion

- *Did Roebling invent the suspension bridge?* No, it is a primitive invention, originally made of twisted vines or ropes. Roebling improved on the idea by using cables.
- *Why is a cable stronger than a chain?* In a cable each strand of wire lends strength to the others, and if one breaks the increased load is shared by the remaining strands.
- *What are some modern inventions that have improved bridgebuilding?* The development of steel and reinforced concrete. Steel is stronger and lighter than iron, and there are different types of steel for different purposes. Some bridges have as many as 18 kinds of steel in them.
- *Are all bridges suspension bridges?* An observant pupil will recall seeing many types—trusses, arches, cantilevers, and simple beams *(see diagrams)*. An unusual bridge crossing Hood Canal in Washington's Puget Sound has a roadway that floats on pontoons and retracts like the head of a turtle to let ships pass. A Wall Chart, *"Bridges and What Holds Them Up,"* appeared in *N&S*, May 15, 1964.
- *What are the "bends?"* If a person moves too rapidly from an area of high pressure to normal air pressure, nitrogen bubbles form in the blood, causing pain and paralysis. Divers working at great depths avoid the bends by rising slowly to the surface.
- *Does any good come from a disaster like that of the Tacoma Bridge?* Engineers must ask themselves what went wrong so it will not happen again. All bridgebuilders now take wind forces more seriously. By putting models in wind tunnels they have learned that the greatest danger comes when the wind angles up against the roadbed from below. Your pupils may recall trying to hold on to a large piece of cardboard or plywood in a heavy wind.

Activities

- Bring in a ball of 2- or 3-ply wool yarn and a spool of nylon thread. Give each child a generous length of each and turn him loose to find out as much as he can about the effect of multiplying the strands and of twisting upon the strength of different materials. Make the analogy to iron and steel cables.
- Children may gain some insight into natural rhythms by this activity: Find the period of oscillation (rhythm) of a simple string-and-bob pendulum —or a playground swing—by counting the number of seconds it takes to make a complete swing forward and back. Use a stopwatch. Give the pendulum a gentle push at the start and notice that, though the arc may get smaller, the period of oscillation remains the same. Change the weight of the bob and your pupils will find no change in the rate of vibration. But see what happens if you shorten the string. The length of the string is the determining factor.

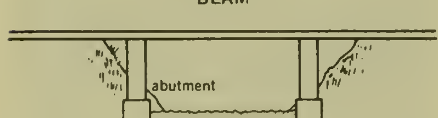
References

- *Time* magazine, August 28, 1964, has a six-page picture spread and up-to-date account of bridge engineering.
- Watch your local newspapers and news magazines for articles about the opening of the Verrazano-Narrows Bridge on November 21.

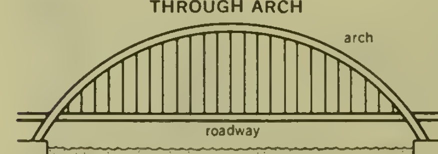
PAGE 8 Valves

Many people keep the physical sciences and natural sciences in widely separated compartments of their minds. This WALL CHART may help pupils to link the two sciences by
(Continued on page 3T)

BEAM



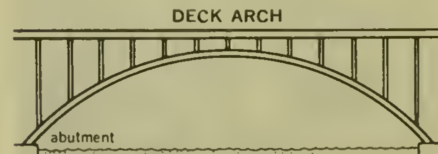
THROUGH ARCH



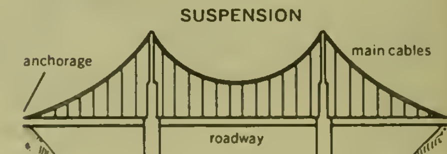
TRUSS

CANTILEVER BEAM

DECK ARCH



SUSPENSION



NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition wth single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE & SCIENCE, The Natural History Press, Garden City, New York 11531.**

Using This Issue . . .
(Continued from page 2T)
showing them that a valve is a valve—whether in a machine or the human body. Remind the class that inventors did not necessarily copy or realize they were using principles found in living bodies. For example, pumps were in use long before scientists understood the circulation of the blood.

You may wish to discuss other common valves with your pupils. For fluids there are radiator, faucet, flush toilet, lavatory drain, and gas hot water heater valves. Window blinds, curtains, drapes, venetian blinds, eyelids, irises of the eyes, and camera shutters and diaphragms act as valves for light. In electrical circuits, there are switches, resistors, and vacuum tubes. A trumpet mute is an example of a sound valve.

Activity

- *Obtain a beef heart from a butcher.* Cut it in half lengthwise so that the children can see its four chambers and the valves connecting the upper chambers to the lower. A beef heart is typical of the hearts of all mammals, including man.

PAGE 11 Exploring

In this second of two articles, Dr. Irwin clears up some popular misconceptions about tropical rain forests while describing his methods of collecting, identifying, drying, and packing plant specimens for shipment to museums around the world. Be sure your pupils note the spirit of cooperation implicit throughout—from the teamwork of the Djukas and the scientists to the world-wide exchange of specimens.

Topics for Class Discussion

- *Where are the great rain forests of the world located?* Rain forests are located wherever there is heavy annual rainfall. They form a belt around the equator, covering more than one-tenth of the Earth's land surface, and can also be found along the northwest coast of the United States. You might compare the annual rainfall in your area (available from the Weather Bureau), with the 100-200 inches that fall in the tropics.
- *How might the tall, straight trees of Surinam's rain forest be useful to man?* Children often think of wood in the limited terms of their daily experience. Help them see our need for poles, pilings, mine timbers, railroad ties.
- *What sort of tests will be made on the blocks of wood Dr. Irwin collected?* People will test them for such things as hardness, weight, strength, resistance to rot and insects, ease of working with hand and power tools, and the ability to hold nails.

Bring out that before a lumbering company goes into such a remote spot, the value of the trees will have to be weighed against the difficulties and expense of cutting them down and transporting them to lumber mills. A square mile of rain forest may contain 200-300 species of trees. Trees of one kind may be widely scattered, making them harder to find and harder to get out.

- *Why isn't the rain forest hotter than about 75 to 80°F., since it is so close to the equator?* Many factors govern the temperature of an area. The deserts of the world hold the heat records, and many of them are far from the equator. For example, temperatures in some parts of California climb to 130 degrees in the shade. The temperature in the rain forest is reduced because sunlight is blocked by the heavy foliage. The temperature is kept fairly stable by the moist air and lack of air movement.
- *How did the popular idea of the rain forest as a thick, tangled jungle originate?* Where the virgin timber is cut down, tangled underbrush flourishes in the sunlight. It is this kind of growth—along roads, rivers, and clearings—that most people see.

Activities

- In many parts of the country it is still possible to collect seeds and leaves for display. Dr. Irwin's techniques, such as tagging the specimens and making notes on them in a "field" book, should be used. Let the class press some specimens between newspaper over the classroom radiator or another warm (not hot) air supply. Be sure they notice how fragile the dried materials become.
- A committee may investigate some drugs currently in use, such as curare, cocaine, and quinine, which come from South American plants.

PAGE 15 Prove the Case

This study of the procedure for isolating disease germs will be a valuable supplement to your regular science or hygiene program. Should your classroom not have an aquarium, or any sick fish, let the children approach the material "as if . . ."

Topics for Class Discussion

- *In this investigation, why is a pure culture necessary?* The investigation would be useless if other germs got in the culture. We would never know which kind of germ were responsible for the disease. Do the children see the reason for using sterile cotton?
- *Ask if anyone remembers having a doctor take a sample of mucus from his throat during a bad sore throat.* Nowadays when doctors suspect streptococcus or diphtheria infections in a patient, they often make cultures of bacteria taken painlessly from the back of the throat with a cotton swab. Then they can examine the cultures for the germs they think may be causing the sore throat.
- *Does a doctor make a culture every time someone gets sick?* No. Point out that we learn to recognize a group of symptoms occurring together as being associated with a particular disease. For example, the symptoms of Ich are white spots, loss of appetite, and breathing troubles. People who keep tropical fish don't test their fish every time they suspect Ich. Doctors go to this trouble when they are seriously puzzled or don't want to prescribe a powerful drug needlessly.

The white spot in this photograph is a mature clinging stage of Ich on a fish scale. It is magnified 100 times.

Encouraging Your Pupils...

(Continued from page 1T)

chairs, floor or tables, each child began his diligent search for truth.

"If this is wrong I'll kill myself." "Oh, I am frustrated." "Now I know, it's suspended across." Such outcries mingled with brief disputes over possession of the masking tape and words of comfort when a fellow worker's idea failed to materialize. "I know. I made the same mistake."

As theories began to bear fruit, there was a pause for orange juice and cookies, evoking memories of previous sessions. "Remember when we put an acetate over the orange juice? It crackled and popped like the Fourth of July."

Neither Rain Nor Snow...

We took advantage of the break to ask one of the two girls in the class, Margot Keller, if she minded coming to school on Saturdays. "Oh, no," she protested, "I never have too much to do on Saturdays, anyway." Her neighbor, Kevin Saunders, informed us that his brother, a part-time physicist, had told him about the class; that he hoped to be a physicist when he reached his majority; and that it only took him 45 minutes to commute from his home in New Jersey. Most of the children come from New Jersey, Westchester County, N.Y., or Connecticut, but to date neither rain nor snow has kept them away.

Milgrom, an alumnus of Columbia and 30 years of science teaching, began his experiment last year, to put to the test a system of teaching techniques he has developed. Graduates of the first Science I have gone on to Science II, which was in session elsewhere in the building. Most members of the original class were children of Columbia faculty members, but this year's class includes outsiders whose parents have become interested. Milgrom limits the group to a number he can handle easily. Pupils are selected not by IQ ratings or written tests but on the basis of their intellectual curiosity; the best recommendation a child can have is enthusiasm.

After the break, Milgrom invited those who felt they had completed the experiment successfully to explain their technique. Several theories which had shown great promise had to be discarded on closer analysis. A dark-haired boy in a bright red sweater found his theory valid —he had suspended a weight in the center of the cup by a knotted rubber band. "When the rubber band becomes taut," he explained, "the container stops." The cup's backward motion was more difficult to analyze and required the combined effort of the class.

"Think about it," Milgrom urged. "You started out with one theory; you must think it through." When the answer came, he produced a toy car and explained that the class had just demonstrated the principle behind its operation, except that instead of employing a steel spring they had substituted rubber bands.

For their thinking during the week he asked them to consider every possible way to move an 18 by 2-inch piece of cardboard he had taped together to form a hoop. "Put the answers in your notebooks," he suggested. "I can think of six ways already," someone volunteered as class disbanded.

Milgrom cleared away the forgotten orange juice cups. "Through our work, the youngsters find out how to observe and reason carefully. They are treated with dignity and with respect for their ideas. And they respond. They soon learn that a hasty judgment is usually not the best judgment."

"Too Many Theories"

The pilot project is supported by the children's parents (who pay a small fee) and by Columbia's School of Engineering, under the Joint Program for Technical Education. The Engineering School plans to study the program as an aid in the development of easily convertible ("Murphy-bed") science laboratories to be used in ordinary elementary classrooms. But the project's main objective is aptly summed up in the words of the Engineering School's [former] dean, Donald Barr [now Headmaster of The Dalton Schools in New York City]:

"The great fault in elementary school science education is that it has been determined by too many theories—too many checklists of definitions, concepts and principles that kids should be fed at certain ages. In a sense, every young child is naturally a scientist, that is, he observes and abstracts; he uses his wits to make sense out of a confusing world. But as he grows, these first instincts are shoved out, and the child is turned into an information machine. In a few cases, his original impulses reassert themselves in junior or senior high school, but by then a lot of his best-thinking time has been lost. We would like to see if we can teach the young child science and lead him into rigorous scientific investigation without that interregnum."

—EDWARD F. PIERCE

nature and science

VOL. 2 NO. 6 / DECEMBER 7, 1964

RATS, RATS, RATS

Why they are useful
Why they are destructive
How they live
How we try to control them

see page 3

ABOUT THE COVER

If you have ever seen a rat like the one on our cover, it was probably a Brown, or Norway, Rat. Its scientific name is *Rattus norvegicus*. Brown Rats are the most common kind of rat in the United States, ranging from Florida to the northern coast of Alaska.

Another common rat in the United States is the Black Rat, which lives mostly in the southern part of the country and near seaports. Its name is *Rattus rattus*. Black Rats are a bit smaller than Brown Rats, which weigh about a pound and are about 20 inches long. Both kinds of rats have coarse fur, large naked ears, and scaly tails. Both are *rodents*, as are mice, squirrels, and beavers. Both came to North America aboard ships from Europe.

Brown and Black Rats are not closely related to native wild rats that live in the woods and fields of North America. You might look in field guides and other books on mammals to find out what kinds of rats live in your area.

Brown and Black Rats thrive wherever humans farm the land and build homes. They destroy billions of dollars worth of food and other property, and carry many diseases. To find out more about the way rats live, see the article "Rats, Rats, Rats" beginning on page 3.

nature and science

VOL. 2 NO. 6 / DECEMBER 7, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

CONTENTS

CREDITS: Cover, p. 2, drawings by Juan Barberis; pp. 3, 10, 11, 13, 14, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, left photo by Leonard L. Rue, right photo by Lew Merrim from Monkmeyer Press Photo Service, drawing by R. G. Bryant; p. 6, photo by Dave Mech; pp. 8, 9, drawings by Gaetano di Palma; p. 12, Amoeba and Hydra photos from Ward's Natural Science Establishment, Inc., potato and fly photos from Bausch & Lomb Incorporated, drawings by R. G. Bryant; p. 13, photo by George Cope from Educational Services Incorporated; p. 14, photo from Weather Bureau, U. S. Department of Commerce; p. 16, photo from Fundamental Photographs.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

RATS RATS RATS

by Laurence Pringle

We may never win the battle against these night-prowling rodents that spread disease and damage things wherever they go.

■ Scratching, crawling, nibbling, gnawing—rats follow humans almost everywhere they go. And wherever rats go, they spoil food, damage property, and carry deadly diseases.

No one knows exactly when or where rats began to live near human beings. According to one theory, Black Rats in Arabia gradually moved from the deserts to the villages. When the Crusaders returned to Europe from Arabia in the 12th century, Black Rats were aboard their ships. They quickly spread throughout Europe. Then, in the 18th century, hordes of Brown Rats were seen scurrying across Russia, spreading westward from Mongolia. They quickly took over many of the areas where Black Rats lived. Today Brown Rats may be the most common rats in the world. *(See "About the Cover," page 2.)*

Disease and Damage

Scientists estimate that, in the past 1,000 years, rats have caused more human deaths than all of the wars ever fought. You will understand why if you follow a rat on a night's wanderings. The rat may trot through a sewer, feed at a garbage pail, and then visit a home or grocery store. As it searches for food, it accidentally picks up and carries disease germs on its feet, fur, teeth, and within its body.

In the Middle Ages, no one realized that rats were the source of some of the worst sicknesses known to man. Fleas and lice often lurk among rat hairs, and these tiny animals sometimes carry the germs of *bubonic plague* and *typhus fever*. Humans may catch these diseases when bitten by fleas or lice from rats. In one year, 1665, a hundred thousand people died in London from the rat-carried plague.

Rats also spread disease as they nibble on fruits, vegetables, grains, meat, and other food—including dead rats. An adult rat eats about 50 pounds of food a year. On farms, rats sometimes kill chickens, and it has been estimated that one rat may cost a farmer as much as $25 a year. Rats once gnawed through the insulation of some electrical wires and plunged most of New York City into darkness. They have started countless fires in the same way. Rats spoil food and damage property worth at least 2½ billion dollars in the United States each year.

Some of the same characteristics that make rats destructive pests also make them valuable animals for the study of human diseases. They need only a small living space, eat almost anything, have many young, and are easy to handle. Thousands of white rats are being used in the search for a cancer cure, in studies of other diseases, and in experiments on learning and memory. These are Brown Rats, but they have white hair and pink eyes. Such animals are called *albinos*.

Life Among the Rats

Scientists have studied both tame white rats and wild Black and Brown Rats in order to learn more about how these animals live. Some of their discoveries have led to

(Continued on the next page)

better ways of keeping rats under control.

For example, scientists have found that rats constantly explore the area in which they live. Their urge to explore is sometimes stronger than fear or hunger. If a hungry rat is put into an unfamiliar cage with some food, the rat will usually explore the cage before eating. Rats also sniff and taste just about any food they find.

It would seem that such snoopy, snacking animals would be easy to kill by hiding poison in food. Yet, rat-poisoning campaigns have often failed. Why?

Some British scientists from Oxford University tried to answer that question during World War II. They discovered that Brown Rats have regular paths between their nests and their food sources. Whenever a strange object—even a harmless stone—was put on a path, the rats kept away from the area. If the object was food, the rats eventually sampled a little of it. If the food was poisoned, the chances were that most of the rats would not be killed, but would just get sick and recover. From then on they would avoid that type of food. This sort of behavior has probably caused the failure of many rat-poisoning programs.

The British scientists outwitted the rats by a method called *pre-baiting.* First, harmless bait was put on the rats' paths. After a few days, the rats had sampled the bait and then eaten it. When poisoned bait of the same kind was put on the paths, most of the rats gulped it down and died.

Scientists at Johns Hopkins University, in Baltimore, Maryland, have been studying rat colonies for about 25 years. In one experiment, Dr. John B. Calhoun put a few Brown Rats in a quarter-acre pen with an unlimited supply of food. Then he studied the growth of the rat colony. Female rats have about six to nine young per litter and can have about nine litters a year. Dr. Calhoun expected that there could be at least 5,000 adult rats in the pen at the end of two years. Instead, there were only 150 adults.

Dr. Calhoun tried to find the reason for the low numbers in this study and in later experiments with groups of white rats. He found that each rat or group of rats seemed to need a certain amount of space in which to live. When too many rats were crowded into an area, they kept bumping into each other, became tense, and were easily irritated. When this happens, scientists say that there is great *stress* in the rat population.

As a result of the stress, the adult rats often fought with each other. Some females did not care for their young; others had no young at all. Some males became cannibals.

Dr. Calhoun's findings agree with those of scientists who have studied groups of other animals. It seems that, even with unlimited food and shelter, the number of animals can only rise to a certain point before stress between the animals causes a leveling-off of the population.

Help Stamp Out Rats

Man has tried to kill rats ever since the Middle Ages, when each town had one or more professional rat catchers. Since then, all sorts of traps and poisons have been used to wipe out rats, without much success. The main problem is that man provides rats with ideal living conditions—lots of

KEEPING AND STUDYIN

White rats are easy-to-keep pets that you can use for your own experiments. You can buy them from pet stores or from a hospital research laboratory. Keep them in cages made of wire mesh (the mesh squares should be ½ or ¾ inch in size). A two-foot-square cage will hold four rats.

Set the cage on a tray covered with wood shavings, sawdust, or other "bedding," and change the bedding daily. Give the rats water and feed them small quantities of such food as lettuce, table scraps, meat, carrots, and sunflower seeds. Now and then put some green twigs into the cage for the rats to gnaw on.

A Food Experiment

What happens if an animal doesn't get a "balanced diet"? You can find out, using two different groups of rats in separate cages. The rats should all be about the same age and size. Give one group their usual varied diet of vegetables, meat, seeds, and so on. Feed the other gr just bread. Be sure to give water to each group.

Weigh each rat before you begin the experiment then weigh them daily from then on. Keep a record of t weights and make notes of any other differences you no You should discover some differences between the groups after about 20 to 30 days. Then begin feeding second group of rats a varied diet and continue weig the animals. What happens to their weight this time?

How "Smart" Are Rats?

You can test the speed of learning in rats by buildi maze from strips of thin wood set between nails driven a piece of plywood (*see diagram*). The strips shoul about four inches high and about three inches apart. C the maze with wire screening to keep the animals f climbing out of the runways.

at can cost a farmer
ut $25 a year by eat-
corn and other grain
ht). However, rats
e excellent laboratory
nals for the study of
nan sickness. These
e rats (far right) are
ng fed samples of
ts to make sure the
ts are not poisonous.

food, wastes, places to nest and hide. A well-planned poisoning and trapping campaign may temporarily wipe out most or all of the rats in an area. However, unless rat holes are plugged, trash cleaned up, and food sources covered, rats are soon back in force.

Until recently, rat poisoning had to be done with great care, because many rat poisons also kill pets, livestock, and humans. Then a scientist at McNeil Laboratories, in Fort Washington, Pennsylvania, accidentally discovered an unusual rat poison. Dr. Adolph Roszkowski was feeding chemical substances to animals, searching for a treatment for *arthritis,* a painful bone disease. One substance, called *norborene,* seemed to have no effect on mice or dogs. "But when we tried what I had projected as a safe dose on rats," says Dr. Roszkowski, "all of them died."

Dr. Roszkowski might have tossed the norborene aside, since it was apparently useless for treating arthritis. Instead, he tested it further, as a poison. So far, it has been fed to 30 different kinds of animals, including cattle, sheep, chickens, and even goldfish. None have died. Norborene also had no effect on humans when it was injected into their skin. However, when rats eat the substance, their blood vessels close down, and the animals soon die.

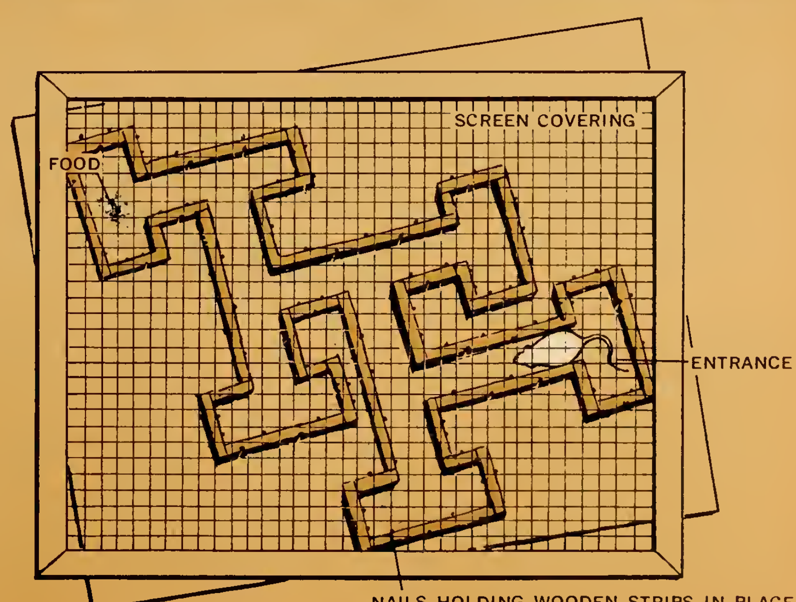
This new poison will be tested further, especially on humans, to make sure that it is safe. If it passes the tests, it will be a powerful new weapon in man's war on rats.

However, no one expects that man will ever wipe out all of the rats in the world. Scientists who recently visited the Pacific Ocean islands that were used for nuclear bomb tests found rats thriving there. The rats had not been wiped out, as expected, by the tremendous explosions. As a matter of fact, these rats have increased in numbers! ■

WHITE RATS

o not feed a rat for 24 hours before you test its learn-speed. Put a small amount of food at the end of the e and place the rat at the entrance. Count the number rors the animal makes before reaching the food. Count s this way: one point for every blind alley entered and point for every corner turned if the rat turns back rd the entrance. When it reaches the end, let it eat ood as a reward for completing the test. Then repeat test 10 times. How many errors does the rat make time? Keep records of your findings. Does the rat e more or fewer errors with each trial? After a few , test the rat in the maze again. Does the rat seem to ember how to solve the maze?

est other rats and compare their learning speed with of the first rat. Do some learn faster than others? Do ng rats learn faster than older ones? Change the pattern e maze and test the rats again.



HOW TO BE A WILDLIFE DETECTIVE

by Dave Mech

Whether you live in the city or the country, you can study the lives of wild animals by following their tracks.

Can you solve this tracking mystery? The tracks in the photo are those of a Muskrat (in the center foreground) and a fox (at the left of the Muskrat trail). The author made the large tracks (crossing the center of the photo) when he found the others. This article tells how he solved the mystery.

■ You don't need to be a policeman to be a detective. You can get much the same thrill and adventure as a police investigator by becoming a wildlife "private-eye." Instead of tracking down criminals, you track animals. Instead of learning about robbers, you learn about wildlife.

Of course, the best way to study an animal's habits is to watch the creature. But that often is impossible. Many animals are active only after dark, and those that are active during daylight are too wary to let you near. If you are a detective, this shouldn't stop you. You simply look for clues that might reveal their habits.

The most useful kind of clues are tracks. These show up best in mud, sand, dusty roads, and in snow. You don't need to venture into the deep wilderness to find the tracks of wild animals. Within the limits of most big cities, you can discover tracks of such animals as rabbits, squirrels, mice, weasels, Raccoons, and skunks.

Look at Your Own Tracks

You already know at least one track—your own. First chance you get, take a look at your bare-foot print. How does it differ from the tracks of other animals? Right away you will notice that it is larger than almost any other track you will find. So you know that *size* can help you tell one kind of track from another.

Now compare your track with the track of a dog. You'll find at least three more important differences: (1) Your track is long, whereas a dog's is round. (2) The toes are all at the front of your track, but a dog's toes are on the front and side of the track. (3) A dog has only four toes. Remember differences in *shape*, for they will help you tell the tracks of one animal from another.

Before you can learn much more about tracks, you need some experience with different kinds. Winter is the best time to get this experience if you live in the northern states. (In areas without snow, you will have a harder time, but you can still study tracks in wet or dusty areas.) A day or two after a snowfall, go looking for fresh trails. Be sure to arm yourself—with a ruler or tape measure, a notebook, a pencil, and perhaps a camera.

How To Study Tracks

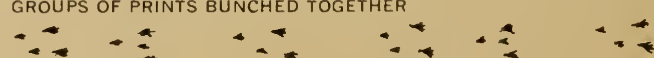
Fields, woods, vacant lots, and even your own backyard are good places to find tracks. Look around bushes, logs, trees, brush piles, and along fences or hedges. When you find a track, examine a single print. How long is it? How wide? How many toes does it have? Make a drawing of the print and jot down the measurements.

Then measure and sketch the spacing of the tracks. Is each print spaced evenly in a trail? Or are there two, three, or four tracks bunched together? How far apart are the groups? If you have a camera, put your ruler near the tracks and take a picture of them. Jot down a note about where and when you photographed them.

Make the same sketches, measurements, pictures, and notes for each different kind of track you find. Then you can compare them with the drawings on pages 8 and 9, or with tracks shown in books (*see listing at the end of this*

SINGLE PRINTS SPACED EVENLY

GROUPS OF PRINTS BUNCHED TOGETHER



article). You can best identify large tracks by looking at individual footprints. Smaller tracks can most easily be told by the pattern of their groupings.

When you recognize most of the tracks in your area, your detective work has just begun—and so has the fun. The next step is to follow a set of tracks. That is the way you learn about how an animal lives—how it gets its food, what it eats, where it lives, how far it travels, and so on.

One very important rule to keep in mind when tracking is never to step on the tracks. You may have to examine them again. I learned this from a cottontail rabbit I once followed. After I had tracked it for several minutes, the track suddenly ended. I had almost decided that the rabbit had sprouted wings when I thought of another answer. Perhaps it had turned around and gone backwards on its own track.

Upon looking at the rabbit's trail, I found it all scuffed out by mine. I couldn't tell whether or not it had backtracked. But by watching carefully along both our trails, I found where the rabbit had taken a long leap off to one side. Then it had continued on its way. As I kept on the trail, the rabbit pulled the same stunt six times. But I had learned, and was able to figure it out each time.

After you track an animal a little way, you may notice that its pace changed. Try to figure out what the animal was doing. A good way to get clues about its pace is to study your own tracks again. First walk for several feet. Then hop. Then run at different speeds. Notice how different your tracks look each time. To imitate a rabbit or squirrel track, lean forward and put your hands into the snow. Then hop, using your hands for leverage and bringing your feet around in front of them. Remember how the track looks, for it will help you tell which way a rabbit or squirrel track is headed. Usually their hind feet are ahead of their front.

A RABBIT'S HIND FEET LAND AHEAD OF ITS FRONT FEET

When tracking an animal, take notes on how far it travels, what kind of cover it uses (fields, woods, swamps), and what it eats. If you can follow it a long way, draw a map of its travels. Try to figure out why it goes where it does. If you find its den, note whether it is a hole in the ground, a hollow log, a tree, or what. Keep notes on where it is so you can come back and track the animal again.

This is exactly the method that scientists sometimes use to study animal habits. For instance, some biologists in Michigan have followed over 2,000 miles of fox trails. They kept track of everything the foxes ate. Their results

ON THE TRAIL OF A WOOZLE

Do you remember the story of how Winnie-the-Pooh and Piglet tracked the mysterious Woozle? As they walked around and around a clump of trees, they found more and more Woozle tracks ahead of them. What was the Woozle?

(Drawing by E. H. Shepard from the book *Winnie-the-Pooh* by A. A. Milne. Copyright, 1926, by E. P. Dutton & Co., Inc. Renewal, 1954, by A. A. Milne. Reproduced by permission of the publishers.)

surprised many people, especially those who think that foxes eat mostly game animals, such as pheasants and rabbits. In one study, the foxes were trailed for 577 miles and killed only three pheasants in that distance. In another area they killed only five rabbits, two quail, and one hare in over 1,000 miles. Both studies showed that mice, shrews, and *carrion* (dead animals), were the foxes' main food.

Solving a "Whodunnit"

Probably the peak of your detective career will come when you figure out a "Whodunnit"—a group of tracks where one animal chased, caught, and killed another. I saw such a set of tracks last spring. A fox had come upon a fresh Muskrat track and followed it. Where the fox caught up to the Muskrat there was blood and sign of a scuffle (*see photo on page 6*). Only one track left the area—the fox's.

There is much more to learn about tracking. With experience you will learn to tell an old track from a fresh one. You can learn to predict where certain animals will cross roads, streams, and valleys. But these things take experience, and there's only one way to get that. Put on some warm clothes and go look for some tracks. And don't forget your notebook and pencil ■

Look in a book store or library for these books on animal tracks: The most complete book on tracks and other animal signs is **A Field Guide to Animal Tracks,** by Olaus Murie, Houghton Mifflin Co., Boston, 1954, $4.50; a mammal identification guide that includes track information is **A Field Guide to the Mammals,** by William H. Burt, Houghton Mifflin Co., Boston, 1952, $4.50; also look for **Animal Tracks and Hunter Signs,** by E. T. Seton, Doubleday & Co., Inc., New York, 1958, $3.95; **Animal Tracks,** by George F. Mason, William Morrow and Co., New York, 1943, $2.75; **Field Guide to Animal Tracks,** The Stackpole Co., Harrisburg, Pa., 1958, $1.50.

nature and science / WALL CHART
December 7, 1964

WHO GOES THERE?

A GUIDE TO ANIMAL TRACKS

RACCOON

Five toes on all feet. Front prints resemble hands and are 2 to 3 inches long. Hind prints are 3 to 4 inches long. In walking, sets of prints are 12 to 30 inches apart. Sets of prints are 2 to 3 feet apart when running.

■ The drawings on these pages show the tracks and trails of 16 animals that are common throughout most of the United States. When you find an animal's track, take notes on its size, shape, the number of toes, and the pattern of footprints in the animal's trail. Then compare your observations with these drawings.

Remember that the size, shape, and clearness of tracks vary with snow or ground conditions. Tracks are distorted when snow thaws, and tracks made in fluffy snow or loose sand are not as clear as those shown here. The diagrams show both front and hind prints if they differ very much. Otherwise, just one print is shown. The captions tell the distances between footprints, or between sets (groups of all four prints) when the animal is walking or running ■

GULL

Prints are about 3 inches long, and about 4 inches apart when walking. Webbed feet (for swimming) are similar to those of ducks, geese, and swans.

RAT

Front prints are like four-fingered hands. Five-toed hind prints are about $1\frac{1}{2}$ inches long and have long heels. Tail sometimes leaves a drag mark between prints. In walking, sets of prints are 3 to 4 inches apart. Sets of prints are 7 to 12 inches apart when running.

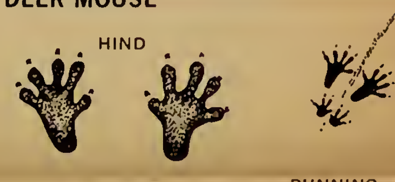
GRAY FOX

RED FOX

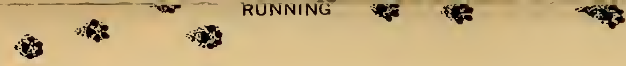
HOUSE CAT

SPARROW

DEER MOUSE



Four toes on all feet. Prints are 1½ to 2½ inches long. In walking, prints are in straight line, 12 to 18 inches apart. Sets of prints are 2 to 3 feet apart when running. Red Fox has small toe pads; Gray Fox has larger, wider pads. Foxes have much hair on their feet, so toe pads may not leave marks.



Four toes on all feet; no claw marks showing. Prints are about one inch long. In walking, prints are 5 to 8 inches apart. Sets of prints are about 30 inches apart when running. The wild bobcat has prints about twice the size of a housecat.

Prints are about one inch long. Sparrows hop, leaving paired prints. Some other birds, such as crows, starlings, and pheasants, walk with prints in single file. Sparrows are perching birds; their side toes are not spread wide from the front toe.

Four-toed front prints are about ¼ inch long. Five-toed hind prints are about ½ inch long. Sets of prints are 3 to 6 inches apart when running. Tail sometimes leaves drag mark between prints.

STRIPED SKUNK

Five toes on all feet. Front prints are 1 to 2 inches long and show claws clearly. Hind prints are 1½ to 2½ inches long and seldom show claws. Sets of prints are 6 to 12 inches apart when running.

DOG

Four toes on all feet; claw marks showing. Prints vary greatly in size, depending on the kind of dog. Cocker Spaniel prints are about 2 inches long; Alaskan Husky prints, 4 inches long. Distance between prints when walking and running also depends on dog's size.

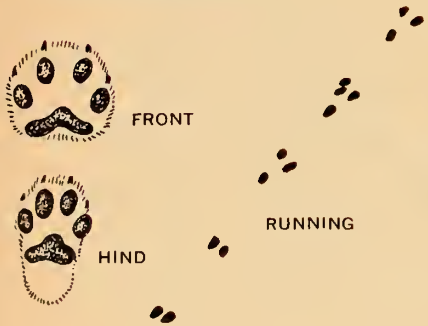
PIGEON

Prints are about 2 inches long. The side toes are spread wide from the front toe, since pigeons do more walking than perching. Wing marks are sometimes left on snow when a bird flies from the ground.

MEADOW MOUSE

Four-toed front prints are about ½ inch long. Five-toed hind prints are about ⅝ inch long. Sets of prints are about 3 to 9 inches apart when running. Meadow mice often tunnel under snow.

LONG-TAILED WEASEL



Weasels have five toes on all feet but the fifth toe seldom shows in prints. Front prints are about an inch long. Hind prints are about 1½ inches long. Sets of prints are 12 to 22 inches apart when running, and hind prints often land in front footprints. Tail sometimes leaves drag mark.

WHITE-TAILED DEER

Pointed prints are about 2¾ inches long. In walking, hind feet are often placed on top of front footprints. Deer can leap from 10 to 22 feet. Dewclaws, which are small unused "claws" behind the hoofs, sometimes show when foot sinks deeply into snow or mud.

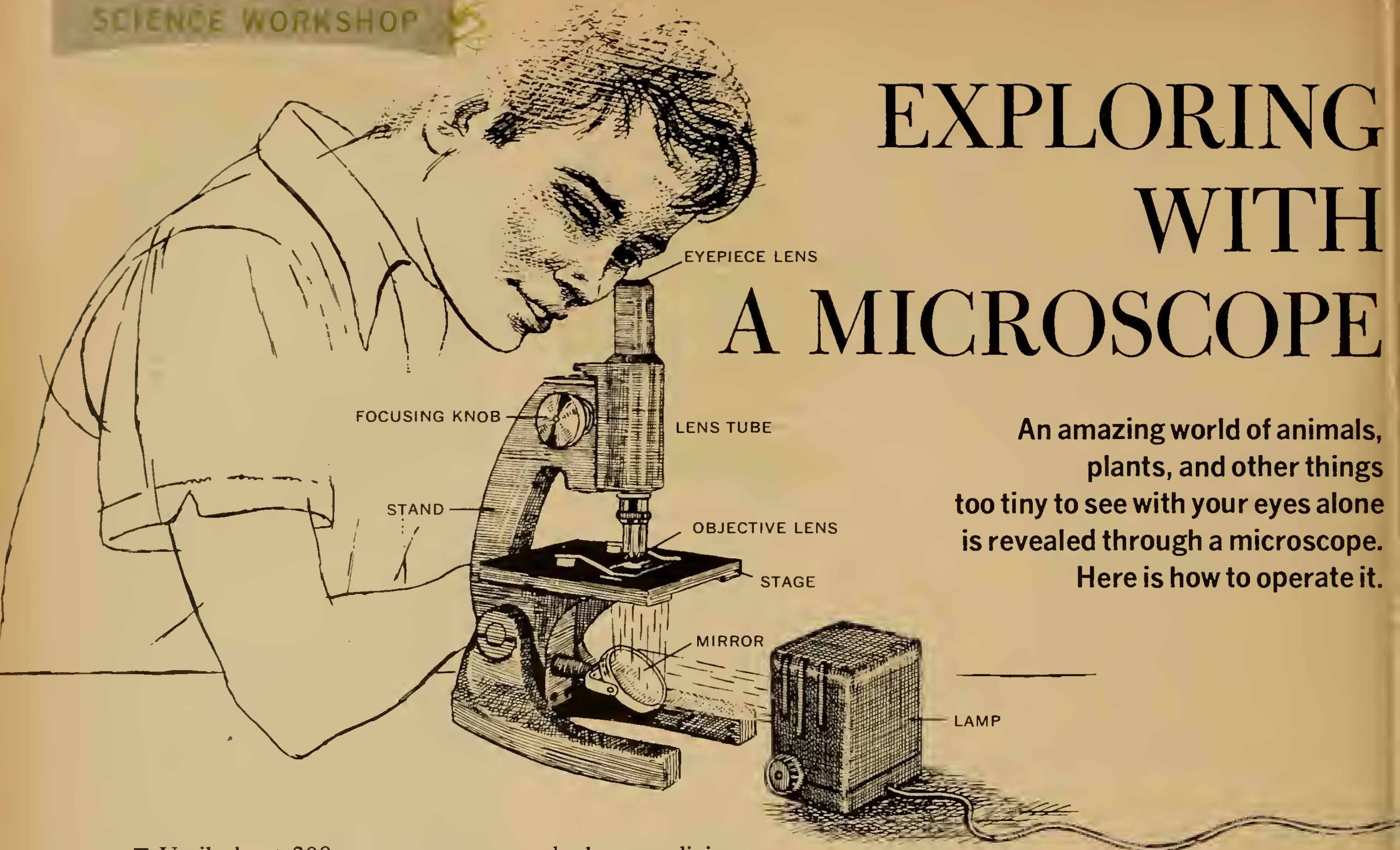
GRAY SQUIRREL

Four-toed front prints are about one inch long. Five-toed hind prints are 2 to 2½ inches long. Sets of prints are 20 to 24 inches apart when running.

COTTONTAIL RABBIT

Claws and toe pads seldom show because of hairy feet. Front prints are about one inch long. Hind prints are 4 to 5 inches long. Sets of prints are 1 to 7 feet apart when running.

EXPLORING WITH A MICROSCOPE



An amazing world of animals, plants, and other things too tiny to see with your eyes alone is revealed through a microscope. Here is how to operate it.

■ Until about 300 years ago, no man had seen a living creature smaller than a cheese mite, a spider-like animal about the size of the dot on this i. But then a Dutch cloth merchant, a man of great curiosity, discovered hundreds of far smaller plants and animals with a simple one-lens microscope *(see page 12)*.

Anton van Leeuwenhoek's simple instrument and his drawings of what he had seen astonished the most learned men of his day. Today we have the advantage of far better microscopes and all the knowledge that scientists have gained since the time of Leeuwenhoek. With a microscope, you too can explore the "invisible world" with the same excitement as Leeuwenhoek.

Through a simple magnifying glass, you can see an object as if it were three to 12 times as large as it actually is, depending on the magnifying power of the lens. A "portable microscope"—a tube that looks like a fountain pen and has a lens in each end—will enlarge an object up to 40 or 50 times. But you have to hold either of these instruments at just the right distance from an object in order to see it clearly, or *in focus.*

A regular microscope (*see diagram*) also has a tube with two or more magnifying lenses mounted in it. The tube is held in a stand that also has a table, or *stage*, to hold the object you are looking at. There is a hole in the stage, with a mirror under it to reflect light up through the object. By turning a knob, you can move the tube up or down to bring the object into focus.

The lens you look through is called the *eyepiece lens,* and the one closest to the object is the *objective lens.* The magnifying power of each of these lenses is usually marked on the tube ("10X" means that the lens enlarges an object 10 times). You can find the total magnifying power of your microscope by multiplying the magnifying power of the eyepiece lens, say 10X, by that of the objective lens, say 20X. In this case, the microscope magnifies the object 10 times 20, or 200 times. Some microscopes have several different objective lenses so that you can enlarge an object by different amounts.

Operating Your Microscope

To use a microscope, you will need some slides, cover glasses, Canada balsam, tweezers, an eyedropper, and a collecting bottle. You can buy these at little cost from a drugstore or a biological supply house. (Ask a high school biology teacher for the name and address of one.)

A good kind of specimen to look at first through your microscope is something flat, like a human or animal hair. Put it on a glass slide and lay a cover glass on top. Place the slide on the microscope stage with the specimen under the objective lens. If your microscope has more than one objective lens, start with the lens of the lowest magnifying power. Now you are ready to make some adjustments.

LIGHT. Place your lamp several inches away from the mirror and tilt the mirror at an angle of about 45 degrees.

Look through the eyepiece lens. Adjust the mirror until you get bright, even lighting. Move the lamp nearer or farther away if necessary. If you don't have a microscope lamp, try a table lamp at a distance of a foot or two.

You can also light specimens from above the stage if your lamp is bright enough. For best results, put a piece of black construction paper under the slide. This kind of lighting is especially good for seeing animals in pond water.

FOCUSING. Some microscopes have only one knob for focusing the lenses. But if your microscope has two knobs, one is for making rough adjustments and the other for fine adjustments. The rough-focus knob moves the tube fast, and the fine-focus knob moves it slowly.

Before putting your eye to the eyepiece lens, move the tube down to about an eighth of an inch above the slide. Then look through the eyepiece lens and move the tube *upward* to bring the image into focus. Focusing upward when your eye is at the lens keeps you from jamming the objective lens down into the slide.

Learn to keep both eyes open. If you have trouble doing this, cut a hole in a piece of black construction paper and mount it on the microscope tube. Then your free eye is concentrated on the black paper.

Usually you won't be able to see all parts of a specimen clearly at one time. By carefuly turning the fine-focus knob, you can bring different levels of the specimen into focus. Thick specimens usually should be cut into thin slices to let light through. Your parents or teacher can help you by making thin slices with a razor blade.

How To Mount Specimens on Slides

A water-drop slide is useful for many specimens you wish to examine. Use an eye-dropper to place a drop of water over a thin specimen on a slide, then put a cover glass over the drop (*see diagram*).

A small insect can be held on a slide with a piece of clear sticky tape. Clear gelatin can also be used. Put the specimen on a cover glass and put one drop of gelatin-and-water mixture over it and one drop on a slide. Set the slide wet side down on the cover glass and let them stand until the gelatin hardens.

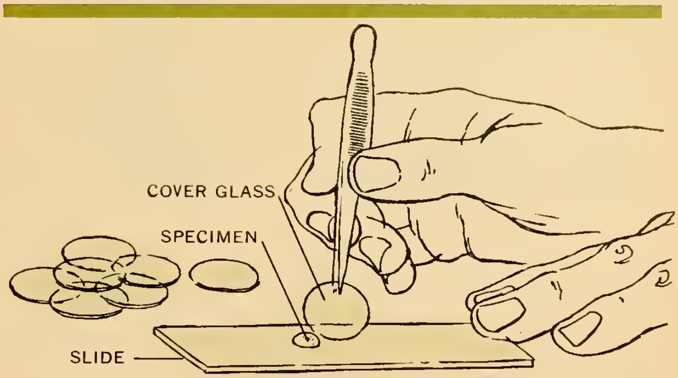
If you want to look at the tiny animals in pond or aquarium water, you can make a vaseline slide. With a toothpick, paint vaseline on a slide in a hollow square or circle the shape of a cover glass. Put a drop of water containing specimens in the center and press a cover glass down gently on top. The vaseline seals the edge and keeps the water from evaporating (*see diagram*).

Another way to prepare a pond-water slide is to make a slide "well" *(see diagram)*. Make holes in several thin squares of cardboard with a paper punch. Apply shellac to the cardboard squares and put them, one on top of the other, in the center of a slide. After the shellac dries, put a drop of water in the "well" and lay a cover glass on top.

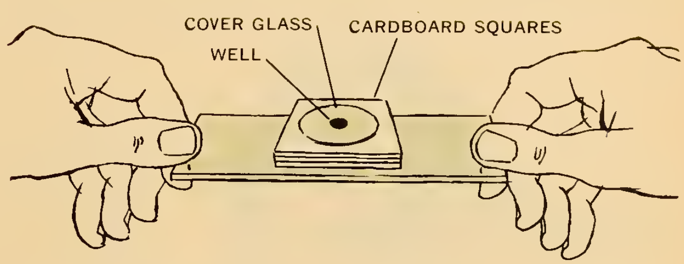
You may wish to look at some of your slides again and again. One way to make your slides permanent is to coat a dry specimen and slide with clear nail polish or clear household cement. But a better way is to use Canada balsam, a clear gum. Lay a dry specimen on a slide and cover it with a drop of Canada balsam and a cover glass. The balsam hardens to preserve the specimen.

Be sure to number or label your slide so that you don't

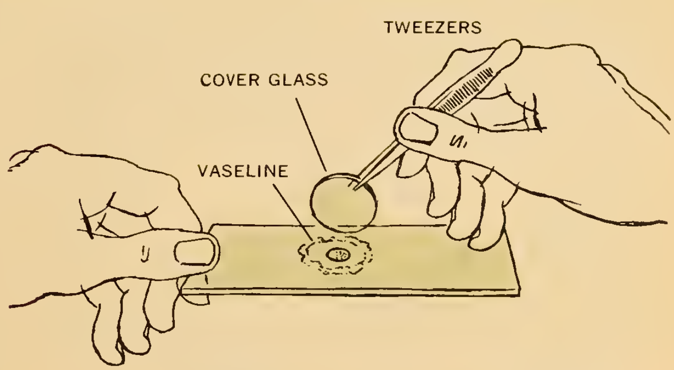
(Continued on the next page)



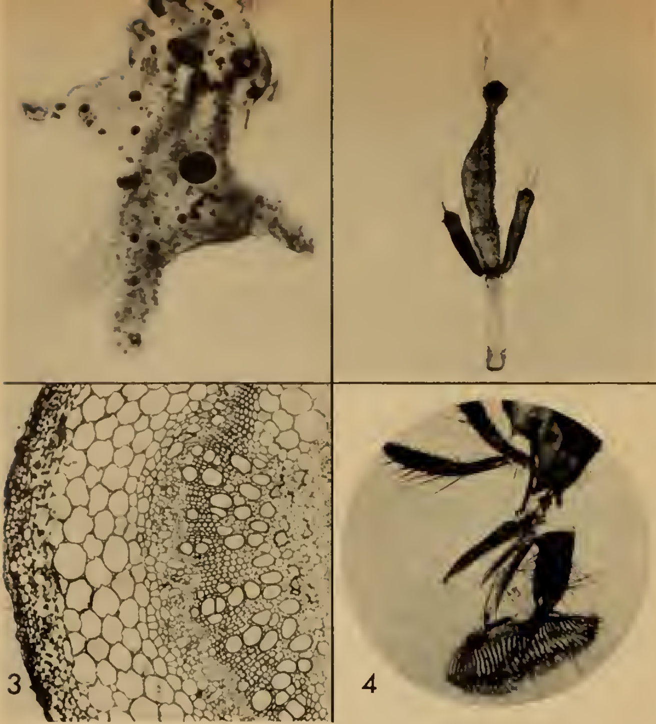
To make a water-drop slide, lay a thin specimen on a slide, put a drop of water over it, and lay a cover glass on top.



A "well" slide can be used over and over. Punch holes in several squares of cardboard, coat each square with shellac, then stack them on a slide to dry before using it.



A vaseline slide will hold drops of pond water. Paint the vaseline on a slide in the shape of a cover glass.



These are some of the fascinating things that you can see with a microscope that magnifies 50 to 200 times: (1) Amoeba proteus, a shapeless, one-celled animal; (2) Hydra, a larger, many-celled animal; (3) cells in a potato stem; (4) the large pad-shaped tongue of a fly (bottom of photo).

THE MAN WHO FIRST SAW "ANIMALCULES"

The man who gets credit for the first satisfactory microscope had little education—perhaps less than you already have! But Anton van Leeuwenhoek, a cloth merchant of Delft, Holland, made lenses that magnified up to about 250 times and revealed objects as small as four-thousandths of an inch in size. During his life (1632-1723), he spent more than 50 years studying "animalcules," as he called little animals, and plants. He found his specimens in canal water, mud, flies, frogs, and the soil.

A suspicious man, Leeuwenhoek kept his best instruments hidden and his greatest discoveries secret from most people. But he did reveal his work to a famous group of scientists, the Royal Society of London, who honored him by making him a member. Nearly all the experiments he did after that are described in letters that he wrote to the Society.

forget what it is. Write the name of the specimen, date and place of collection, and some description in a notebook.

What To Look for

If you look at specimens of plant or animal life through your microscope, you will often see tiny, thin-walled "boxes," or compartments, of various shapes. These are *cells*, the "building blocks" of life. You can see rows of them in a thin slice of onion skin or a slice of cork.

Some of the plants and animals you see may have only one cell. A simple animal like *amoeba* is one cell that keeps changing in shape. Something it splits into two new cells. More complicated animals and plants have many cells. Here are some things to find out when you look at living specimens through your microscope:

SIZE. Can you see the specimen without a microscope? How many times are you magnifying the specimen? How big is it?

SHAPE. Is the specimen round, oval, square, or more complicated in shape? Does it change shape? Are all the parts the same? Does one side look like the other side? Are all the cells alike?

ACTIVITY. Does the specimen move? Does it use "hairs," "arms," "legs," or other parts to move itself? Do any animals seem to be eating other animals? Are any cells splitting to form new cells?

STRUCTURE. Are there single cells or many cells? Can you see cell walls, or things inside the cell walls? Are there "hairs," "arms," "legs," or openings around the outside of the specimen?

Looking at non-living things through a microscope can also be great fun. Bits of soil, sand grains, particles scraped from rocks and minerals, crystals of table salt or other chemicals—such things reveal their structure under a microscope. You won't see any cells in such specimens, but you will discover their shape, color, size, smoothness, or roughness, how they fit together, and whether light shines through them, for example.

There's an endless variety of different things that you can examine through a microscope. Scientists use their microscopes to identify specimens, to compare different specimens of the same kind, and to study the changes that take place in living and non-living things. You can do all of these things with your microscope ■

For more information on using a microscope, look for these books in your library or bookstore: **Hunting with the Microscope,** by Gaylord Johnson and Maurice Bleifeld, Sentinel Books, New York, 1963, $1; **Experiments with a Microscope,** by Nelson F. Beeler and Franklyn M. Branley, Thomas Y. Crowell Company, New York, 1957, $3.50; **The Microscope and What You See,** by Martin Keen, Wonder Books, New York, 1961, $1 (hardcover); and **Strange Worlds under a Microscope,** by Margaret Cosgrove, Dodd, Mead & Company, New York, 1962, $3.50.

prepared by DAVID WEBSTER

brain-boosters

MYSTERY PHOTO

What skeleton is this? Does it run, walk, or hop?

Fun with Numbers and Shapes

Around the lake are 4 big houses and 4 little houses. The people in the little houses want to build a fence to keep the people in the big houses away from the lake. But the people in the little houses want to be able to get to the lake themselves. Draw a line to show how one fence could be built to do this.

Can You Do It?

When an Alka Seltzer tablet is dropped into water, bubbles of "Alka Seltzer air" are made. Can you use some tablets to get a bottle of pure Alka Seltzer air? There must be no "room" air in the bottle, just Alka Seltzer air.

For Science Experts Only

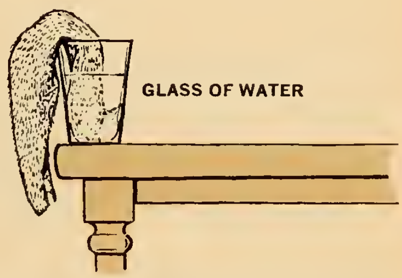
How can you tell a hard boiled egg from a raw one, without cracking them open?

Have You Heard This One?

What belongs to you, but is used more by other people?

What Do You Think Would Happen . . .

. . . If you arranged a glass of water and a washcloth as shown in the illustration? Try it. When you do, be sure to anchor the glass so it won't tip over. And fix the washcloth so it won't fall out.



Answers to Brain-Boosters appearing in the last issue.

Mystery Photo: When electricity travels through a wire, the wire becomes a magnet. This causes the iron filings to make circles around the wire. What would the filings look like if the wire loop were a regular magnet?

Can You Do It? A piece of paper cut like this with a hole in the center will make shadows like the ones shown. What other shadows will this shape make?

For Science Experts Only: The compass was on a light for the ceiling. Hold the compass directions over your head. Are east and west now correct? Would the directions be right if you looked at them in a mirror or through the back side of the paper?

Fun with Numbers and Shapes: This is the way the cross can be cut to make a square.

Here are two other ways to do it.

NOW YOU SEE IT NOW YO

When you see a mirage, it is not your eyes playing a trick on you, but something else. Since mirages can be photographed, *something* must be there—but what?

by David Linton

■ Here was the moment they had been waiting for. The year was 1818. The scene—the ice-filled waters between Baffin Island and the many small islands of the Canadian Arctic. For several hundred years explorers had been searching for a short-cut from the Atlantic Ocean into the Pacific Ocean by going round the north of Canada.

Sir John Ross had to make a decision: Should he sail his ship farther into Lancaster Sound in hopes of finding a passage to the Pacific? Or should he give up the search and return to England? At the far end of the Sound he saw what he thought was a range of mountains blocking the way. If there was a Northwest Passage, he said, Lancaster Sound could not be the way to it. Ross decided to turn back.

Ross had been wrong. We know now that what he thought was a mountain range was a mirage.

What Makes a Mirage?

Travelers in the desert are sometimes surprised to see what looks like a lake far ahead of them. But when they try to reach the lake, they find that it either disappears or moves farther and farther away as they try to approach it. The "lake," of course, is only a mirage. So is the "water" you often see ahead of you on a highway on a sunny day.

Many people think that mirages are "all in the mind." However, a mirage is just as real as what you see through a telescope or photograph with a camera *(see photograph)*.

To see an object, your eyes must usually be pointed directly toward it, because light travels in a direct line from the object to your eyes. But suppose that the light were bent as it traveled to your eyes. The light would reach your eyes from a different direction, and you would see the object as if it were somewhere else—higher, lower, or to one side of where it actually was *(see diagram)*. This is what happens when you see a mirage.

What makes light follow a bent path? One way you can bend light is to send it from the air into a piece of glass—not straight in, but at an angle to the surface of the glass. Light travels slower through glass than through air because glass is *denser* than air. This means that the particles of material that make up a piece of glass are packed closer together than the particles that make up air.

When a light beam crosses the boundary between the air and the glass *at an angle*, the edge of the beam that enters

This "lake" mirage was photographed in Death Valley, California. The "lake" is actually an image of the sky that appears on the desert floor because the light from the sky was bent on the way to the camera (see diagram on page 16).

ON'T NOW YOU SEE IT NOV

the glass first is slowed down while the other edge of the beam is still speeding through the air. The beam is therefore bent in the direction of the first edge that met the glass *(see diagram)*. When the beam moves from the glass into

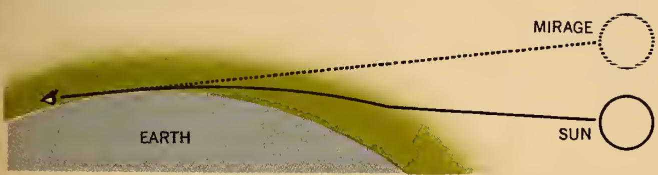
the air, it is bent in the opposite direction. Light is bent when it moves from a medium of one density into a medium of another density.

PROJECT

This drawing shows the side of a stack of glass sheets. Each sheet is made of denser glass than the sheet above it. Try to draw the path of the light beam as it passes through the stack. Does the beam bend farther each time it moves into a denser sheet of glass? Does this make the beam seem curved?

Like this imaginary stack of glass sheets, the Earth's atmosphere is made up of layers of air of different densities. The particles of air are packed together closest at the bottom of the atmosphere; usually the higher you go above the surface of the Earth, the thinner the particles are spread.

When the Sun is overhead, its light goes straight through the atmosphere to your eyes. The light is slowed down a bit as it goes through denser and denser air, but it is not bent. At sunrise or sunset, however, light from the Sun enters the atmosphere at a sharp angle, and the result is a mirage. Although the Sun appears to be right on the horizon, it is actually *below* the horizon, out of your direct line of sight *(see diagram)*. As light from the Sun moves



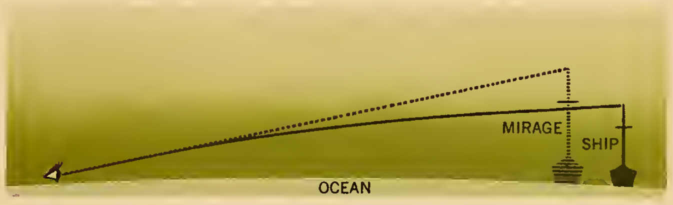
through the denser and denser air, it is bent in a curved path. But your eyes see the light as if it had traveled *straight* from the Sun to you.

WHAT WOULD HAPPEN IF...

...you were on a planet much smaller than the Earth, where the density of the air at different levels in the atmosphere was just enough to bend light all the way around the planet? Could you see your own back?

One type of mirage is seen usually near a seacoast. It makes things seem as if they were stretched upward. Ships, icebergs, and islands appear to be much taller than they really are. Sailors call this "looming." Sometimes the objects seem to be floating just above the water.

Looming is caused by an unusual layer of air at or near the ground or sea. In that layer, the light goes from thin air to dense air in a much shorter distance than usual. Because of this, light from the top of a ship, for example, is bent more than light from the bottom of the ship is bent on the way to your eyes. This produces the stretched-up image (*see diagram*).



Looming is the only type of mirage that ever seems to be near. The others are always in the distance, and they move away, or disappear, if you go toward them. Sometimes looming makes nearby objects look much bigger than they really are. Fridtjof Nansen, the great polar explorer, almost shot one of his favorite dogs because he thought it was a Polar Bear. The captain of a ship in Newfoundland once saw what looked like a white motorboat ahead of his ship. It did not move, so he changed course so as not to run into it. When the ship came close, the "motorboat" flew away. It was a seagull!

The "lake" in the desert and the "water" on the highway are examples of another type of mirage. It can be very cold in the desert at night, but when day begins the Sun heats up the ground quickly. The air near the ground is

(Continued on the next page)

warmed up and becomes thinner than the cold air a few feet above the ground. This reverses the usual order of density in the atmosphere. Light from the blue sky on the horizon is bent as it moves from the higher dense air to the layer of thinner air, so that you see the blue sky as if it were on the desert or the road ahead (*see diagram*).

Another type of mirage makes things appear upside down in the sky. This type can occur either in the desert or at the sea coast, when a layer of warm, thin air is trapped between two layers of colder, denser air. The mirage of the object may also be changed in size, shape, or position. Sometimes the real object and the mirage are visible at the same time. When that happens, the upside down mirage usually touches the top of the object. In other cases the object itself is not seen. It may be so far away that it is over the horizon.

The crew of a Canadian government supply ship in the Arctic once saw a sailing ship upside down in the sky. The image was so clear, they reported, they could see the ropes in the rigging and men walking about on the deck. Later in the summer they met the actual ship. By comparing the logs of the two ships they found that they had been 80 miles apart when the mirage occurred.

Mirages that Form Totem Poles

Sometimes two types of mirage occur together. An object may appear stretched upward and may have an upside down image on top of it. Once in a great while an object will appear several times. The images are one on top of the other like a totem pole. One will be right side up and the next one upside down, and so on. Such mirages are caused by layers of thin and dense air in a sort of atmosphere "sandwich." The rarest mirage of all is seen when the image of a mountain, tower, or cliff appears upside down *below* the real object.

Mirages do not stay still for very long. They may disappear if there is a slight wind or if the air becomes warmer. They can change or disappear if the person looking at them moves. Usually they are seen best from near the ground. If you climb a hill to get a better view, the mirage usually vanishes. The helmsman at the wheel of a ship sometimes sees an "island," when the lookout in the crow's nest at the top of the mast can see nothing.

Although mirages do not usually stay the same for very long, there are places where they occur again and again. One place is the coast of Labrador. A cold current comes down from the Arctic there and the sea is very cold, but in the summer the land is warm. Certain islands off the coast cause looms so regularly that ships steer by them even when the islands are actually *below* the horizon.

Mirages are not often so useful. Usually they are simply a nuisance, and sometimes they are a real danger. There is probably some truth in stories of desert travelers dying of thirst while trying to reach phantom "lakes." Also, we are fairly certain that it was a mirage that delayed the discovery of the Northwest Passage from the Atlantic Ocean to the Pacific Ocean ■

This mirage was made by heating a sheet of dull metal (bottom half of picture) and the air just above it. Light from a sheet of paper (top half of picture) is bent so the camera "sees" the paper and letters as if they were on the metal.

nature and science

TEACHER'S EDITION

VOL. 2 NO. 6 / DECEMBER 7, 1964 / SECTION 1 OF TWO SECTIONS

Using a Microscope in an Elementary School Room

by Bernard Friedman

■ The availability of Federal funds for science teaching equipment has triggered a rapid growth in the use of microscopes in the elementary schools within the past two years.

Although inexpensive Japanese microscopes have been available for some time, only recently have microscope manufacturers looked with interest at the elementary school market. Now one of the nation's largest manufacturers has produced a series of instruments for elementary pupils. Included in this new line are 10-power and 100-power plastic microscopes, priced at $12 each. An illuminating lamp for use with these microscopes sells for $3. Other microscopes, with stereo and zoom-focusing features, cost about $50.

Today it is fairly widely accepted that microscopes can be useful in teaching science in the elementary school. But many elementary teachers with little or no science background are reluctant to teach the use of equipment with which they are unfamiliar.

In some school systems, science supervisors are setting up in-service training programs to overcome this obstacle. A simple handbook that the pupil can read as he works with his microscope is "Your Microscope and How To Use It," available for 70 cents from the Science Materials Center, 59 Fourth Avenue, New York 3, N. Y. This approach takes much of the load off the teacher.

A teacher who wishes to get started with microscopes should select an instrument designed for elementary pupils. Used or hand-me-down high-school microscopes that are more complicated than necessary for elementary use should be avoided. Dissecting microscopes, which give a pupil an enlarged, three dimensional view of a biological specimen that he is cutting apart, are not widely used in the first six grades.

Bernard Friedman is Technical Director of Scientific Instruments at Nikon, Inc., a manufacturer of microscopes and other optical instruments. A former biology teacher in New York City schools, he now teaches classes in microscopy.

One type of "microscope" sometimes employed in elementary schools is actually a slide viewer which resembles a microscope. Although this device may have a place in teaching and is generally accompanied by good photographic color transparencies, the pupil should not get the idea that he is using a microscope. Manufacturers of such slide viewers warn teachers to make this clear to their pupils.

Selecting a Microscope

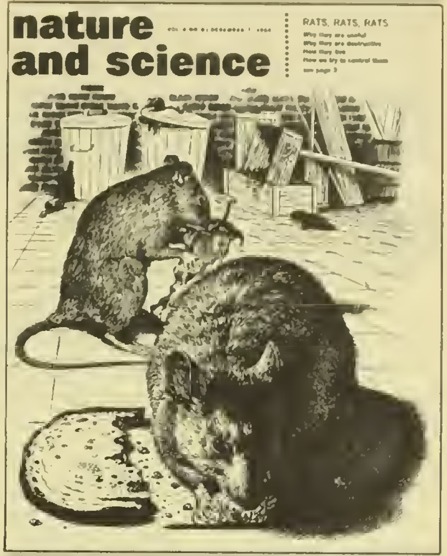
Probably the single most important consideration in teaching the microscope is to make sure that pupils see something clearly as soon as possible. If youngsters don't see anything, they aren't going to be interested. It is results that count. The purpose of the microscope is to make something visible in sharper focus and in finer detail than it could be seen otherwise.

The compound microscope selected for science teaching at the grade school level should be of the simplest type, consisting of an objective lens, an eyepiece, a focusing mechanism, a platform or stage for the specimen, and a mirror or an attached light source.

The most desirable grade school microscope is one that is very easy to operate, tamper-proof, and sturdy enough to withstand constant hard use by pupils. There should be no removable parts and unnecessary accessories. The light source should be sufficiently large and bright so that the specimen can be quickly and conveniently illuminated, either by light from below the stage that is transmitted through the specimen or light from above that is reflected from the specimen.

The first and most important lesson to be learned is that power is not synonymous with "seeing more." The highest magnification is very often not the most desirable. It is often helpful to first observe the specimen with the unaided eye, then with a hand magnifier, and finally on a carefully prepared slide under the microscope. Magnifications greater than 200x should generally not be attempted at the grade school level. The transition from the macroscopic to the microscopic

(Continued on page 4T)



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Rats, Rats, Rats**
These adaptable, destructive rodents thrive on our farms and in our cities. Scientists study the lives of rats to find better ways to control their numbers. Your pupils can perform feeding and learning studies with white rats.

● **How To Be a Wildlife Detective**
Your pupils can study the habits of wild animals by identifying and following their tracks.

● **Who Goes There?**
The tracks and trail patterns of 16 common mammals and birds.

● **Exploring with a Microscope**
How to operate a microscope and use it to investigate the miniature world of tiny plants and animals.

● **Now You See It, Now You Don't**
Mirages are not imaginary phenomena; they result when light is bent as it passes through layers of air of different density.

IN THE NEXT ISSUE

Special-Topic issue on THE FAMILY OF MAN. The search for the earliest man, and what scientists have found ... A WALL CHART of man's "family tree" shows the evolution of primates ... How the human hand evolved from fishes' fins ... Parts of the body grow at different rates ... Forms of marriage and the family among different peoples.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Rats, Rats, Rats

While man has succeeded in overcoming many animal pests, he has never been able to conquer the lowly rat. The reasons for the rodent's survival are well set forth in this informative article.

Topics for Class Discussion

- *What other familiar animals are rodents?* Squirrels, mice, chipmunks, groundhogs, beavers, and porcupines are a few. Rodents are the most abundant mammals in number of species and individuals.
- *What is the outstanding characteristic of rodents?* Rodents have very long front teeth, used for gnawing. Their incisors are self-sharpening and, unlike our teeth, are constantly growing from permanently active pulp. If for any reason a rodent's teeth are not worn down, or are worn unevenly, the teeth grow so long that the animal cannot eat and dies. Sometimes the bottom teeth grow in a curve and pierce the animal's brain.
- *What qualities have helped rats survive so successfully?* Careful reading of the article reveals that rats are prolific, hardy, and adaptable.
- *Does overcrowding make people tense and irritable?* Scientists are still cautious about drawing analogies between stress in rat populations and in human populations, but your pupils may better understand the concept of stress as it affects animal populations if they think of it as applied to themselves. Have them consider what happens when a classroom is overcrowded, when 6 or 7 people make a long trip in the same car, or when several children share the same bedroom for an extended period of time.

Activities

- The Bubonic Plague makes an interesting topic for investigation. Your pupils will learn that it has always been most severe in the great trade cities of the world. Only in the past 30 to 40 years have international controls been effective in checking the spread of this disease.
- A reading of Robert Browning's *Pied Piper of Hamelin* will be an enjoyable finale.

Keeping and Studying White Rats

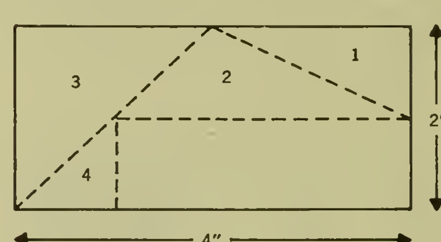
Here are a few more tips for taking care of white rats in the classroom:

- Keep the rats warm and cover the cage at night and over weekends.
- Give the rats a sand-box "bathtub" for rubbing grease from food off their fur.
- Teach your pupils to handle rats gently. Like most small animals, rats like frequent gentle fondling, soft talk, and being scratched behind the ears.

Learning by Trial-and-Error

Rats find their way through the maze by trial-and-error learning, improving through repetition. A maze tests more than learning. For example, a rat's performance also depends on its health and on the sensitivity of its vision and sense of touch. Your pupils will enjoy putting themselves through another test of learning speed. Here's how:

For each child in the class, prepare a puzzle from a piece of paper twice as wide as it is high, cutting it according to this diagram. Discard the unnum-



bered piece. Each child should receive four scrambled pieces. At a given signal, he should try to arrange them to form the letter "L." Meantime, you should be writing the elapsed time on the board every 10 seconds so the children can see how long it takes them. Have your pupils scramble and re-do the puzzle five times, timing themselves each time. They will observe that, generally, each successive trial takes less time.

PAGE 6 Wildlife Detective

Because most wild mammals are shy or nocturnal, their behavior is difficult to observe. We can interpret it by following tracks and other signs. Unless children get outdoors and *look*, the study of wild mammals will be largely book lessons.

Suggestions for Classroom Use

Have your pupils discuss places in your area where mammal signs are likely to show up. Proceed with the observations on an individual basis. If

PHOTO BY DAVE MECH

If you photograph a track, place a ruler or pencil near the track to show how big it is. The size and shape of this track help to identify it as the front paw print of a Raccoon.

anyone plans to take a camera, advise using a portrait attachment for pictures of small tracks.

Encourage students to bring in sticks showing toothmarks, nuts and acorns that have been gnawed open and casts of tracks.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition wth single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE & SCIENCE, The Natural History Press, Garden City, New York 11531.**

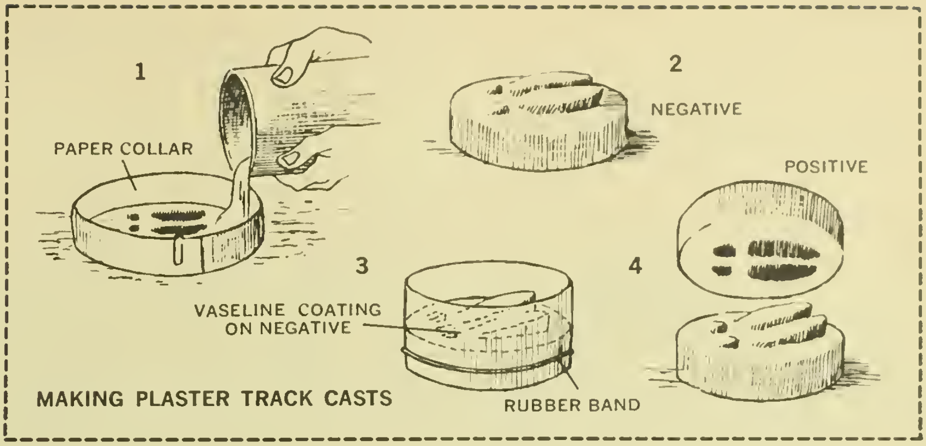
Using This Issue...
(Continued from page 2T)

Making Casts

Casts of animal tracks in mud or ice are easily made by pouring a mixture of plaster of Paris and water into the track. If the children practice mixing plaster of Paris in school they will have no difficulty on the trail. Use quick-setting plaster, available at hardware stores. Add enough plaster to fill the track, a little at a time, to ½ cup of water in a tin can, or plastic container. When the mixture looks like pancake batter, pour it into the track (*see diagrams*). A very neat job results from placing a stiff paper collar fastened with a paper clip around the track. The plaster may be lifted off after setting for about 15 minutes. Any mud can be cleaned off with an old toothbrush at home.

If the air is very cold, casts can be made in snow by spraying the track with water from an atomizer. This will harden the track. As a further precaution against melting, mix some snow into the wet plaster.

This cast will be a "negative" reproduction of the track; that is, the paw marks will protrude. To make a "positive" cast, first coat the negative cast with vaseline, then set it in the paper collar and pour plaster mixture over it until the protruding paw mark is covered. When the plaster has set, you can separate the positive cast of the track from the negative cast. If the negative is removed carefully each time, many positives can be made from it.



MAKING PLASTER TRACK CASTS

PAGE 14 Now You See It

Mirages are not products of the imagination, but optical illusions caused by atmospheric conditions that make objects appear distorted or moved in space. The article explains how light from an object is bent into a curved path as it passes through layers of air of varying density. The eye sees the light as if it had traveled in a straight line from the object, so the object appears to be in a different place (or shape) than it actually is.

Suggestions for Classroom Use

Before the class reads the article, you might ask if anyone remembers seeing "puddles" on the highway that disappeared as he rode closer. What explanations do your pupils offer for this? Tell them that this article should clear up a mystery that even their parents may not understand.

In discussing how light is bent when it moves from one medium into a medium of different density that slows it down or permits it to speed up, you might use this analogy: When an automobile moves directly from a paved road onto a gravel road, it is slowed down by the gravel but it continues in a straight line if both front wheels cross the boundary from pavement to gravel at the same time. But if the automobile crosses that boundary at an angle, the right front wheel, say, is slowed down by gravel before the left front wheel is slowed down, and the car turns to the right—unless the driver uses the steering wheel to keep it from turning. When the car moves from gravel back to pavement at an angle to the boundary, the wheel that reaches the pavement first speeds up before the other wheel does, making the car turn in the direction of the slower wheel.

A beam of light is turned in a similar way as it moves from air to glass, from glass to air, or even from air of one density to air that is denser or less dense.

Topics for Class Discussion

- *Is the Sun (or the Moon, or a star) ever exactly where it appears to your eye to be?* Yes, but only when it is directly over your head, so that its light travels to your eyes at a right angle to the layers of air in the Earth's atmosphere. Since the Sun can never be directly over your head north of the Tropic of Cancer, people in the United States never see the Sun exactly where it is located in space.
- *Are "twinkling" stars a kind of mirage?* Yes. A star's light does not really flicker. The twinkling is caused by light from the star being distorted as it passes through shifting currents of warm (thin) and cold (dense) air in the atmosphere. A similar phenomenon can be observed at home. Hot air currents rising from a radiator or toaster will make objects behind the air currents appear to wiggle.
- *Why do we think that the mirage on the hot road ahead is water?* As the article explains, what we see is really an image of the sky, but because a bright spot on the ground usually means "water" (a lake or puddle), we think the mirage is "water." Previous conditioning often determines how we describe a mirage.
- *Why may a mirage disappear when the viewer moves?* A person will see a certain mirage only if he is in the path of the *bent* light coming from the object in question.

Activities

- To better understand mirages of objects beyond the horizon, such as the rising Sun, each child should perform this simple act: Place a penny in an empty cup and bend down until the edge of the penny just disappears beyond the rim of the cup. Now *slowly* fill the cup with water. The penny will appear to "loom" up the side of the cup. In this analogy the penny is the Sun, the rim of the cup is the horizon, and the water is the Earth's atmosphere.
- Have your pupils check the time of the apparent setting of the Sun with the sunrise and sunset tables given in newspaper weather reports. Official times are often calculated from the Sun's actual position in the celestial sphere and do not correspond exactly to what we see. If your pupils repeat this activity for several days, they may find that the discrepancy averages about 8½ minutes.

Using a Microscope...
(Continued from page 1T)

level is best made in easy stages. It is impossible to describe a forest to anyone by first examining the bark on one of the trees.

Taking Care of Your Microscope

The surfaces of the eyepiece and objective lenses must be kept scrupulously clean. Finger smudges will destroy the image in a most exasperating way. The accumulation of dust on the glass surfaces, though less of a menace, can also mean the difference between a thrilling new experience and despair.

To avoid all this, the microscope should be kept in a clean, dry place and covered with a plastic bag when not in use. Dust can safely be removed with a small, good quality camel's hair brush or, preferably, blown off with a small ear syringe, available in most drug stores.

Lens smudges can be cleaned with special lens tissue or an old, well washed, clean linen handkerchief. After the dust has been removed, gently blowing on the lens and wiping carefully and completely with a rotary motion will be sufficient. Stubborn cases will require slight moistening of the tissue with xylene or toluene. Small lenses are most conveniently cleaned with good quality medical swabs or Q-tips. The slides and cover glasses should also be checked for smudges or dust. Clean them by immersing in a weak soap or detergent solution and wipe dry with a clean piece of silk or well washed linen cloth.

Preparing Specimens

The next deterrent to a fruitful and exciting experience with the microscope is an improperly prepared specimen. For observations with transmitted light, avoid a too thick or crowded specimen. The object to be studied should be placed in the center of the slide and a drop or two of water or other liquid added. The cover glass should be carefully placed over the drop to avoid air bubbles. Invariably, many youngsters will carefully examine all aspects of the bubble and carefully avoid the specimen. It might even be a good idea to first demonstrate what a bubble looks like under the microscope.

If too much liquid is added, it will tend to flow out under the edge of the cover and the cover may float around in the liquid. Liquid on top of the cover glass will destroy the image. Too little liquid will result in air pockets under the cover glass. With a bit of experience, the correct amount of liquid will be quickly determined. Fibrous materials should be teased apart with two needles. For moving specimens it is helpful to gently tap the cover glass with a needle or toothpick. This will reduce the depth of the preparation and make it more difficult for the organism to swim out of focus.

Opaque objects must be illuminated from above, making use of the light reflected from the specimen. Bouncing the light off the specimen at different angles will cause marked differences in the appearance of the specimen. Since the amount of light entering the objective lens depends on the degree to which the specimen reflects light, it may sometimes be necesary to add another light to get a sufficiently bright image. Avoid shining any light directly into the objective lens. This will destroy the clarity of the image.

Too much hunting around for the specimen should be avoided. It is best to first determine where on the slide the specimen is located and then carefully center it under the objective lens. *Always start with the lowest power first.*

It cannot too often be repeated that anything you can think of that will fit onto a slide is worth a try under the microscope. Of course, the best beginning is made with the most interesting specimens. The look on a pupil's face when he sees his first little animal swimming around in the tiny drop of water he has just placed on the slide is a never to be forgotten experience ■

The Microscope in Your Science Program

by Glenn O. Blough

■ Because of the fascination which highly-magnified specimens hold for the viewer there is always the danger of allowing the microscope—a visual aid peculiar to science—to become an end in itself. For this reason a word of caution may be in order to avoid the "microscope show" approach and to correlate use of the instrument to the particular phase of science under consideration at the moment.

It is desirable to devote one introductory lesson to the technique of using a microscope and to making microscope slides. After that, the microscope can be brought out when the topic being studied will be more thoroughly understood through minute visual examination of one or more parts of it. Here, as elsewhere in science teaching, the pupil is allowed to discover as much as he can for himself.

Following are a few . . . examples of how to use this scientific instrument to its greatest advantage in making the science curriculum more meaningful. . . . We suggest the microscope for examining:

1. A butterfly wing to see its minute scales and note how structure contributes to use.

2. A wing feather of a bird to see details of structure related to flight.

3. A drop of pond water to discover a world of otherwise invisible animals.

4. Pond scum (algae) in connection with food of water animals and interdependence of living things.

5. A very thin smear of blood cells, and a strand of hair, in connection with the study of the human body.

6. Blood flowing in the tail of a tadpole or goldfish, or in the web of a frog's foot, to understand more about circulation.

7. The tiny one-celled plants called bacteria, to learn more about the causes and spread of disease. (A handful of hay soaked for a few days in water is a good source of harmless, rod-like bacteria.)

9. A fish scale to examine its growth rings.

11. A bee's stinger and other parts of a honey bee to see adaptation for protection, food-getting, pollination and flight.

12. Mouth parts of mosquitos and butterflies as examples of sucking insects, and grasshoppers and beetles as examples of chewing insects, to discover various adaptations for food getting.

13. Antennae of various insects to see how they differ in structure—some knobbed, some tapering, some feathery, etc.

14. A section of an eye of a fly or grasshopper or other insect for an understanding of structure.

18. The cells of leaves in a study of food manufacture in plants.

23. Pollen of different kinds of flowers in a study of plant reproduction.

27. Small pieces of silk and wool cloth to see how it is woven and the difference in the fibers.

30. A saturated solution of table salt and water to watch the salt crystals form. (Blowing gently hastens the process by promoting evaporation.)

31. Different shapes, colors, and sizes of grains of sand to understand better what sand is and how, when driven by the wind or used as sandpaper, it can wear away surfaces.

32. Prepared slides of microscopic materials which pupils themselves are not able to make ■

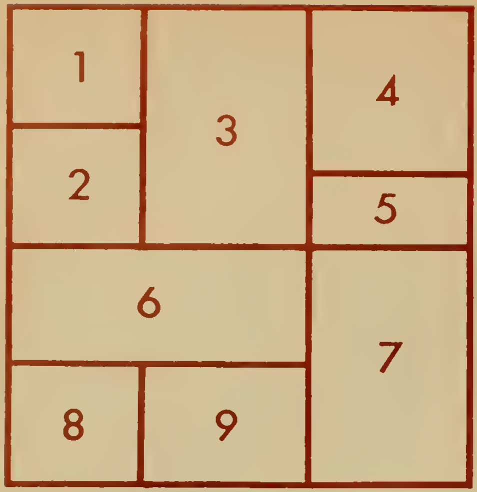
Dr. Glenn O. Blough is an Associate Professor of Education at University of Maryland, and co-author of Elementary School Science and How To Teach it. *This material is excerpted from his two-page leaflet,* "The Microscope in the Elementary Science Program," *single copies of which are available from Educational Materials & Equipment Company, P.O. Box 63, Bronxville, N.Y.*

nature and science

VOL. 2 NO. 7 / DECEMBER 21, 1964

SPECIAL-TOPIC ISSUE

THE FAMILY OF MAN



ABOUT THIS ISSUE

This special topic issue is devoted to a subject that humans find especially fascinating—man himself. The theme of the issue—The Family of Man—is shown by our cover pictures of people from all over the world: (1) Siberian Eskimo, (2) Australian Aborigine, (3) Brazilian Indian, (4) Polish, (5) Chinese, (6) Semite, (7) African, (8) North American Indian, and (9) Italian.

The article beginning on the next page tells what scientists have learned about your ancestors, while the WALL CHART shows the "family tree" of man and other primates.

"From Fins to Fingers" traces the development of the human hand, and "Growing Up in All Directions" tells how your body changes as you grow from a baby to an adult. "How To Look at Other People" points out the fascinating differences — and similarities — between life in your family and family life in an African village.

This special issue was prepared with the advice of Dr. Harry Shapiro, Chairman of the Department of Anthropology at The American Museum of Natural History. Editor of the issue for *Nature and Science* was James K. Page, Jr.

("The Family of Man" was the theme of a famous exhibit of 503 pictures, selected by Edward Steichen, at the Museum of Modern Art in New York City.)

nature and science

VOL. 2 NO. 7 / DECEMBER 21, 1964

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Caillicz
CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

CREDITS: Cover, photo No. 4 by Laurence Pringle, photo No. 9 by Gaetano di Palma, others from The American Museum of Natural History; p. 3, bottom, and p. 6, photos copyright by the National Geographic Society; p. 3, top photo by Jack Manning; pp. 4, 16, drawings by R. G. Bryant; p. 5, drawing by Juan Barberis; p. 7, photo by Mrs. Carroll Williams, from Educational Services Incorporated; pp. 8, 9, drawings by Gaetano di Palma; p. 10, top drawing by Joseph Sedacca, bottom drawings by Graphic Arts Department, AMNH; p. 12, x-rays from Babies Hospital, New York City; p. 13, photo by Colin Turnbull; p. 15, French wedding photo from Rapho Guillumette Pictures, Xhosa wedding photo by Jack Arnold from Frederic Lewis Inc., Nepal and Korea wedding photos from Wide World Photos.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

In search of the first man

by Diane Sherman

A newcomer to the family tree may be the father of us all.

■ Deep in a canyon in East Africa, two years ago, Dr. Louis Leakey and his wife, Mary, made one of the most exciting discoveries in the history of man's search for his earliest ancestors. They found fossil bones of a man-like creature that appears to have lived nearly two million years ago. Dr. Leakey has named the creature *Homo habilis,* which means "man able to do things." Was he the first man?

The Leakeys are both *anthropologists* (scientists who study man). They dug the remains of *Homo habilis* out from what must have been the floor of a campsite. There were simple tools scattered about, and heaps of bones of catfish and small animals that *Homo habilis* may have eaten. In spots, Dr. Leakey and his wife found stones piled together in what seem to have been the foundations for very simple huts or windbreaks.

They found parts of the skeletons of five different people, including a woman and a child. But there were enough of these fragments to tell a good deal about *Homo habilis.* From the leg bones, scientists can tell that he walked upright and that he was only four feet high. In certain ways, his skull was shaped very much like ours, and his feet—like ours—had parallel toes.

Homo habilis is very old. *Was* he the earliest man?

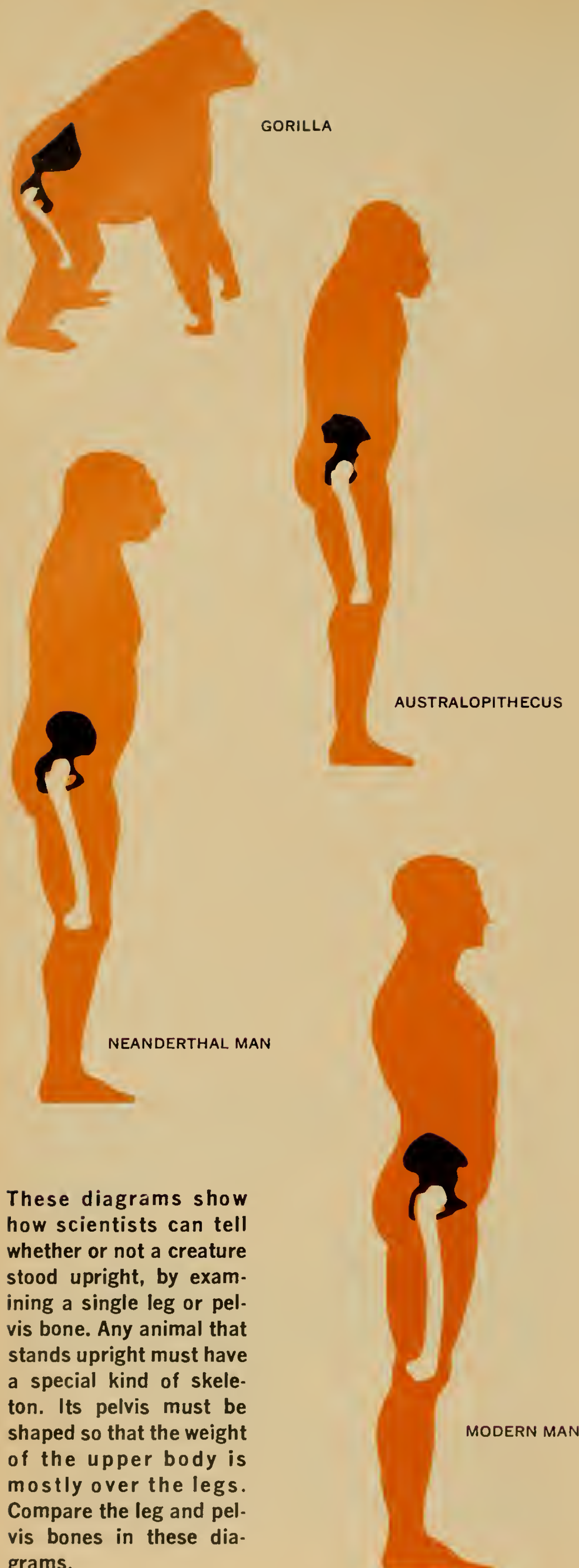
Early Man or Russian Soldier?

People have been looking for the earliest man since Charles Darwin, the great English naturalist, published a book titled *The Origin of Species* in 1859. In that book, he explained the theory of evolution and suggested that men had developed a long time ago from ape-like creatures. But three years before, in 1856, workmen digging out a cave in the Neanderthal valley of Germany had found some most peculiar fossils. They seemed to be the bones of a man, but what a strange man! He couldn't have had much of a forehead, because the top of his skull was low. There were heavy ridges across his brow and all his bones were very thick.

People were not sure what to make of Neanderthal man. One scientist at that time thought he must have been a

(Continued on the next page)

Dr. Leakey and his wife, Mary, painstakingly dig out the delicate bits of bone and tools of prehistoric man from the rock and dust in Olduvai Gorge, Tanganyika.



These diagrams show how scientists can tell whether or not a creature stood upright, by examining a single leg or pelvis bone. Any animal that stands upright must have a special kind of skeleton. Its pelvis must be shaped so that the weight of the upper body is mostly over the legs. Compare the leg and pelvis bones in these diagrams.

Russian soldier who had gotten sick while chasing Napoleon's army back into France in 1814 and had crawled into the cave to die. Others thought he was just a freak.

But as more fossils of Neanderthal men were found in other parts of Europe, many scientists began to accept them as an earlier kind of men, a kind that had lived a long time ago. Perhaps there were fossils still buried of even earlier men—"missing links" that were even more like apes.

Men from Java and Peking

A young Dutch doctor named Eugene Dubois was determined to find out. In 1887 he sailed for Java, in the East Indies. Dubois thought that man had probably descended from ape-like creatures in a warm country. He also believed that fossil men would most likely be found where apes were still living. Java is a warm country and the home of the orangutan, one of the great apes. It seemed a likely place to search.

Many people thought he was crazy to go to such trouble to find something that only *might* exist, but after several years of patient digging, he found the top of a skull. It was low and flat, like the skull of an ape. But it was too big for an ape—and too small for a man.

Nearby, Dubois found a human-looking leg bone. It had belonged to a creature that walked upright. Dubois decided that the skull and the leg bone belonged to the same creature—the missing link he had been searching for. He named it *Pithecanthropus erectus,* meaning "the ape-man who walked upright." But many scientists wanted more evidence before they would accept Java man as a true early man.

Then, in 1929, a skull was found in Peking, China. Because it was whole, the Peking fossil showed more plainly that its owner had been a man, not an ape. As excavations continued under Dr. Franz Weidenreich, chipped stone tools were found. Not only did these Peking men make tools, but bits of charcoal showed that they used fire as well. They even had clay hearths.

A little later, back in Java, more skulls were found by a young German scientist, G. H. R. von Koenigswald. When these skulls were placed side by side with the Chinese skulls, they proved to be quite a bit alike. Peking man is now called *Pithecanthropus pekinensis,* to show that he is quite close to *Pithecanthropus erectus.*

We now know that these ape-men lived between 500,000 and 250,000 years ago. Their remains have been found in North Africa as well as in China and Java. They were over five feet tall and lived in bands, gathering nuts and berries and hunting deer and other animals.

Starting in 1925, new discoveries were made in South Africa. A fossil skull found by a workman in a quarry was sent to Dr. Raymond Dart, of Johannesburg. Dr. Dart thought that the brain case was too small for the skull to have been a man's and he named his find *Australopithecus,* or "southern ape."

Yet the creature had some oddly human features. For example, its upper jaw was shaped like a man's and the teeth were small, even, and human-looking. Dr. Dart became more and more convinced that *Australopithecus* was closely related to man.

In 1936, Dr. Robert Broom, of Pretoria, South Africa, found another similar skull. Two years later, he came across still another. Since then, many more fossils have been found. They show that the Australopithecines, as these creatures are called, walked upright, as we do. Animal remains were found near their bones, which suggests that they were hunters. Stone tools were found nearby but we don't know for certain that the Australopithecines made them. Animal bones were also found at their campsites and these may have been used as weapons or tools.

What Makes a Man?

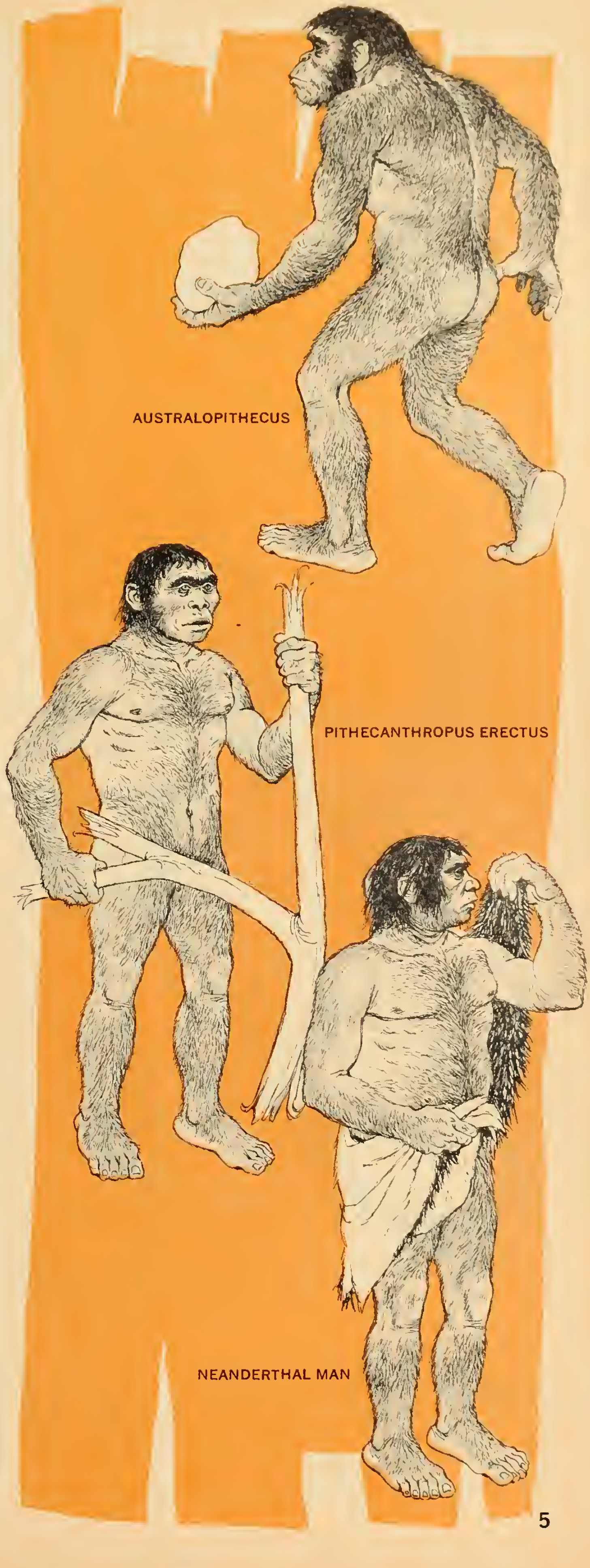
What kind of creatures were the Australopithecines? Were they extra-intelligent apes? Or were they early men? The question of what makes a human being is a hard one to answer. We didn't become men all of a sudden. There was a gradual change from "ape-like" to "human-like" to "human," and it took a very long time. The Australopithecines had many characteristics we consider human. For example, they walked upright and their teeth were much like ours.

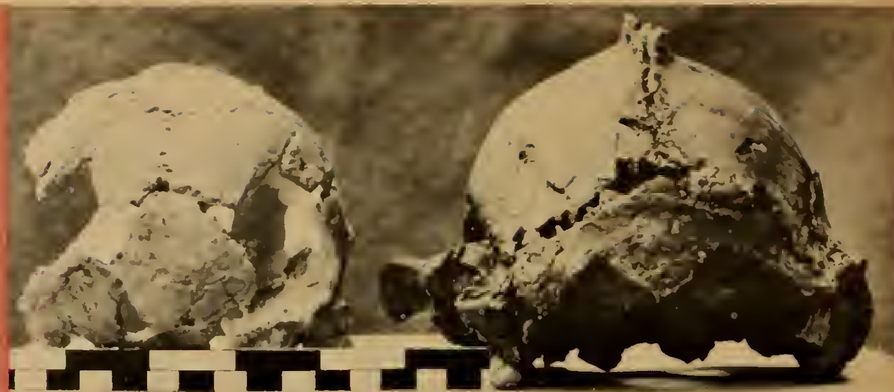
Upright posture is an important part of being human but there are other things, too. Before we can say that a creature was human, we have to know how he lived. Did he pick up a likely looking bone to use as a club whenever he happened to find one? Or did he deliberately hunt certain kinds of animals because he knew their bones would make useful tools or clubs? Was he satisfied with the club he found? Or did he know how to split it just so, to make it sharp?

In other words, we want to know if he had foresight, if he could plan his actions ahead. For example, a chimpanzee may pick up a stick to reach something. Or he might throw a stone that is handy. But a chimpanzee will not make a tool. He cannot sit down and *shape* a tool in order to solve a particular problem. Man, then, has been called the tool-maker, because he is the only creature who *makes* tools.

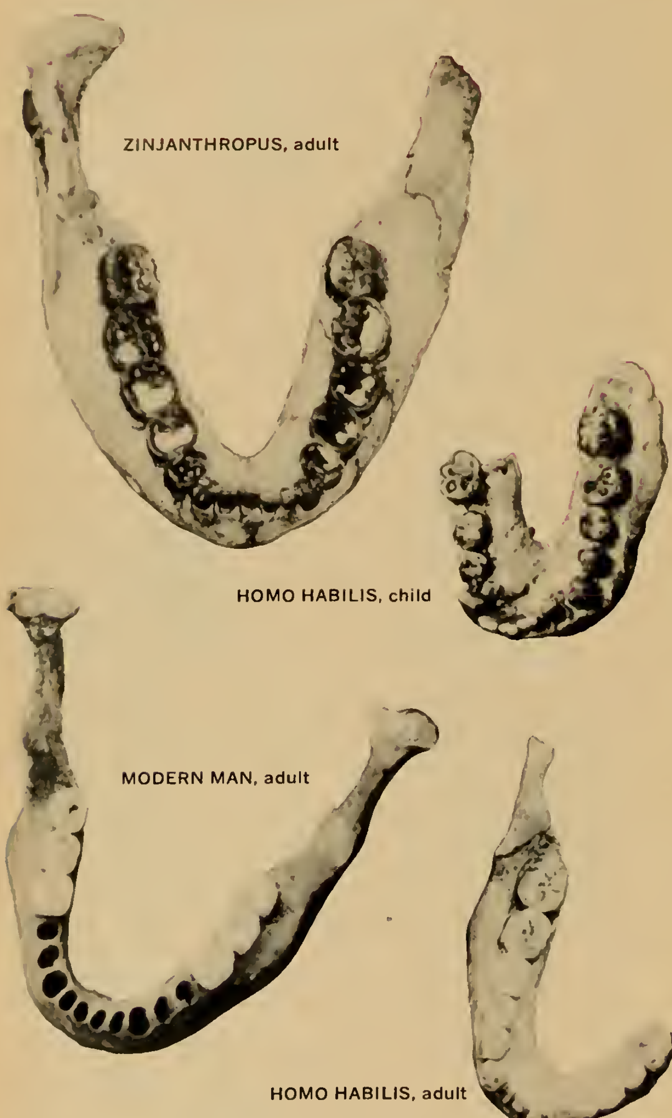
While the Australopithecines' remains were being discovered, Dr. Leakey was digging for fossils at Olduvai Gorge in East Africa. Olduvai is a narrow canyon, 300 feet deep and 25 miles long. Long ago, it was cracked open

(Continued on the next page)





The ridged skull of Zinjanthropus (right) is widest at the bottom. The skull of Homo habilis (left) is widest at the top, more like modern man's.



The jawbone of Zinjanthropus is larger and heavier than that of a human. The smaller jawbone of Homo habilis is more like a human jaw. After comparing human jawbones with those of Homo habilis, Dr. Leakey believes that Homo habilis may be a direct ancestor of man.

by an earthquake, exposing layers of fossil-studded mud and sand that had turned into rock with the passage of time.

Ever since 1931 the Leakeys had been digging here. They had found thousands and thousands of fossils of extinct animals—and numerous small chipped stones that must have been used by early man as simple cutting tools. Who had made these tools? Through year after year of patient digging, the Leakeys had found no trace of the early tool-makers.

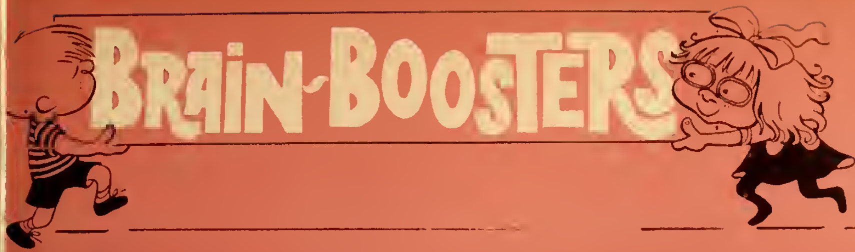
The Man from Zinj

Then, in 1959, the Leakeys found a skull. It was bigger than an Australopithecine's but smaller than that of modern man. The bone structure of the face looked nearly human, though the forehead was very low. Strangest of all were the giant back teeth. The Leakeys named their discovery *Zinjanthropus,* "man from East Africa," and his age was fixed at 1,750,000 years, making him the earliest fossil man yet discovered—if he was a man.

Dr. Leakey had found pebble tools along with *Zinjanthropus.* But as the Olduvai excavations went on, it appeared that the tools had not belonged to *Zinjanthropus* but to another human-like creature. For, on the same campsite, the four-foot high *Homo habilis* was discovered, and Dr. Leakey believes the tools to have been his.

Scientists used to think that each man-like fossil showed a separate step in the development of man. But here were *Zinjanthropus* and *Homo habilis*—living side by side. Perhaps *Zinjanthropus* and the Australopithecines are not our direct ancestors at all. It is more likely that there were several different man-types, all descended from the same ape-like ancestor. Only one of them eventually gave rise to modern man, the others, like *Zinjanthropus* and the Australopithecines, left no descendants.

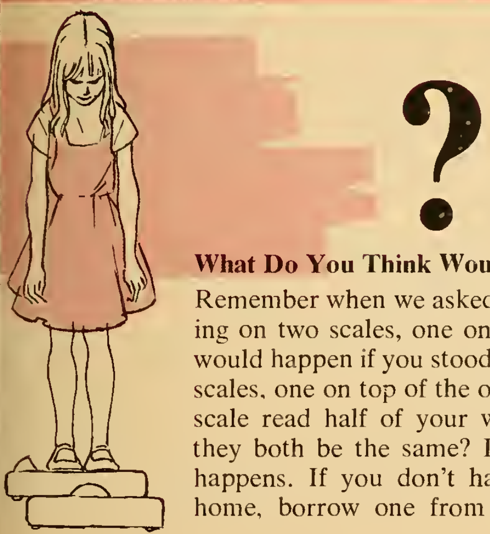
Homo habilis may well be our direct ancestor. But he may not. His fossil bones are still being studied and the search for more fossils is still going on. We know much about early man, but there is a great deal more to be learned ■



prepared by **DAVID WEBSTER**

Can You Do It?

Can you blow up a balloon while it is over the top of a pop bottle? Put a balloon on a bottle like the picture shows and try it.

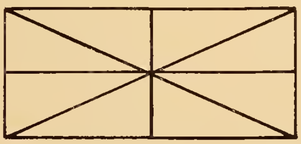


What Do You Think Would Happen?

Remember when we asked you about standing on two scales, one on each foot? What would happen if you stood on two bathroom scales, one on top of the other? Would each scale read half of your weight? Or would they both be the same? Do it to see what happens. If you don't have two scales at home, borrow one from someone else.

Fun with Numbers and Shapes

How many letters can you find in this figure?



submitted by Marietta Nelson
Atlanta, Georgia

For Science Experts Only

Jim said that a fan would keep an ice cube cooler so that it would not melt as fast. George, however, thought the fan would make the ice melt faster. Who do you think was right? Why? Maybe you could try it yourself.

MYSTERY PHOTO

What is it?

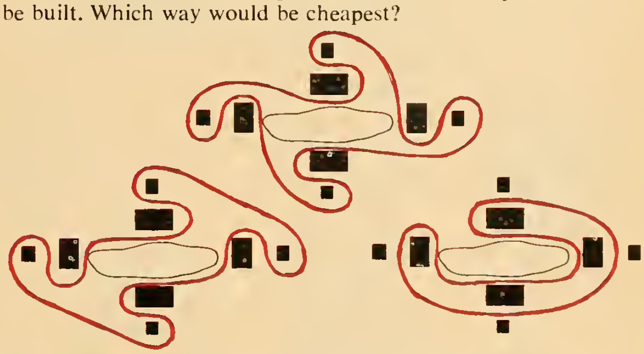
Answers to Brain-Boosters in the last issue.

Mystery Photo: The skeleton is a rabbit. Its long hind legs are for hopping. Can it go faster uphill or down?

Can You Do It? To collect pure Alka Seltzer air, you will need an empty baby food jar, or a small glass, and a pan deeper than the jar or glass is high. Fill the pan with water. Then put the jar in so that it fills with water. Now turn the jar upside down in the pan without letting any room air get into it. Next tuck an Alka Seltzer tablet under the jar and hold the jar steady as the tablet fizzes. The water in the jar gets pushed out by the Alka Seltzer air.

What Do You Think Would Happen? The water would climb up through the washcloth and then drip down it until the glass was empty.

Fun with Numbers and Shapes: Here are three ways the fence can be built. Which way would be cheapest?



For Science Experts Only: Try to spin each egg on its end. A hard boiled egg will spin for awhile like a top. What will a raw egg do?

Have You Heard This One? What belongs to you, but is used more by other people?
Answer: Your name.

A CORRECTION: Would a piece of iron and a piece of aluminum that are balanced on a stick in the air still balance if the whole thing were put into water? Several readers have pointed out that the answer to this question that was printed in the October 5 issue is incorrect. When placed in water, the two pieces of metal would not balance any longer, but would tip downward on the iron side.

THE EVOLUTION OF MAN

Man

■ In the light orange part of this WALL CHART, you can see some of the present-day members of a group of animals called primates, including man. In the darker orange part you can see how the primates have evolved from a small insect-eating animal that looked something like a shrew. Also, you can see some of the major steps along the way to modern man.

The first primates lived about 60 million years ago. It is very hard to imagine such a long period of time, but you may be able to get some idea of it by looking at the time scale on the bottom. First, see that the period from the time of *Homo habilis* to today is only a small part of the whole period from the first primates to today. On this scale, the time from the ancient Egyptians to today is not as wide as this letter "I" ■

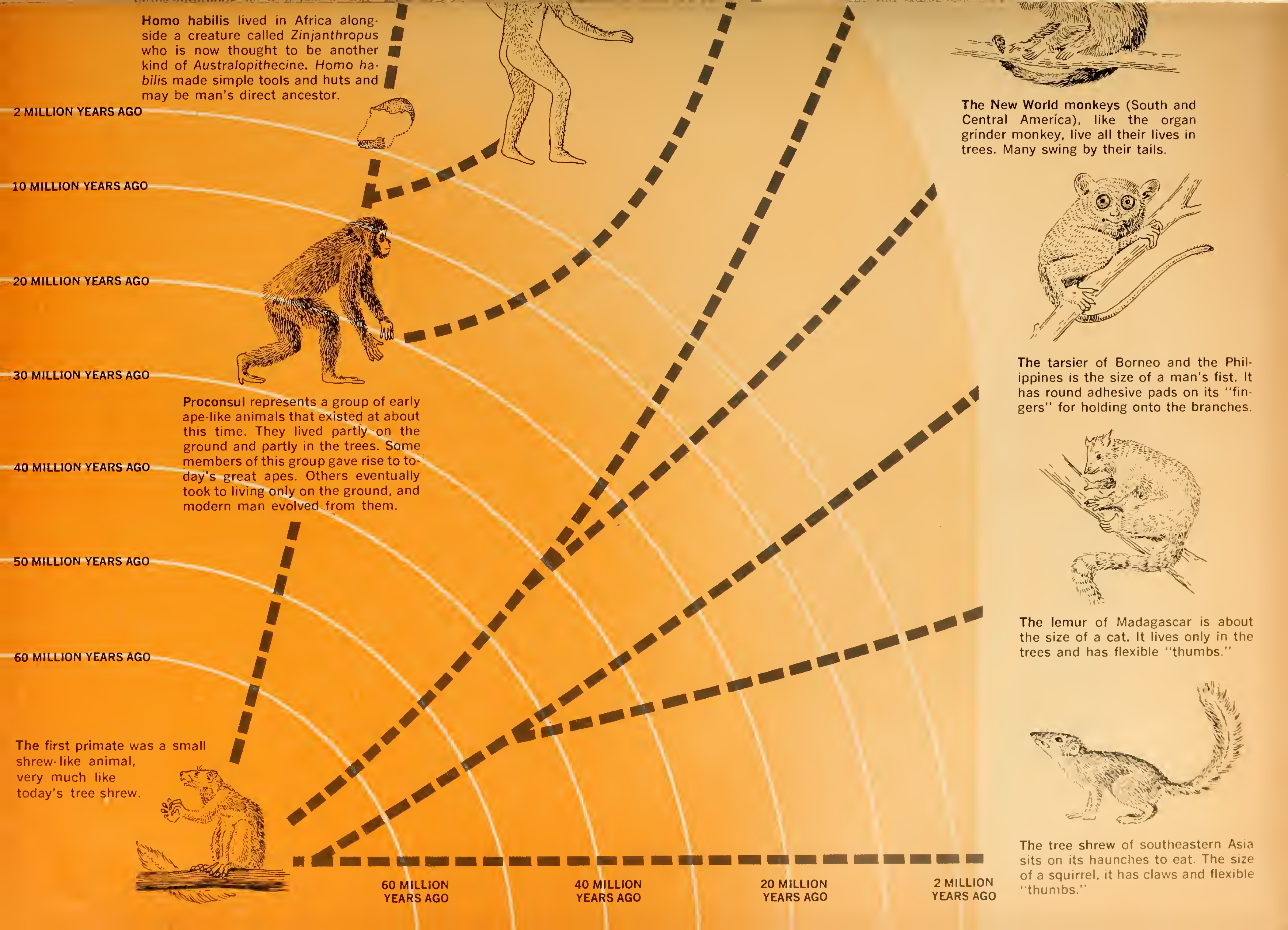
The great apes of Africa and Asia include chimpanzees, gibbons and orangutans. They are primarily tree dwellers, except for gorillas, which stay mostly on the ground. Gorillas move about in a semi-erect posture, leaning on their knuckles.

Neanderthal men lived in Europe and Asia between 45 thousand and 100 thousand years ago. The later forms were offshoots from the human line and died out.

Pithecanthropus lived between 300

The Australopithecines lived between one million and two million years ago in Africa. They had many human-like

The Old World monkeys (Africa and Asia) live mostly in the trees. Some


Homo habilis lived in Africa alongside a creature called *Zinjanthropus* who is now thought to be another kind of *Australopithecine*. *Homo habilis* made simple tools and huts and may be man's direct ancestor.
2 MILLION YEARS AGO
10 MILLION YEARS AGO
20 MILLION YEARS AGO
30 MILLION YEARS AGO
Proconsul represents a group of early ape-like animals that existed at about this time. They lived partly on the ground and partly in the trees. Some members of this group gave rise to today's great apes. Others eventually took to living only on the ground, and modern man evolved from them.
40 MILLION YEARS AGO
50 MILLION YEARS AGO
60 MILLION YEARS AGO
The first primate was a small shrew-like animal, very much like today's tree shrew.
60 MILLION YEARS AGO
40 MILLION YEARS AGO
20 MILLION YEARS AGO
2 MILLION YEARS AGO
The New World monkeys (South and Central America), like the organ grinder monkey, live all their lives in trees. Many swing by their tails.
The tarsier of Borneo and the Philippines is the size of a man's fist. It has round adhesive pads on its "fingers" for holding onto the branches.
The lemur of Madagascar is about the size of a cat. It lives only in the trees and has flexible "thumbs."
The tree shrew of southeastern Asia sits on its haunches to eat. The size of a squirrel, it has claws and flexible "thumbs."

FROM FINS . . . TO FINGERS

by Harry L. Shapiro

Think of all the things you can do with your hands. You can throw a ball, hold a bat, write a letter, and sew with a tiny needle. So many things we can do depend on our hands that it is hard to imagine how civilization could have developed without them. How did man's hands develop?

■ The story begins millions and millions of years ago. Some scientists believe that some early fishes started to leave the water. Gradually they evolved into *amphibians,* the first animals with backbones to live on the land. In the process, the fins of these fishes became changed into legs that supported the weight of the amphibians and allowed them to travel about on the land *(see drawing above).*

With some changes, the basic design of the early amphibian leg and foot was passed on, over millions of years, to the reptiles and then to mammals. During this time there were many extreme changes from the basic design. The front legs of some reptiles developed into the wings of birds. The horse eventually lost all but its middle toe, which became a hoof for running over the ground. The seals, which began as land-dwelling mammals, gradually developed flippers after they took to the water.

Dr. Harry L. Shapiro is Chairman of the Department of Anthropology at The American Museum of Natural History.

The "Opposable Thumb"

One group of mammals, called the primates, took to the trees before their hands and feet had become greatly altered for moving around in any of these special ways. Instead, the first digit, or "thumb," became separated from the others. It became what is called the "opposable thumb," which means that the thumb can be brought into contact with all other fingers *(see diagram).* This very important change made it possible for the primates to grasp the branches as they moved about. It also meant that a primate could pick up an object easily with one hand. You have probably seen monkeys in the zoo, picking up food with one hand while they cling to their perch with the other.

Some of the great apes, like the chimpanzees, learned to swing through the trees hand over hand, using their hands like hooks. As they gradually became more and more adapted to this kind of motion, their hands became longer and their thumbs smaller. A long thumb would have interfered with the use of their hands as hooks.

An "opposable thumb" can touch all of the other fingers, for grasping (left). The shorter thumb of a chimpanzee (center) is less able to hold small objects than is the thumb of a man (right).

In the meantime, some early ape-like primates came out of the trees and lived on the ground *(see pages 8 and 9)*. Eventually they walked erect, needing only their legs to move around on the ground. Their hands were completely free to do other things besides cling to branches—they could pick up bones and stones to use as tools or weapons. Later, these creatures learned to use their hands to make weapons—very crude ones at first, to be sure. It is at this point, perhaps, that we can say our ape-like ancestors became humans.

But to use their hands so skillfully, our ancestors needed intelligence. Scientists believe that the increase in intelligence among the early men is in some way connected with the use of their hands. Probably, the most skillful of these creatures who were learning to make tools had an advantage over their fellows. If they could make a better tool, or a better weapon for killing game, then they would have a better chance of surviving. Their superior ability would be passed on to their children, and to other members of their social groups or bands. The most skillful, most intelligent bands would be the most likely to survive and spread, while the less skillful would eventually die out.

Over countless generations, very slowly at first, our ancestors learned to make better and better tools and weapons. They learned to build houses and make clothes that would permit them to live in the colder climates that they moved into as they spread around the world. Later they learned to grow food and to write. Further changes in the human body were no longer necessary, for men could now make and grow the things they need to survive in different places and climates.

Now man can fly without developing the wings of a bird. He can cross the ocean without acquiring the body of a seal and he can live in the Antarctic without growing fur. All of this, and much more, is possible because of the hand, and the brain to use it ■

GROWING UP
IN ALL DIRECTIONS

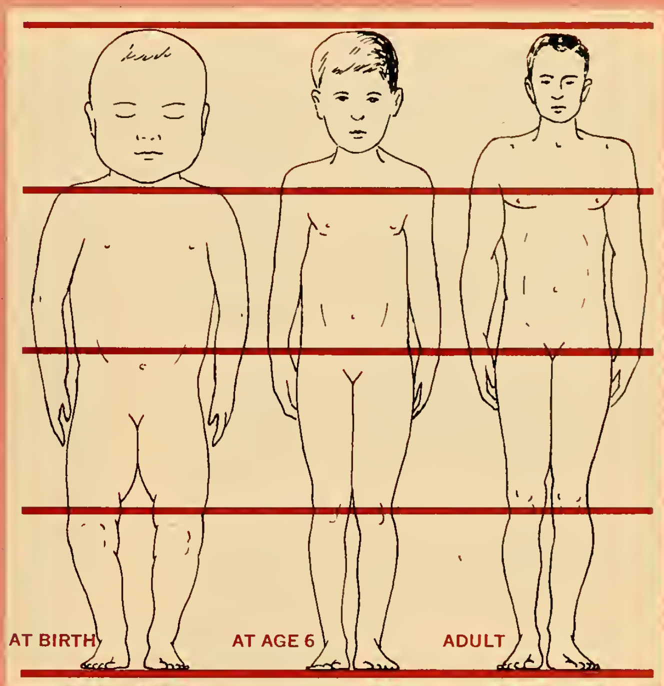
by Ethel J. Alpenfels

■ When you were born, you had a very big head. At least it was big compared to the rest of your body. Not only was it big, it had a "hole" in it. But don't worry. First of all, newborn babies are supposed to have big heads. A baby's head grows very fast, making room for his brain, which also grows rapidly.

At birth, your brain weighed one-fourth of what it will weigh when you are full grown. In the first six months of your life, your brain doubled in weight. Then it grows more slowly, reaching almost full size when you are 12.

What about that "hole" in your head? It was the soft place on the top of your skull that all babies have. The skull bones started to close over it about two months after you were born, and while you were still a baby, the soft spot was completely covered over.

At 12 years old, then, your brain is almost full size, but the rest of your body has a long way to go. Your arms, legs, feet, and hands have been growing all the time of course, but at different rates. This means that some parts grow more than others in the same amount of time.



When you were born, your head was very large compared with the rest of your body. As you grow up, your head slows down while your arms, legs, and body catch up.

Your skeleton has been changing in other ways, too. Many parts of a newborn baby's skeleton are made up not of bone but of *cartilage,* a tough, elastic substance like gristle. At different ages, different parts of this cartilage

(Continued on the next page)

Dr. Ethel J. Alpenfels is a Professor of Anthropology in the School of Education at New York University.

gradually turn to bone. For example, the cartilage in your ankle joint becomes bone several years before the cartilage in your wrist joint becomes bone.

Some Parts Grow Faster than Others

The organs of the body also grow different amounts during the same period of time. We have seen that the brain grows very fast in the early months of life and then slows down. The liver and the kidneys grow more slowly and at a more even rate. The reproductive organs develop very slowly in childhood and later they develop faster.

The growth rates of various parts of the body follow a definite pattern and a definite timetable. The same is true of most other living things.

While all humans grow according to the same basic plan and timetable, there is room for many differences. Up until the age of 9 or 10, girls are usually shorter and lighter than boys of the same age. Then they have a sudden spurt of growth until, at 13 or 14, they are taller and heavier than most boys their own age. Then the girls begin to slow down. By their late teens they have reached their adult height. Boys, however, have a fast spurt of growth at about the age of 14, and by their early twenties they have just about reached their adult height.

After a person reaches adult height, he begins to shrink, ever so slightly. A man may lose as much as a quarter of an inch every ten years for the rest of his life. This is caused by the shrinkage of the cartilage in the joints and the spinal column.

X-rays show the wrist of a newborn baby (left), made up mostly of cartilage. By the age of seven (right) much of the cartilage has turned to bone. By looking at such x-rays doctors can make a good guess of a person's age.

PROJECT

If you are going to have your height measured, the best time to do it is early in the morning. Scientists say that we are as much as ¾ of an inch taller in the morning than when we go to bed at night. Can you think why this is so?

Differences in human growth patterns are found among the peoples of the world. The pygmies of Africa are very short: An average pygmy is well under five feet tall. There is another African tribe called the Watusi who are just the opposite: Among the Watusi a six-foot man would be considered rather short, and an eight-foot tall Watusi is not unusual.

Also, individual people inherit different growth patterns. How often have you heard it said that "it runs in the family"? A high or low hairline, tallness, shortness, a large nose, a small nose, an in-between nose, all these physical traits do indeed follow family lines.

What Makes the Difference?

There are many, many things that determine what you are going to look like when you are full grown. First of all, because you are a human being, you can't end up looking like a rabbit. And, if your parents were pygmies and your parents' parents were pygmies, it would be highly unlikely that you would end up as tall as a Watusi.

What you inherit from your parents is important, but we know that man's environment is important, too. That is, where people live, the climate, the kind of soil, the amount of water, the scarcity or abundance of food, and how they earn their living—all of these things have had a great deal to do with how people grow. Throughout human history, groups of people have moved to different places around the world and they have changed their ways of life. Over the generations, these changes in environment are likely to make differences in growth patterns.

And just as groups of people are different, so each person starts off with a different pattern of body build. But that's not all there is to it. Your pattern can be affected by many things—childhood disease, accidents before or after birth, whether or not you eat balanced meals, and even the amount of rest you get.

Have your parents said that you are taller than they were at your age? Wherever records have been kept for long periods of time, they show that most adults today are taller than their parents, just as *they* were taller than *their* parents. This increase in height is often said to be the result of eating better foods, but scientists believe that there are probably many other causes as well ■

How To Look at Other People

by Colin Turnbull

Do people who live differently from you seem "uncivilized"? Their actions may seem strange, but they are doing the same things you do—in a different way.

■ You were probably born in a hospital surrounded by doctors and nurses. To protect you from germs, they may have kept you away from your parents for many hours. If you had been born in a primitive tribe in Africa, or South America, or in Southeast Asia, or any place where there are no hospitals, it would have been quite different.

A woman who is about to have a baby in such places works right up to the last moment. Then, without any great fuss, she has her child with the aid of a family member or friend. Within an hour or two she is back at work, with her baby strapped on her back. You would probably think this uncivilized. But she would think it "uncivilized" to be parted from her baby for an instant.

Of course if there is a hospital nearby, it is safer to let the doctors and nurses take care of the baby at first. But what's important in each case is that each mother is interested in the health of her child. She does whatever she can to protect it.

A pygmy woman ties a vine around her baby's waist or wrist. This may seem strange to us, but the pygmy woman would be just as curious about the gauze masks that an American mother and all the others in the hospital room with her wear to shield a newborn baby from germs.

Every mother has the same thing in mind—protection—and every mother does the best she can. The African woman has some medicines made from herbs and roots and plants, and these may help in safeguarding her baby. But against the danger that her baby might die, she seeks help from the supernatural. When a pygmy mother in Africa places a vine around the wrist of her infant, she is placing her newborn under the care of her God, the Forest.

Much of the "magic" that we read of in books about primitive people is really their way of admitting that they don't know *all* the answers. It's their way of placing themselves under the care of their God.

Certainly there are many differences in the way people do things, and so to us, other people often seem crude and uncivilized. But before we pass judgment on other people, we should try to discover why they do the things that seem so strange to us.

Marriage and Families

You probably have read about the kings and queens of Europe making political marriages. Thus the King of France might marry the Queen of Austria, whether he knew her before or not. In this way they would link their two countries together. In a sense, any marriage is like this because it links not only two people, but also their families, and often their families' property.

When you're asked about your family, you think first of your parents and your brothers and sisters—those people who live at home with you. But you can stretch out your family a long, long way if you try. Think of your uncles and aunts and cousins; then think of the husbands and

(Continued on the next page)

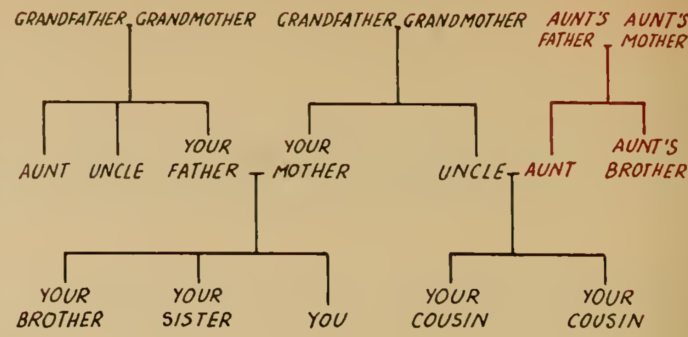
Colin Turnbull has spent several years living with the pygmies of the Congo. He is Assistant Curator of African Ethnology at The American Museum of Natural History.

Nearly all of the people in an African village are related, so the whole village sometimes acts as a family.

INVESTIGATION

HOW LARGE IS YOUR FAMILY?

Try tracing your relatives this way, writing down their names on a chart like the one shown here. Get your parents to help. To make it clear who are your "blood" relatives and who are "in-laws," you can use a different colored pencil for in-laws. You might think about those terms—blood relatives and in-laws—and why we use them. Count up the number of relatives whom you have seen more than four times in the last year. Did you greet them all the same way? Did you do the same things with them? How many have you never seen at all?



wives of your uncles and aunts, and *their* families. And the farther back you go, through grandparents and great grandparents, the bigger your family becomes.

Most Americans don't see any but their closest relatives very often. On the other hand, most Africans are surrounded by relatives all their lives. In an African village or band, most of the people are related somehow, and everyone has to cooperate to keep the people fed and clothed. In the forests of the Congo, for instance, all the able men and women will go out to hunt small game for food. The older people have to stay behind to take care of the young children while their parents are gone. Even if they are not directly related to each other, the children will call them "grandmother" or "grandfather." Not only that, but they will all behave and feel as if they were related.

Different Names for Relatives

The names African people have for their relatives are very important—and often strange. We would think it very odd if someone called his mother's brother "male mother." But this is often done in tribal Africa, just as the father's sister will be called "female father."

After all, everyone in the village or band knows who the real mother and father are. The important thing is to know which members of the family are on the father's side, which are on the mother's side, and to what generation they belong. For in a West African tribe, your mother's brother, like your mother herself, is responsible for your education and upbringing. At the same time, your father's sister, just like your father, has quite different duties. In our society, it doesn't really make any difference if your aunt is your father's sister or your mother's sister—so we use the same name for both.

Here is another example. A common name in Africa for a member of your mother's family is "Person of the Room." The room means the room where you were born, the room of your mother. Just to call someone "Person of the Room" is to ask for all the affection and loyalty you could ask from your real mother.

So we can see that when an African man and woman get married, they are linking together a great number of people into a close knit family. In fact, the whole tribe thinks of itself as a single family, descended from a single ancestor. Probably most members of African tribes *are* related to each other in one way or another, although few members of the tribe could trace all the actual relationships. What is important is that they *believe* themselves to have all come from a common ancestor, and to be the same family. Therefore, they believe that they all have duties to each other, the same way you feel certain duties to your brothers and sisters or your parents.

No Police?

When we think of politics and government, we think of the President of the United States, or of Senators, or kings, or maybe even policemen. Many of the primitive peoples of the world have no kings or policemen. It is easy to think of such people as backward.

But think of it this way: If there is a quarrel in your family, do you call the police or do you try to settle it among yourselves? Even if a member of your family stole something from you, would you rather settle it between you or in a court of law? Would you feel different if it were a close relative, or a distant relative you hardly ever saw? Even in the United States, where we do have policemen and governors and a president, "family" feelings are important in keeping law and order. In the smaller and simpler tribal societies, like those of Africa, family feelings are the most important of all.

Scientists have found that groups of people in different parts of the world live in many different ways. But they have also discovered that these different ways of thinking and acting are simply ways of trying to solve the problems of living that face all members of the Family of Man ■

FOUR WAYS TO A WEDDING

■ Throughout the world, a wedding is celebrated as one of the most joyous occasions in the lives of the families and friends of the bride and groom. But the ways in which weddings are conducted vary quite a bit in different places. In the United States, the bride usually rides to the church in an automobile with her father, who gives her away. The groom gets there as best he can with the aid of his friends. These photographs show how the bride or groom goes to the wedding in four other countries ■

In Korea, a groom wearing a traditional costume travels on horseback from his home to the place where the wedding ceremony is held. All his property, packed in a box, goes with him. He may travel as much as two days.

In this French village, the bride and her father walk 2½ miles from their farm to the church. She must cut a ceremonial ribbon strung across the road before each farmhouse on the way.

In the Kingdom of Nepal, a Hindu groom is carried to his wedding in a traditional sedan chair, with an umbrella to shelter him from the Sun's rays and a band to mark the occasion.

Among the Xhosa, a tribe in South Africa, friends or relatives of the groom "kidnap" the bride and carry her off to the groom after they have made arrangements for the marriage with the bride's parents.

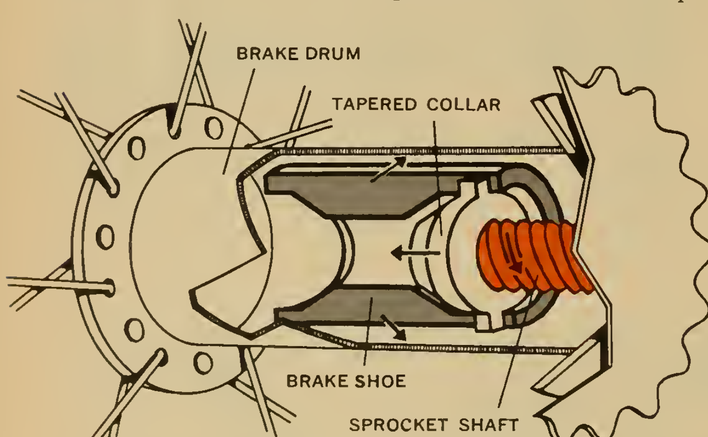
HOW IT WORKS

Brakes

■ What happens when you "jam on your brakes" when you're running fast? You stop, of course. But what makes you stop?

When your shoes plow up the ground or scrape against the hard surface of a playground, *friction* slows you down. Whenever two surfaces rub against each other, friction slows down the moving objects. For example, friction with the air slows down a baseball or a football. The greater the friction, or rubbing, the greater the braking power. Why is it harder to walk on ice than on the pavement?

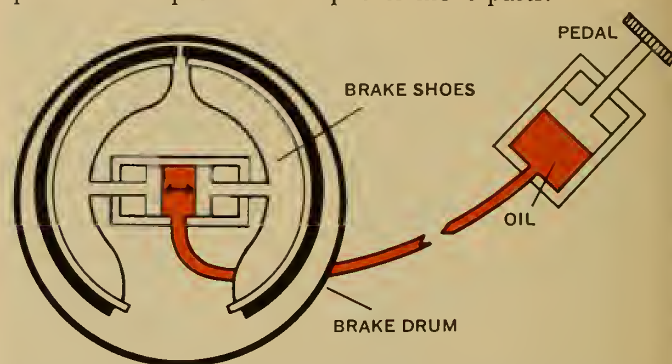
Automobiles, railroad cars, and your bicycle all have brakes that produce friction by making part of a wheel rub against a different object. When someone works the brakes, he pushes the two surfaces together and the wheel stops.



Pushing your bicycle pedal backward turns the rear wheel sprocket and unscrews the tapered collar from a sprocket shaft. The collar moves between the brake shoes (only one is shown) and forces them outward against the brake drum.

Here is how one kind of **bicycle brake** works. Around the rear axle is a metal cylinder called the *brake drum,* which turns with the wheel *(see diagram).* When you push backward on a pedal, you cause two *brake shoes* to push against the inside surface of the brake drum. This produces friction and the wheel either slows down or stops, depending on how hard you push on the pedal.

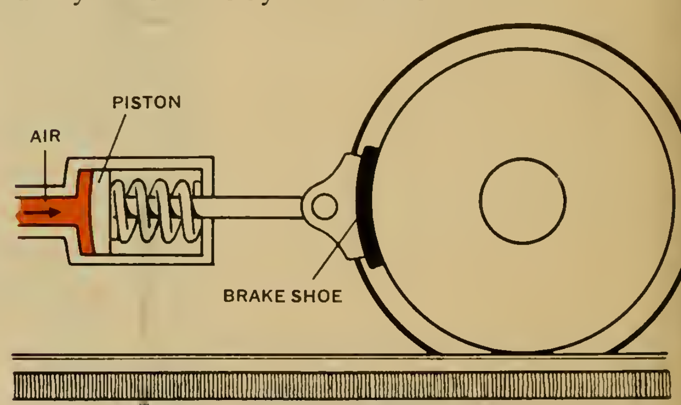
Here is how one kind of **automobile brake** works. The brake pedal pushes a piston into a cylinder filled with oil. This increases pressure on the oil. An oil-filled tube runs from this cylinder to another one near a wheel *(see diagram).* The increase in pressure on the oil in the first cylinder is passed along to the oil in the tube and to the oil in the second cylinder. The pressure in the second cylinder moves two pistons attached to brake shoes. The shoes press against a turning brake drum on the wheel. Friction between the brake shoes and brake drum slows or stops the wheel. This is a *hydraulic* brake system; it depends on the pressure of liquid to move parts.



Pushing an automobile brake pedal puts pressure on oil in a tube. The oil pushes the shoes against the wheel brake drum.

Railroad car brakes, like the "hissing" brakes on buses and large trucks, are operated by air pressure, rather than oil pressure. An increase in air pressure in the tubes and cylinders of the system pushes the brake shoes against the moving surface of the wheel itself *(see diagram).*

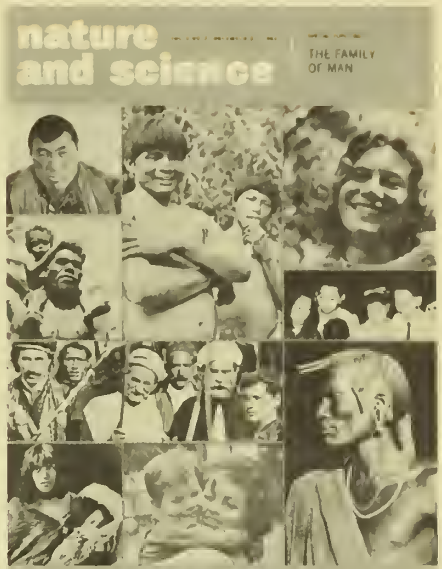
What kind of brakes does your family car have? What kind of brakes does your bicycle have? Do hand brakes on a bicycle work like hydraulic brakes? ■



Compressed air enters a railroad brake cylinder and pushes a piston, which pushes brake shoe against a wheel.

nature and science
TEACHER'S EDITION

VOL. 2 NO. 7 / DECEMBER 21, 1964 / SECTION 1 OF TWO SECTIONS



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

IN THE NEXT ISSUE

(The next issue will reach you about four weeks after this one.)

A Museum scientist studies Orinoco River turtles to help save them from extinction... How to keep and study young turtles... The WALL CHART compares old and new boat designs ... The use of codes and ciphers, for spies and for fun, is explained... Test the effect of gravity on plants with simple equipment and six Coleus plants... A Brain-Boosters quiz on the first seven issues of the school year.

Answers to some questions about
Man's Evolution and Culture

■ There are at least three important questions that your pupils may pose on reading this issue. For added background in dealing with these questions, we present below some quotations from leading anthropologists. The quotations are from books that are non-technical and available in paperback editions *(see list at end of article)*. They are highly recommended to those wishing to pursue the subject further.

> **A NOTE ABOUT THIS ISSUE**
>
> This issue of *Nature and Science* is devoted almost entirely to the science of anthropology—the study of man and his work—explained, we hope, in terms that will open up new vistas for your pupils.
>
> The subject matter is delicate, and you may want to read the magazine and plan your classroom discussion of it with special care before giving it to your pupils.
>
> We have attempted to show that anthropology is an ongoing study *of* man *by* man. It has no final answers. Rather it progresses, like any science, toward improved understanding and further questions.
>
> If your pupils pose questions that you find difficult to answer, you may find that by posing further questions of your own your role as a teacher will be best fulfilled.
>
> —THE EDITORS

Did Man Evolve from the Apes?

"No anthropologist today holds that man 'descended from an ape'—if by 'ape' is meant any of the living forms of such animals: gorilla, chimpanzee, orangutan, or gibbon. But all do agree that contemporary men *and* apes *and* monkeys (Old World and New World) evolved from the same general *anthropoid* mammal, and this belief is based not only on similarities of form and behavior, but also on scores of extinct but overwhelmingly corroborative 'missing links' discovered in datable geological settings. . . .

"In the view of some specialists, *hominoids* evolved from the anthropoid line in the Miocene geological epoch, some 20 million years ago, thereby diverging from the lines that eventually evolved into Old and New World monkeys. Then, . . . the *hominoids* became differentiated into *hominids* and *pongids*, the former leading toward man and the latter toward today's apes. . . . There cannot have been large numbers of [hominids]—one specialist's guess is that they numbered no more than a million—and because of their subsistence technology it is not unlikely that they were scattered about in small nomadic bands. And of course we have no way of guessing the nature of their languages, their social structures, or their views of the universe.

"In any event, it seems quite clear that these hominids, despite their small brains, were well along the road to the condition we call 'human'."

—DOUGLAS L. OLIVER, *Professor of Anthropology, Harvard University*

What Makes a Human?

"Man has been set apart from the other animals by his upright posture and highly developed brain. He has been distinguished as the creature that laughs, speaks, or thinks. He has also been described as the creature that has a culture. These attributes are all true, some at least in degree, but perhaps the fundamental fact that makes most of them possible and certainly sustains all of them is the technology that has become so much a part of man that it is virtually impossible to conceive of him without it.

"The simple ability to use tools is perhaps not a completely exclusive faculty of man. Apes are known to use sticks or boxes to attain a goal. But no other animal has employed tools so persistently as even primitive man has done, and it is only among man's closest primate relatives that anything like this propensity appears. But man not only uses stray objects as tools—as extensions of his arms and hands—but he makes them artfully and, in the course of human evolution, with increasing skill and variety. The purposeful chipping of a crude fist axe...

(Continued on page 2T)

Man's Evolution and Culture
(Continued from page 1T)

or even of the simpler pebble tool, is already far beyond the demonstrable capacity of any animal including the apes. And no other animal except man has shown the slightest ability to build on past achievement and to develop the accumulation of technology that culture and civilization represent."

—HARRY L. SHAPIRO, *Chairman, Department of Anthropology, The American Museum of Natural History*

What Is Culture?

"Culture is all those things that are *not* inherited biologically. It consists of everything that has ever been accepted as a way of doing or thinking, and so taught by one person to another. Because that is how it is passed on, and—this is vital—that is how it can change and grow so readily. It is the entire knowledge, and patterning of behavior, which humans have, and of course it must be taught and learned for the very reason that it is not inborn.

• • •

"A digging stick of a particular kind, for digging up wild vegetables for food, is culture. So is . . . the idea of marriage. . . . Gibbons pair off permanently for mating. But there is a distinction. Different gibbon societies have no choice in the matter; their kind of mating is all the same because it is entirely controlled by biology instead of biology plus convention; it is in their natures. That is why their monogamy cannot be compared with human monogamy, and why their mating is not marriage. . . . As for sticks, chimpanzees can use them in ways of their own devising, and even fashion them. . . . But this actually happens at random. It is not created, maintained, handed on, and understood, as a regular prop of chimpanzee life."

—WILLIAM HOWELLS, *Chairman, Department of Anthropology, Harvard University*

Sources of Quotations:

Invitation to Anthropology, by Douglas L. Oliver, The Natural History Press, Garden City, N.Y., 1964, 95 cents.

Man, Culture, and Society, edited by Harry L. Shapiro, Oxford University Press, New York, 1960, $2.25.

Back of History, by William Howells, revised edition 1963, Doubleday Anchor Books, Garden City, N.Y., $1.45 ■

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 The First Man

This article describes the highlights in man's search for knowledge about his prehistoric beginning. Your pupils will see that there are still many gaps in our knowledge.

Although evolutionary concepts are well established in the modern world, some people have difficulty accepting these concepts. There is perhaps no way to resolve this dilemma. However, you may find the following suggestions helpful.

1. Suggest to the child that people search to find explanations for the origin of the universe and life on Earth. In their search, different people have come up with different answers. The story of evolution is the scientist's answer, based on evidence of the *physical* world.

2. Invite the child to ask his parents and religious advisor for their views, and to consult books he respects.

3. To avoid disrupting the rest of the class, defer further discussion to a later time when you can talk in private with anyone who may be troubled by some of the ideas in this issue.

Topics for Class Discussion

In addition to the questions discussed in the article beginning on page 1T, you may wish to bring up the following points:

• *Why aren't scientists able to tell for sure exactly how man evolved?* Bring out that these investigations deal with developments that took place before recorded history — which goes back only 7,000 years. There are no books or other writings to consult. Also, fossils of early men are scarce, partly because the population of early men was small. Anthropologists can learn a great deal from fossil bones and skulls, but there is still much to learn.

• *What is a "missing link"?* A popular misunderstanding of human evolution is that there is a single "missing link" between *Homo sapiens* and ape-like men. Actually there are many "missing links" in the chain of man's evolution, and in the evolution of other organisms. A "missing link" can be any species or genus necessary to relate one fossil to another.

Activity

From a meat market, obtain the foreleg shank bones of various animals, such as a steer, a calf, a lamb, and a pig. Make sure the butcher knows they are for science, not soup, so he doesn't mutilate them. Boil away the remnants of meat and let the class examine the clean bones for differences and similarities.

PAGE 8 Evolution of Man

This WALL CHART shows the main lines in the development of primates. Your pupils should notice that the monkeys branched off long before the development of man-apes. The chart will help your pupils to see that no *living* member of the apes or monkeys is man's ancestor, a common misinterpretation of evolution. Remind them that the lines of evolution shown in the chart continue to change as new discoveries are made. This simplified view of primate evolution has omitted many side branches and twigs of the primate family tree.

Use the time scale at the bottom of the chart to point out the relatively short time that humans have existed. How thin a line would represent the 7,000 years of recorded history?

Discuss the physical characteristics that the higher primates have in common. Important ones are a large brain, front-facing eyes set in socket of bone, a hand with grasping fingers and opposable thumb, and eye-hand coordination.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition wth single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE & SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue...
(continued from page 2T)

PAGE 10 Fins to Fingers

This article illustrates the important concept that living things adapt to their environment. Modern man survives, not by further bodily adaptations, but by using his brain and hands to make what he needs. The earlier theory that the species *Homo sapiens* was the first to use tools has given way to the modern understanding that the use of tools by man-apes led to *Homo sapiens.* The relationship of the use of tools and *Homo sapiens* is more precisely described as an *interaction* rather than direct cause-and-effect.

Topics for Class Discussion

- *How many things can you do with a stone?* Children are apt to think of tools in terms of hardware store items. Actually, stones can be used for many jobs that specialized tools now do—pounding, cutting, scraping, grinding, spearing meat, as well as killing and wounding.
- *Are hands a kind of tool?* Yes. Have your pupils think of ways they have used their hands when no tools were available, such as hammering, unscrewing jar tops, using their nails as picks and screwdrivers, and so on.
- *Has man stopped evolving?* Scientists feel certain that man is now, and will continue evolving, but they cannot be sure what the changes will be. While laymen often speculate on what's to become of our stomach or teeth or legs due to changes in our habits of eating and locomotion, scientists rarely make any predictions.

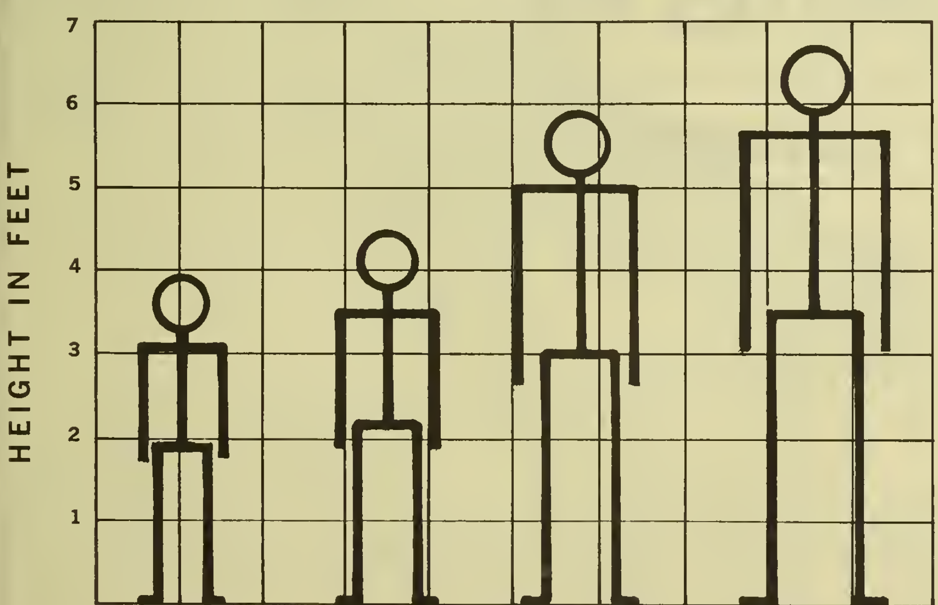
PAGE 11 Growing Up

Most children, by the age of nine, ten, or eleven, are probably familiar with the idea of their own growth taking place in spurts, having heard the family doctor or visiting relatives comment on it. The article brings out that it is quite normal to expect different rates of growth in different parts of the body and in different individuals. It is also quite normal for whole groups of people to have unique growth patterns. This awareness should help your pupils face the perplexing changes in their own preadolescent development with some equanimity.

Activity

Have the children measure themselves and the members of their families, noting the length of the head and torso as well as overall height. With rulers or graph paper, let each draw his family's body proportions to scale. Stick figures will suffice (*see diagram*). They should be drawn in order, beginning with the youngest member, and labeled with the size and age of each member. Make sure each child uses the same scale.

A bulletin board display of the drawings should show quite a variety among families, yet bear out the basic pattern of change from babyhood to adulthood.



Your pupils can measure themselves and their families, then record their findings on graph paper. Be sure to have them label the sex and age of each family member.

PAGE 13 Other People

This article will also have the effect of making your pupils look at *themselves*—this time in relation to the role of the family. Future generations of mankind will face many problems of living, and many anthropologists feel that only by understanding ourselves better will people be able to solve these problems.

If your pupils come to think of themselves and people round the world as members of a vast human family in which there is unity among diversity, they will have a good start.

Suggestions for Classroom Use

Hopefully, all readers will participate in the suggested activity of tracing one's family tree. By contrasting aspects of the role of the family in tribal Africa with their own, many insights into American life will be gained.

Most children in a class probably will have a small family—parents and children—in the home, with relatives spread out around the country. Many will have self-supporting grandparents. What does this tell them about American society? It is mobile, for one. Children, upon growing up and marrying, often move elsewhere and fend for themselves. You might try to arrive at an average family size for the class and explore the roles which each member plays. What do fathers do? Mothers? What jobs or obligations do children have? Do parents or the rest of the family teach children anything? Who sees about religious training?

It is equally important to stress the underlying similarities that may emerge from a study of this kind. For example, the protective relationship of mothers to their babies, the expression of some kind of family pride (though we extend it to include club, school, and nation), cooperation to get things done, education of the young, and some way of keeping law and order.

References

- Your pupils can learn much from this classic collection of photographs from all over the world: *The Family of Man,* compiled by Edward Steichen, Maco Magazine Corp., New York, 1955, $1.50 (paperbound).

One Project for Introducing Anthropology into the Elementary School Curriculum

by Wilfrid C. Bailey

(Reports about new approaches to science teaching are published for your information and do not necessarily imply endorsement of these approaches by N&S *or The American Museum of Natural History.)*

■ Recent improvements in the content of natural sciences, mathematics, and foreign language curriculums have impelled elementary school curriculum builders to take a new look at social studies as a purveyor of knowledge. In other words, it is not enough just to teach about Indians and to learn about wigwams and teepees. Teachers now want to have these bits of knowledge add up to something and convey certain concepts about mankind. Children are able to grasp more of this sort of thing than we are used to giving them credit for.

Projects for developing ways of meeting these needs have been established at a number of educational institutions. The University of Georgia, for one, has set up a project (financed through a grant from the U.S. Department of Education) to develop a sequential curriculum in anthropology for grades 1-7.

The Georgia Anthropology Curriculum Center is working on units requiring 20 to 25 classroom days that can be introduced at some convenient point in an existing social studies program. The theory is that this would be the least disruptive to an already crowded overall curriculum.

Bridging Natural and Social Sciences

Participants in the project also believe that the content and methods of anthropology can help teachers to bridge the natural and social sciences and can provide unifying concepts for the study of history, geography and the behavioral sciences.

Two types of material will be produced for the units—those for the use of the pupil and those for the teachers. At the first grade level, the bulk will be for the teachers but the materials for the pupil will increase with each grade level.

Achievement tests will be prepared to verify the stability of the materials as measured by transmission of knowledge and conceptualization. The materials will then be revised on the basis of the test results and teacher feedback and prepared for final editing and publication.

The units will be tried in schools that have agreed to use the materials for the five years the project will run. The cooperating school teachers will consist of two groups: those who receive systematic instruction in the yearly anthropology institute and those who do not receive such training. The purpose of this is to test the degree to which such training is necessary in order to use the units.

In order to increase effectiveness of our work at the Georgia Anthropology Curriculum Center, in Athens, Ga., we would like to hear of your experience and problems in teaching anthropology in elementary grades ■

Dr. Wilfrid C. Bailey is a Professor of Anthropology at the University of Georgia and co-Director of the Georgia Anthropology Curriculum Center.

nature and science

VOL. 2 NO. 8 / JANUARY 18, 1965

Can scientists save the Arrau river turtle from being wiped out?

see page 3

"DEATH RACE" OF THE ARRAU

HOW TO "FLY" A BOAT/ see page 2

ABOUT THE COVER

The boat shown above with "wings" outstretched is the same boat you saw speeding over the water in the photograph on the cover of this issue. The "wings" are called *hydrofoils,* and a third one is attached to a long rudder and propeller shaft at the back end of the boat.

Hydrofoils do not carry the boat through the air as an airplane wing does. Instead, they are all swung down into the water as the boat gets under way. As the boat picks up speed, the underwater wings rise upward in the water in the same way that an airplane wing rises in the air, and they lift the boat about five feet above the surface.

This boat, the *Denison,* was built by the Grumman Aircraft Engineering Corporation at Bethpage, New York. It is one of the largest hydrofoil boats in the United States. The *Denison* is 104 feet long, weighs 95 tons, and could carry 80 persons. A gas turbine engine drives the boat at speeds of 70 miles an hour or more, and it can travel over waves that are 10 feet high.

The hydrofoil boat is one of several shapes that scientists and engineers have devised to make boats go faster in and over the water. These shapes, and how they work, are shown in the WALL CHART on pages 8 and 9.

nature and science

VOL. 2 NO. 8 / JANUARY 18, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; **SENIOR EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** David Whieldon; **EDITORIAL ASSISTANT** Linda Britton; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Don Cailliez **CONSULTING EDITOR** Roy A. Gallant

PUBLISHER Richard K. Winslow

CIRCULATION DIRECTOR J. D. Broderick; **SUBSCRIPTION SERVICE** Charles Moore

Contents

CREDITS: Cover, pp. 2, 9, hydrofoil photos from Grumman Aircraft Engineering Corporation; pp. 3, 4, 5, photos from Janis Roze; pp. 4, 8, 9, 10, 11, 13, 14, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 6, 7, drawings by R. G. Bryant; p. 8, hovercraft photo from Bell Aerosystems Co., submarine photo from Electric Boat Division, General Dynamics Corporation; p. 9, test tank photo from Stevens Institute of Technology; p. 14, snow photo by Laurence Pringle, skeletons photo from AMNH; p. 15, X-rays by Peter Bent Brigham Hospital, from Educational Services Incorporated, mealworm photo by Mrs. Carroll Williams, from ESI.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE. The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

"DEATH RACE" OF THE ARRAU

by Janis A. Roze

Our expedition to South America to learn about these fascinating river turtles revealed as much about how they die as about how they live.

■ When we woke up and rolled out of our jungle hammocks, there in the dawn light was the rare event we had traveled so far to see. The shore of our island was covered with hundreds of black, shiny bodies—South American river turtles. We were delighted to see them, for the turtles were the reason for our expedition to the central Orinoco River in Venezuela *(see map on the next page).*

There were 10 of us, including five scientists from the Central University of Venezuela. Months ago, back at the University in Caracas (Caracas is the capital of Venezuela), we had carefully prepared equipment, instruments, food, and other needs for the trip. Our aim was to reach some of the small islands in the central Orinoco River. Once on these islands we would be able to study the large turtles which the Venezuelan Indians call *Arrau.* The scientific name for these turtles is *Podocnemis expansa.*

The Arrau is the largest fresh-water turtle in the New World. The females grow to about two feet long and weigh about 50 pounds. The males are a bit smaller. These turtles live in the Orinoco River and its tributaries. In November thousands of them migrate from all parts of the river to a few beaches where they lay their eggs.

I became interested in the Arrau about five years ago. As head of the Zoology Department at the Central University, I had heard reports that the Arrau were gradually disappearing. It seemed that fishermen were catching too many of them. Hundreds of Venezuelan fishermen depend on the turtles for food and money.

I wanted to find out if the Arrau could be saved. The best way to learn about the turtles is to study them in their natural surroundings. In this way we discover all we need to know about the place and conditions in which they live.

We left Caracas in early January and drove south for three days until we reached the Orinoco River near the border between Venezuela and Colombia. Then we loaded our equipment into boats and traveled four hours or so down river. We made camp on Cuba Island *(see map).* The island is about five miles long and two miles wide. Its beach is an important site for Arrau egg-laying.

(Continued on the next page)

"Death Race" of the Arrau (continued)

From our camp, we had to walk a mile or so to reach the beach where the turtles would gather. We could scan several miles of the shore with telescopes. After our camp was set up, all we could do was wait for the turtles to arrive.

The Long Journey of the Arrau

There is no winter in the tropics, so the rivers never freeze, but there are rainy and dry seasons. When it rains, the Orinoco and the smaller rivers flowing into it swell and overrun their banks, flooding the nearby land. The Arrau roam all over the flooded areas, eating fruits, roots, and flowers. When the dry season begins in November, the flood water slowly retreats and the turtles swim toward the main stream of the Orinoco and to their island breeding grounds. The journey is a long one, taking days or several weeks.

Although the beginning of the dry season varies from year to year, the first turtles usually appear on the island shores during the second half of January. The males arrive first, and the females a few days later. After mating, the males disappear, probably returning to other parts of the river. The females begin basking in the sunlight at the water's edge. They seem to need the hot sunshine for the development of their eggs.

Sometimes we could see several thousand Arrau along the edge of the beach. We could also see hundreds of turtle heads sticking out of the water, looking for a free spot to bask. Day after day we watched them through our telescopes, counting them and studying their behavior.

How To Look Like a Turtle

The female turtles basked in the sun for about a month. Then one night a group of them began crawling toward the highest parts of the beach. Their egg-laying was about to begin. When the females reached the dry sand, we could hear them in the darkness for hundreds of yards. Each step made a peculiar "gurc-gurc" sound in the sand.

We sneaked down to the beach to learn more about the egg-laying. We could see hundreds of turtles. They crawled clumsily, from time to time flipping sand onto their backs. However, we soon found that the turtles could also see us in the darkness. They turned around and ran back to the water. Next we tried creeping on our hands and knees, but that didn't work either. They were still afraid of us and again retreated to the water. Eventually, we learned that the best way to move among the turtles was to drag ourselves along on our bellies.

We started moving around exactly as they did. When a female approached us, we even flipped sand onto our backs as they did. It worked. By the third or fourth night, we could pass for a fellow turtle without any trouble. It was only then that we were able to study their egg-laying.

After a female selects a nesting site, she starts digging a hole about two feet wide and two feet deep. She uses all four feet to dig. The digging is a long, difficult job because the soft, sandy walls cave in easily as the hole gets deeper. After almost an hour of steady work, the hole is nearly ready. To finish it, the turtle uses her hind legs to dig a small hole, or "nest" at the bottom of the big hole.

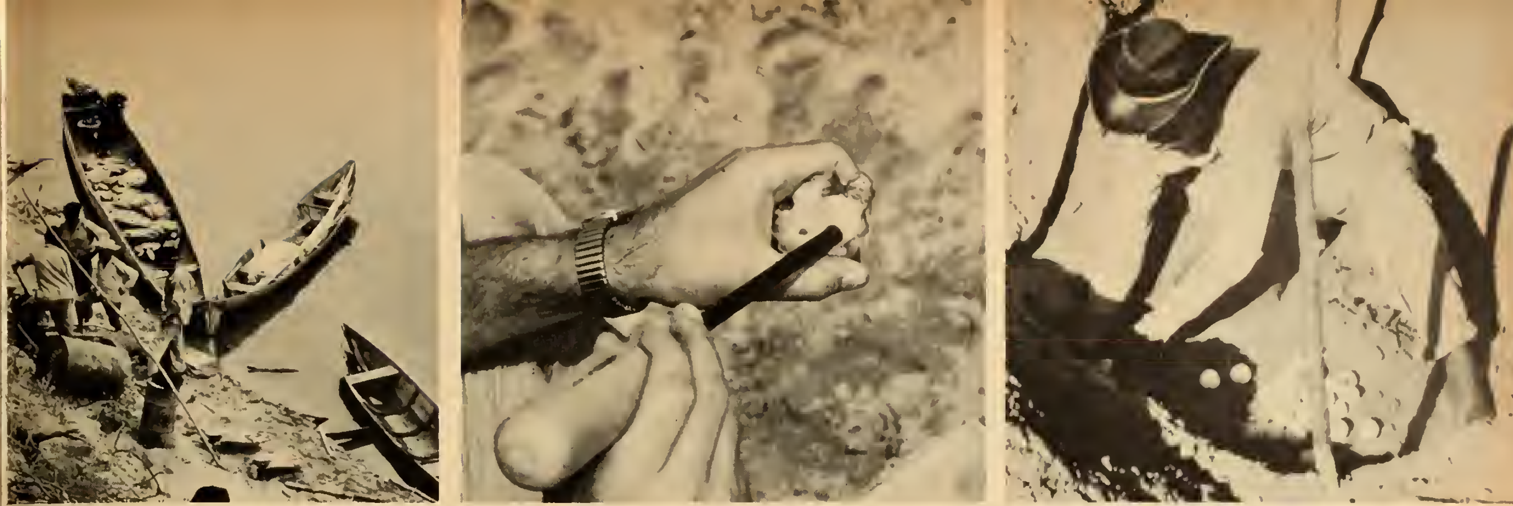
Without lifting her body, she starts to lay her eggs in the small hole. Some large females lay as many as 150 eggs, although the usual number is about 80. The small turtles lay only about 45 eggs. Once a turtle starts to lay her eggs, she is not afraid of anything. We could move around freely and even touch the turtles. We put our hands into the nests to find out exactly how the turtles use their tails to spread the eggs evenly in the nest.

When the last egg is laid, the female carefully covers the nest and the large hole with sand. Again, it is exhausting work, and when she is finished she hardly has enough strength to crawl back to the river.

The Race with Death

By mid-April, all of the females have finished laying their eggs and begin to migrate back to their home area.

This female turtle has almost completed the nest hole where she will lay her eggs. After laying about 80 eggs, she covers them with sand and returns to the river.



Fishermen catch thousands of female turtles and take them to markets in boats (left). In order to learn more about the turtles, scientists put identity marks on young ones (center) and let them go to find out where they travel and how fast they grow. The scientists also dig up turtle nests to study the eggs (right).

The beach is abandoned and lifeless. However, three feet beneath the surface are millions of turtle eggs developing. After 45 days the eggs hatch. The young turtles cut through the protective eggshell and then struggle upward through the sand. By day the hot, tropical Sun heats the surface sand, sometimes to 130°F. The young turtles wait until late at night or early in the morning, when the sand cools a little, before they break out at the surface. Sometimes the first showers of the rainy season cool the sand.

Once on the surface, the young turtles start racing downhill to reach the water. However, waiting on the beach are many birds—such as vultures, storks, and soldier birds—which feast on the young turtles. A large bird can gulp down as many as 32 whole young turtles, and there are hundreds of birds on the beach. The smaller birds catch the hatchlings and pick out the heads and legs, leaving the shells. Soon the beach is covered with thousands of empty turtle shells.

The "death race" is not over when the young reach the water. Crocodiles, caimans (a kind of crocodile), and many fishes also feed on them. One crocodile we cut open had nearly 50 turtles in its stomach. Only when the young turtles reach deep waters are they safe. Sometimes only one out of 10 escapes death and disappears into the river.

In certain years, many of the eggs do not hatch. In 1963, the rainy season began early and the flood waters killed millions of eggs and young turtles still in their nests.

You may wonder why the Arrau have not all died out long ago. In view of their high death rate, how have they survived? Scientists have found that animals that are preyed upon a lot by other animals produce many, many young. Because of their great numbers, enough of the young survive so that the species carries on. Even if nine out of ten young turtles are killed, the female turtles all together lay so many eggs that some young are bound to live and grow to be adults.

It is not the crocodiles, caimans, storks, vultures, soldier birds, and other animals that threaten to kill off the Arrau. It is man.

How the Turtle Raiders Work

Hundreds of years ago, explorers of South America saw the Arrau and described that they were seen in great numbers. Baron von Humboldt, a German explorer-naturalist, traveled up the Orinoco in 1800 and saw about 130,000 nests on one beach alone. Historians also mention the Arrau "with thousands of females producing millions of eggs." But this is in the past.

Since some mysterious instinct, which we do not yet understand, makes the Arrau return to the same beaches each year, the local fishermen know just when to expect them. They wait until the females crawl onto the beach at night. Then they rush among them, overturning all of the turtles they can find. Once they are flipped onto their backs, the turtles are helpless and cannot right themselves. When there are no more turtles to be turned over, the fishermen collect the helpless animals and carry them to the opposite shore of the island where boats are waiting to carry the catch to local markets. It is a custom in many Venezuelan families to eat a dish of turtle meat or turtle eggs (from inside the female turtles) during Easter Week.

Fishermen on a turtle raid may catch more than a thousand females in one night. Most of these turtles have not been able to lay their eggs. With more and better motorboats available to carry the turtles to new markets, the fishermen have tried to catch more and more of the animals. Each year, the number of females returning to the beaches drops lower and lower.

In 1962, we figured that there were only about 30,000 to 40,000 nests on one of the beaches where the turtles gather. There are just four main beaches. We estimate that

(Continued on the next page)

These young turtles are being let go after the author marked them. Dr. Roze is now studying coral snakes at The American Museum of Natural History in New York City. He lives in New York with his wife and three children.

"Death Race" of the Arrau (continued)

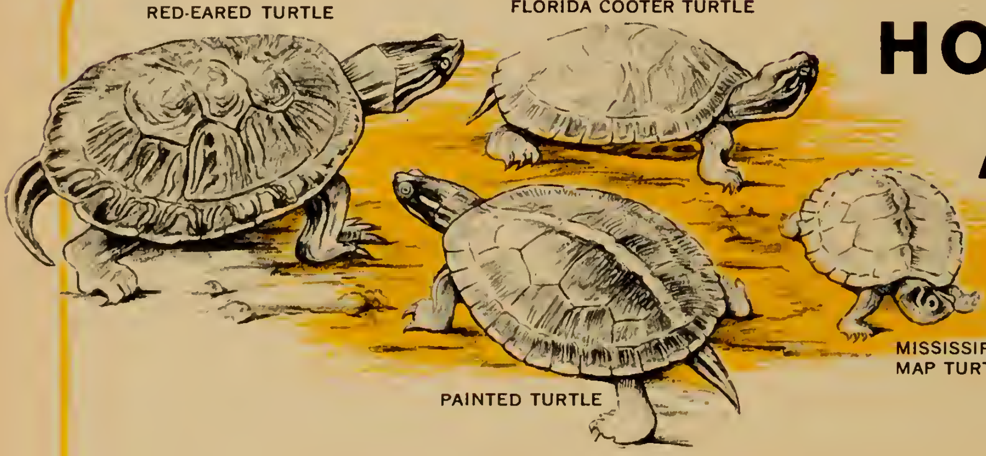
there are a little less than 200,000 female turtles left. In the past three years, the fishermen have caught about 10,000 females a year, and their numbers are steadily dwindling.

When we sent a report about the Arrau to the Venezuelan government, a law was passed to protect the turtles from hunting for five years. The government also gave us money for a five-year study of the Arrau, beginning in 1961. Since the fishermen along the Orinoco depend on the turtles for food and money, the government leaders hope that we can discover how to keep the turtles from dying out and still allow the fishermen to catch some of them. Perhaps we can put a limit on the number of turtles the fishermen can take each year. We can also protect the young turtles from the "death race" by killing some of the animals that eat them, and by carrying them by boat to areas where the predators are not so plentiful.

We have studied not only the Arrau themselves, but also their *environment*—all of the conditions which affect the animal. While on Cuba Island, we took measurements of the amount of sunlight, the speed and direction of the wind, and the temperature of the air, sand, and water. At the same time, we watched the turtles to see how these weather conditions affected their activities.

We also measured and marked adult and young turtles, then let them go. If a marked turtle is recaptured, we can find out how far it traveled from the beach, and how much it has grown. So far, we have found that some females travel about 100 miles to reach a nesting site. Also, females keep returning to the same beach, year after year.

There are still many unanswered questions about the lives of the Arrau. For example, how long does it take for a young turtle to grow into an adult? Why do the females lay their eggs only on certain beaches? The answers to questions like these may help us save the Arrau ■



HOW TO KEEP AND STUDY YOUNG TURTLES

■ Young turtles are harmless, fascinating animals that you can easily care for and study. You can buy them from pet shops or variety stores. Most young turtles sold as pets are either Red-eared Turtles or Mississippi Map Turtles, but they may be any of a dozen or more kinds. The proprietor of a pet shop may be able to help you identify yours. (For books on turtle identification and care, see the list at the end of this article.)

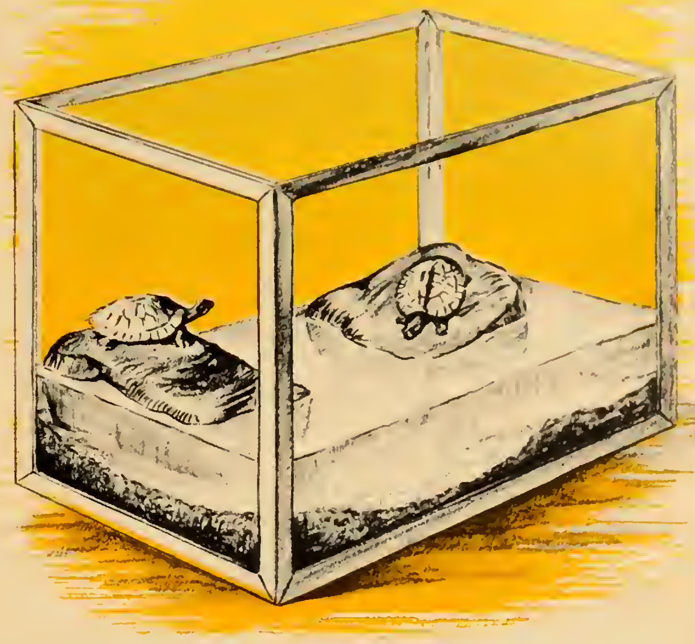
A small aquarium is an ideal turtle home, and a five-gallon aquarium is big enough for about a half dozen young turtles. Although many turtles spend most of their lives in water, they need to climb out onto dry land once in a while. One way to give your turtles both land and water is to put rocks or pieces of wood into the aquarium. Make sure that the rocks are close-grained, without sharp edges that will cause sores on the turtles' lower shells. You can also make a sloping beach of sand for the turtles to crawl onto, but sand is hard to keep clean.

Turtles often sun themselves. However, window ledges are often drafty in winter and very hot in summer. For a "Sun," set a gooseneck lamp near the aquarium. This will also help warm the water. If the water temperature goes below 70 degrees Fahrenheit, turtles are likely to become sluggish and refuse to eat. A temperature of from 75 to 80 degrees is ideal for most kinds of turtles.

Many of the thousands of young turtles sold each year die from neglect, and the most common cause of death is starvation. Be sure to feed your turtles well. They should be fed three or four times a week, with fresh raw hamburger, raw chopped fish, or chopped earthworms. Most turtles eat some plants, so fruits and lettuce should be fed to them occasionally. A little powdered calcium (from a drug store) should be mixed with their food once in a while. It helps the growth of the turtles' bones and shells.

Raw meat can make a mess in an aquarium, so remove any uneaten food after letting the turtles feed for about an hour. Whenever the water gets dirty, replace it with clean water of about the same temperature. Incidentally, many turtles can eat only underwater, so there should be at least an inch of water in the aquarium.

The best way to tell whether a young turtle is receiving a good diet is to observe its growth. Weigh and measure it every two weeks or so. A healthy, well-fed turtle may double its size in a year.



Keep your turtles in an aquarium that has at least an inch of water in it. Turtles must have some smooth stones to climb onto, and you may have to set a lamp nearby to keep the water temperature near 75 degrees F.

Studying Your Turtles

Once your turtles are established in an aquarium, you can begin to study them. For example, how does a turtle swim? Does it use its tail? How are its feet used? Can a turtle swim backward?

Here are some other ways that you can investigate the lives of turtles:

1. Turtles are cold-blooded animals, which means that their body temperature is near the temperature of their surroundings. You can use a thermometer and some ice water to observe the effect of cold temperatures on turtles.

Put a turtle into a jar or other container with water that is fairly warm—about 75 to 80 degrees Fahrenheit. The water should be deep enough for the turtle to put its nose above the surface while standing on the bottom. Measure the temperature of the water with the thermometer. Then count the number of times that the turtle comes to the surface for air in a half-hour. Keep notes of your findings.

Remove about half of the water and replace it with ice water so that the temperature is about 50 degrees. Count the number of times the turtle comes to the surface for air at this new temperature. Does the turtle breathe faster or slower at the low temperature? In what other ways does the cold water affect the turtle's behavior?

2. If you have several turtles of the same kind, you can compare their growth while feeding them different foods. First, divide your turtles into two groups. To tell them apart, file a mark on the edge of the upper shell, or *carapace*, of the turtles in one group. Leave the other turtles unmarked.

Feed the turtles in two different feeding pans. One group should be fed hamburger, lettuce, and fruit. Feed the other group "turtle food" which you can buy from a pet shop or variety store. Weigh the turtles every two or three weeks and find the average weight of each group. Keep a record of your findings. Which group grows the fastest? Which food is better for your turtles?

3. Does color influence the turtles' choice of food? Try offering your turtles hamburger colored with vegetable dye. Do they prefer certain colors?—ALAN MARK FLETCHER

To identify turtles, see the Golden Nature Guide, **Reptiles and Amphibians,** by Herbert Zim and Hobart Smith, Golden Press, New York, 1953, $1; a useful pamphlet on turtles and their care is **The Care of Pet Turtles,** by H. G. Dowling and S. Spencook, New York Zoological Society, New York, 1960, 25 cents.

MOVING BOATS FASTER... IN AND OVER THE WATER

■ Ever since a man first crossed a stream by sitting on a floating log and paddling with his hands, people have been trying to make boats go faster. One way was to push the boat through the water with greater force. This was done with oars, sails, then engine-driven paddlewheels and propellers. Another way was to reduce the *friction* that holds the boat back as it moves through the water.

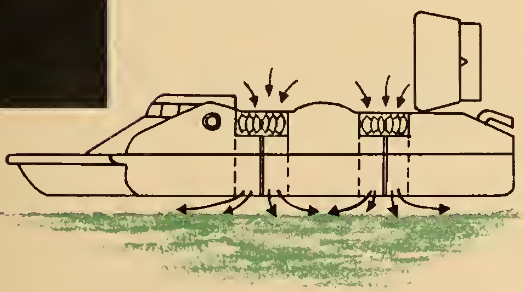
Tiny particles of water form a "skin" on the *hull*, or body, of a moving boat. The rubbing of these particles against the particles of water flowing by the hull creates *skin friction*. As the front of the boat moves through the water it makes waves, and other waves are made at the back end of the boat where the water closes in again. Submarines, as well as surface craft, are held back by *wave friction*.

The larger the area of a boat's hull, and the faster it is moving through the water, the greater the friction. You can test this by pushing your hand through water in a tub. Push with your fingers only, then with your whole hand—first slowly, then rapidly.

This WALL CHART shows some of the new boat shapes that engineers have devised to overcome friction and make boats move faster in and over water ■

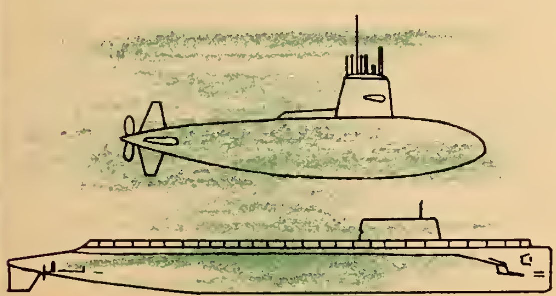
A HOVERCRAFT, or air-cushion vehicle, rides above the water instead of through it, without touching the water. It glides on a cushion of air that is supplied by large fans (see *diagram below*). Propellers mounted on top of the craft drive it forward. Hovercraft can travel over land as well as water.

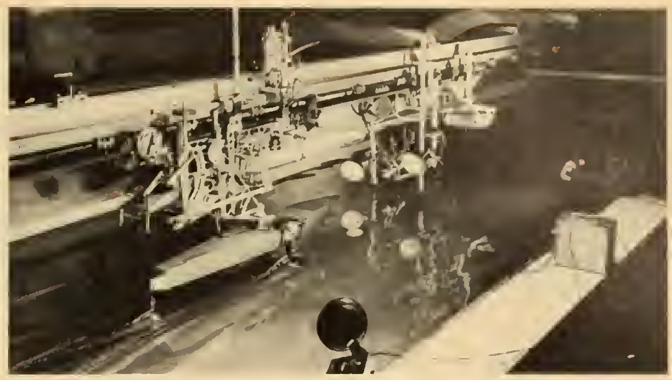
LARGE FANS draw air from above the hovercraft and force the air out through openings in the bottom. The air presses downward against the water just enough to keep the craft one to three feet above the surface. When the fans stop, the hovercraft settles down in the water and floats.



SUBMARINES like the U.S.S. Skipjack (shown at left as it was being launched) can move faster underwater than most ships can go on the surface. Because of its shape (see *diagram below*) its nuclear-powered engines can push it through the water at speeds that may reach 50 miles per hour.

THE SKIPJACK (below, top) is shaped something like a football so that water flows around it without forming waves at the front and back ends. Earlier submarines, even the nuclear-powered U.S.S. Triton (below, bottom), are shaped more like surface ships. The faster they go, the more wave friction tends to hold them back and waste their driving power.

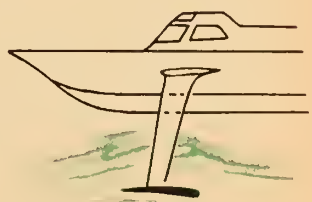




MODEL SHIPS are towed through large tanks of water like this one to test how much friction holds them back at different speeds. Engineers can then predict how a full-size ship of the same shape will move at different speeds.

A HYDROFOIL BOAT (above) has a hydrofoil, or "wing," on each side, and one at the rear with a large propeller and rudder attached. The hydrofoils are lowered into the water for high-speed travel (see cover).

THE "WING" of a hydrofoil is shaped like an airplane wing, bulging more on top than at the bottom (see solid black area in diagram at right). The water that flows along the top bulge travels farther—and therefore faster—than the water that flows along the bottom bulge in the same period of time. The faster moving water does not push down on the wing as strongly as the slower moving water pushes upward, so the hydrofoil rises in the water, lifting the boat.



SREHPIC

Secret codes and ciphers have fascinated men for centuries. This article tells a little bit about them, and shows you how to invent codes and ciphers.

■ For as long as men have been able to write, they have used secret writing to send messages intended to be read only by one other person, or by a select few. Yet, some experts say that for every man who is clever enough to invent a system of secret writing, there is another man, somewhere, who is clever enough to "break," or unscramble, the message and read it.

Writing in Codes

There are two main methods of secret writing—*codes* and *ciphers*. Although many people use the two words loosely, codes are quite different from ciphers. A *code* is simply a special dictionary in which each word is represented by a group of letters, usually five. For example, the word COME could be represented by the letter group MFGTY. The message COME HERE QUICKLY might come out in code as MFGTY BNHYU LKJUV.

The person who receives the message must also have a copy of the dictionary, or code book, if he is to decode and understand the message. All he would have to do to decode the message is turn to that part of his code book in which the code words are listed alphabetically:

BNHYU	HERE
LKJUV	QUICKLY
MFGTY	COME

If a code book ever falls into the hands of someone who is not supposed to have it, that code is worthless and it is time to invent a new one. There have been times in history when codes have been broken, or read, without the capture of the code book.

The most famous example is that of Herbert O. Yardley, chief of the American Code Breaking Bureau. In 1920 he was given the job of breaking Japanese diplomatic codes. A group of typists worked for four months straight just to make lists of word parts, or *syllables,* found in ordinary Japanese telegrams. Yardley wanted to find out which syllables were used more than others. When the typists finished, they had lists of 10,000 syllables. It took about the same length of time to count and index 10,000 Japanese code groups. He compared the most common syllables in the telegrams with the most common code groups. One by one he figured out the meaning of the code groups and within a year he had broken the difficult Japanese code.

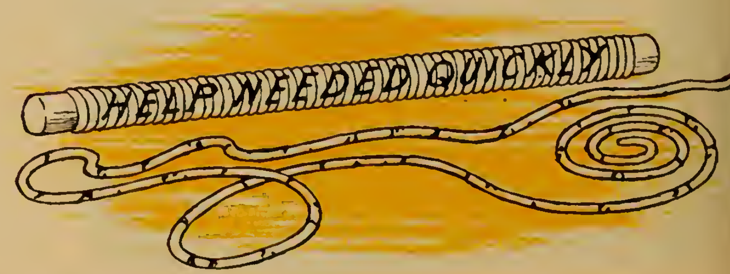
Today's code-breaking experts use electronic computers. These machines can do in days the sorting and counting of code groups and syllables that used to take months to do. The best method of "breaking" a code, however, is to get the user's code books without his knowing or suspecting it. If the user suspected anything, he would immediately change his code, and the job of breaking it would have to start all over again.

Writing in Ciphers

Anyone writing in code is limited by the number of words in his code book. If he wants to use a word that is not listed in his book, and therefore does not have a code group of letters for the word, then he has to make one up. He must make sure that the other people who have copies of the code book are sent the new word.

Writing in *ciphers* is different. A code dictionary is not needed. Any word at all can be put into cipher by the sender and worked out by the receiver of the message.

One of the oldest known ciphers was used by a Spartan general. He wrapped a narrow strip of cord around a rod. Then he wrote his message across the turns, down the length of the rod. When the cord was unwound the message was broken into disconnected bits. It could be read only by someone who had a rod of the same diameter, or who knew the trick of this kind of cipher. A messenger usually used the cord as a belt, and if he were caught by the enemy the belt just seemed to show some odd designs.



NA SEDOC

by Gerard Mosler

In some codes, different numbers or pictures are substituted for the letters of the alphabet. The dancing men shown here stand for letters in the alphabet and form a coded message. Will the number of times each picture appears help you to break the code and read the message?

A cipher written in such a way is called a *transposition cipher,* one of the two kinds of ciphers. In a transposition cipher, the letters of the message—called the *clear*—remain the same, but they are shuffled around according to a plan. There are many, many ways to shuffle the letters of a message. Some of them may be very difficult to break. Here is an easy example:

```
E N E M Y W
I L L A T T
A C K T O M
O R R O W X
```

Write your message (the clear) in rows of any number of letters (here six), then read from top to bottom to put the message into cipher: EIAO NLCR ELKR MATO YTOW WTMX. Or, you can write them in groups of five letters, as is usual: EIAON LCREL KRMAT OYTOW WTMXF. The letters X and F are called *nulls.* They are used to fill out the incomplete groups and to make it still harder to break the cipher.

If you want to take a message out of cipher, simply reverse the process by writing the cipher message from top to bottom and read the clear off from left to right. You must, of course, know that the letters are arranged in a frame of 6 by 4 letters. But you can have any kind of frame you want. Such transposition ciphers are, of course, very easy to break.

One way to make them safer is to introduce a *keyword.* The keyword tells you in what order to write the lines from top to bottom. Suppose that our keyword is NATURE, and that we arrange the clear as before:

```
N A T U R E
-----------
E N E M Y W
I L L A T T
A C K T O M
O R R O W X
```

Now write the top-to-bottom columns in a number order directed by the keyword. Since A is the first letter in the alphabet, the column beneath A is written first. E comes next in the alphabet, so we write the column under E second. The N column will be written third, and so on through the sixth and last, or U, column.

So our ciphered message reads this way: NLCR WTMX EIAO YTOW ELKR MATO. Or, in groups of five letters it would read: NLCRW TMXEI AOYTO WELKR MATOF.

PROJECT

Try deciphering this transposition cipher message. The keyword is CIPHER, and the message is arranged in a frame of 6 by 5 letters. AEEDI TSNHX NARTS GNTWL EHUIM TREFF.

In deciphering, you must, of course, reverse the process. Keywords can be changed at will, so that a different one can be used for each message. The sender and receiver need only have a list of keywords and both agree on exactly when to use them.

Substitution Ciphers

The second kind of cipher is called the *substitution cipher.* It is the one most commonly used today. As its name says, one letter is substituted for another. One of the earliest known substitution ciphers goes back to Julius Caesar, the famous Roman general who conquered almost all of Europe 2,000 years ago. He simply wrote the alphabet twice, one line under another; but he started the second, or cipher, line with the letter C and ended it with A, B. Suppose that he wanted to write the word CENT in cipher. It would come out EGPV.

```
Clear  A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Cipher C D E F G H I J K L M N O P Q R S T U V W X Y Z A B
```

The word ENEMY would read GPGOA in cipher. The receiver of the message need know only the key—that the cipher alphabet was shifted to the left by two letters.

PROJECT

Here's another message to decipher. It is written in a substitution cipher in which the cipher alphabet starts with K and ends with J. PSPDR KSB QBYEZ XYG LKCON KD GOCD KSBPSOVN GSDR DRSBDI WONSEW BKXQO WSCCSVOC.

(Continued on the next page)

TABLEAU

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
B	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a
C	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b
D	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c
E	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d
F	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e
G	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f
H	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g
I	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h
J	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i
K	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j
L	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k
M	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l
N	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m
O	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n
P	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Q	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
R	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
S	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
T	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
U	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
V	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u
W	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
X	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Y	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x
Z	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y

Srehpic dna Sedoc (continued)

Since Caesar's day, some very keen minds have experimented with ciphers. One thing they tried to do was avoid having the most common letters repeat themselves.

The English alphabet has 26 letters. Five of them are vowels (AEIOU) and 20 are consonants, with Y considered a semivowel. Some letters, such as Z, Q, and J, are rarely used. Others are used very often. The letter E, for instance, is used 200 times as often as the letter Z; the letter S is used three times as often as the letter G. The most common letter is E. Here are the 26 letters of the alphabet arranged in order of usage—from E, which is most often used, to Z, which is least used:

E T A O I N R S H D L F C M U G Y P W B V K X J Q Z

The vowels A,E,I,O,U make up more than one-third (40 per cent) of all the letters used in writing. The most often used consonants are H,N,R,S,T. They are used almost as often as the vowels, making up 33 per cent of the letters. The first five letters of the list make up nearly half (45 per cent). The first nine letters, E,T,A,O,I,N,R, S,H, make up nearly three-quarters (70 per cent). These studies of how often the letters of the alphabet are used were made by counting the letters in thousands upon thousands of words. Samuel Morse did this when he invented his Morse Code. So did the author Edgar Allan Poe, who was very much interested in the science of codes and ciphers, called *cryptography*. Poe's interest in cryptography is shown in his fascinating story "The Gold Bug."

A Break-through in New Ciphers

In the 1500's a French nobleman, Blaise de Vigenère, invented a cipher. It has become known as *The Vigenère Tableau* (pronounced *tab-low*). His main aim was to prevent the most common letters from repeating themselves in the cipher message. This was the greatest weakness of Caesar's and other early substitution ciphers. In all of these early ciphers each letter in the clear message was always represented by the same cipher letter—just as in newspaper cryptograms today! Vigenère asked only that the sender and receiver agree on an arrangement of letters which both parties could carry in their heads. The *tableau* shown here is an example.

To make the cipher difficult to break, the tableau is used with a keyword. First, the clear is written down with the keyword, letter for letter, written above. The keyword is repeated as often as necessary.

Keyword L O V E/L O V E/L O V E/L O V E
Clear h e l p n e e d e d a t o n c e
Cipher S S G T Y S Z H P R V X Z B X I

The *tableau* can now be used to put the clear into cipher. L, the first letter of the keyword, is found by running along the alphabet at the top of the *tableau*. Then H, the first letter of the clear, is found in the left hand column. Reading down from the L and across from the H gives the S. Continuing by reading down from O and across from E produces another S. Down from V and across from L gives G, and so on until the cipher message reads:

SSGTYSZHPRVXZBXI.

Notice that the five E's of the clear, which would have been represented by the same letter five times by the simple substitution alphabet, are now represented by four different letters. When one knows the keyword, reading the message with the help of the *tableau* is simple.

Many later cipher geniuses took the Vigenère *tableau* as their starting point. Over the years, many brilliant ciphers have been invented, but they have succeeded only in firing the imagination of still greater geniuses who managed to break the cipher, considered unbreakable until then.

Today's cipher systems, however, are far more advanced than those described in this article. Complex machines can put a clear message into cipher as fast as the clear can be typed on its keyboard ■

PROJECT

This message is in tableau cipher. Use the tableau on this page to decipher it. The keyword is SCIENCE. HKKOHRTDCVWSTSENWGXGVXKNXRGRAPKIAVVS NZEVNVGCLWGCXAQVJEKHSA.

Do Plants Always Grow Up? Up? Up?

by Richard M. Klein and Pamela C. Edsall

■ Cows and cars, people and plants—all things on Earth are affected by *gravity,* which is the attraction between these things and the center of the Earth. However, different things are affected by gravity in different ways. Heré is how you can investigate the effects of gravity on plants.

To set up your laboratory, you will need some stiff cardboard, a protractor, scissors, pencil and paper, sticky tape, six cardboard one-quart milk containers, and six Coleus plants. Coleus is a common house plant *(see drawing),* that you can buy from a garden or variety store or a supermarket. Be sure that the plants are nearly alike—with straight stems, the same leaf pattern and colors, and about the same height (at least five inches).

Cut off the upper part of the milk cartons to make six short "pots." Plant the Coleus in the pots and number the pots, 1 through 6. Then, with scissors, tape, cardboard, and protractor, make sloping supports for four of the pots *(see diagrams).* Two of the supports should have a slope of 30 degrees and the other two should slope at 60 degrees.

Since light affects the growth of plants *(see "Shaping Plants with Light,"* N&S, *Nov. 2, 1964),* you will have to put the plants in a dark place during the experiment. Put them in a closet, a deep drawer, or a big box. Set one pot upright. This is the normal, or *control,* plant which you can compare with the others. Set Pot 2 on its side *(see table).*

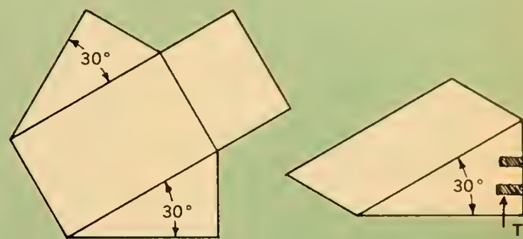
Arrange the other four pots on the supports as shown in the table—one leaning uphill at 30°, another leaning downhill at 30°, a third leaning uphill at 60°, and the fourth leaning downhill at 60°. If necessary, tape the pots in place. Make a table like this one to record your findings.

Leave the plants in the dark overnight, making a note of the number of hours they are left in darkness. Next morning, take the plants out. In what direction are the stems of the plants growing? Measure the angles that the stems have made in changing their direction of growth. Do this by holding a sheet of paper against the stem and tracing its outline. Trace it from its tip to the point where it enters the soil. Since plant stems cannot bend sharply without breaking, the middle part of the line will be a curve. To measure the angle, use the straight line traced from the base of the stem to the bend, and the straight line traced from the tip of the stem to the bend.

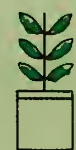
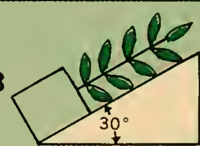
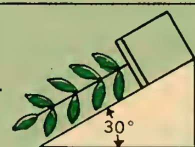
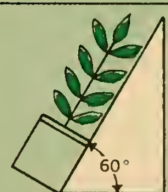
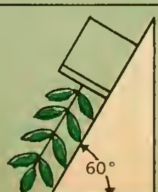
As you measure the angles, write them in the table. Compare the angle made by each plant's growth with the 90° angle of the control plant. Did all of the plants grow in the same direction as the control plant?

If you allow the plants to stand upright for two or three days, will they straighten out? Be sure to water them. What would happen if you repeated the investigation, but did not keep the plants in the dark? Let light from a lamp fall on the plants for the same number of hours that the plants had been left in darkness. Are the angles the same this time? ■

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden. Miss Edsall is his Research Assistant.



USE CARDBOARD AND TAPE TO MAKE SLOPING SUPPORTS FOR FOUR OF THE MILK CARTON "POTS."

NUMBER OF POT AND POSITION OF PLANT			ANGLES YOU MEASURE
1		Control	
2		90° from normal	
3		60° from normal	
4		120° from normal	
5		30° from normal	
6		150° from normal	

brain-boosters

prepared by DAVID WEBSTER

These Brain-Boosters are based on articles that have appeared in the past seven issues of Nature and Science. You may have to experiment, though, to find the answers to some of the questions.

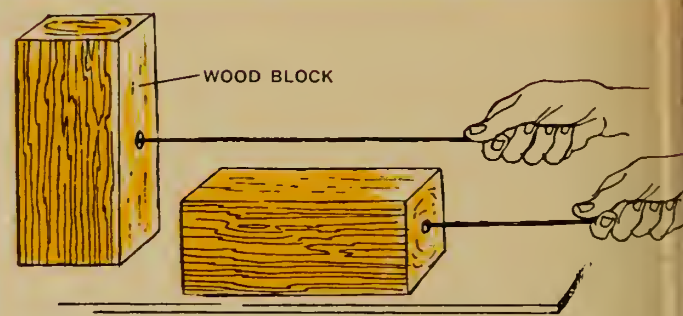
1. This photograph shows that snow has melted away from the bases of some dead plant stalks. Can you explain why?

2. Why would you be unable to cool off your kitchen by leaving the door of the refrigerator open?

3. Suppose that you put a little water into a clear plastic bag, held the end of the bag tightly so that the water wouldn't leak out, then laid the bag on a newspaper. What would you see if you looked at the words through the bag of water? What would the words look like if you put more water into the bag?

4. Harry wanted to find out how beans would grow in the dark. He planted a bean seed in some dirt under a large box. After the bean plant had grown about a foot tall, it turned light green. Harry decided that this color was because the plant had no light. What is wrong with Harry's experiment? What else could have made the plant turn light green? How could you do the experiment better?

5. One of these skeletons is a baby human and the other a baby chimpanzee. Which is which and why?



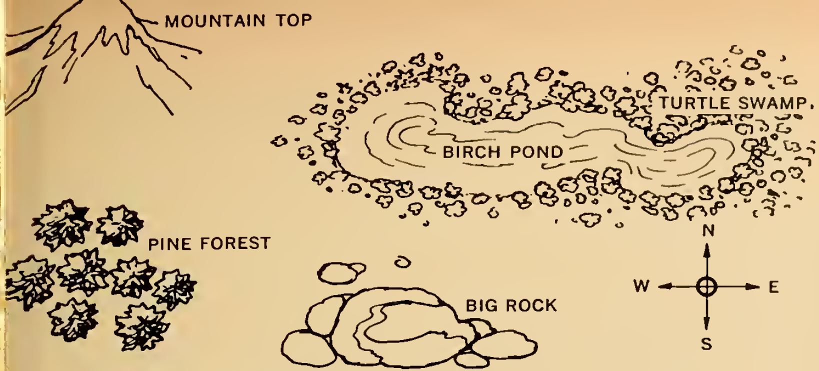
6. A block is first dragged along a table top on its end and then on its side *(see diagram)*. In which case would there be more friction?

7. Can you make a valve with a sheet of paper that will let you blow out of your mouth easier than you can breathe in through your mouth?

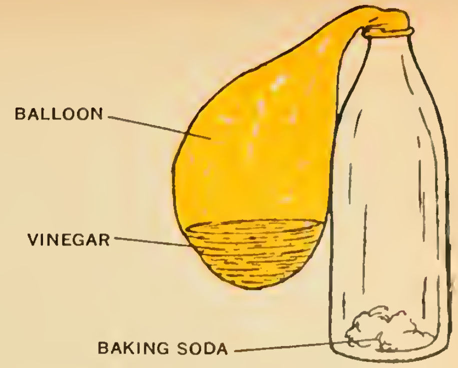
8. Why are the iguanas disappearing from some of the Galapagos Islands?

9. Which way were these animals going?

10. Here are two pendulums. Each has a string of the same length. The weights on both are the same, but are attached differently. Will the pendulums go back and forth with the same frequency? If not, how should the strings be adjusted so they will? Try this. What happens?

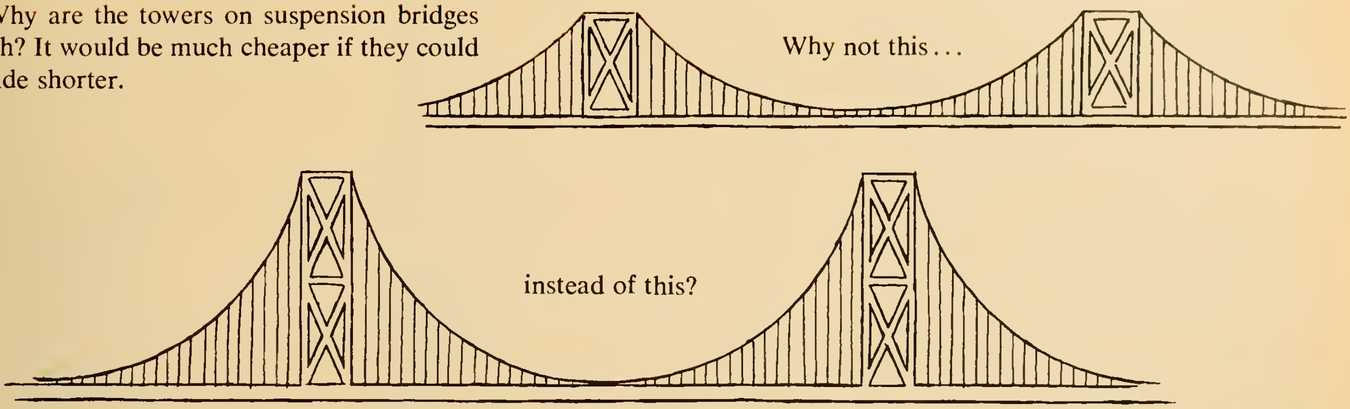


11. A biologist is attempting to locate a deer by triangulation. The direction of the deer from the mountain top is east, and from the big rock it is north. Where is the deer?



12. What happens when the vinegar in the balloon is dumped into the bottle? Try it.

13. Why are the towers on suspension bridges so high? It would be much cheaper if they could be made shorter.



14. The two X-rays are of a child's wrist, one at age 2½ and one at age 10. Which is which and how can you tell?

Answers to Brain-Boosters in the last issue

Mystery Photo: The photograph was of the hind end of a mealworm. Here is what the front of a mealworm looks like.

Can You Do It? One way to blow up the balloon a little is to put the bottle in some hot water. Why does this make the balloon get bigger?

What Do You Think Would Happen? If you stood on two bathroom scales, the top scale would show your weight. The bottom scale would show your weight plus the weight of the top scale. What would happen with *three* scales?

Fun with Numbers and Shapes: There are at least 13 letters in the figure: E, F, H, I, K, M, N, T, V, W, X, Y, Z. If you make all letters with straight lines instead of curved lines you can find every letter in the alphabet.

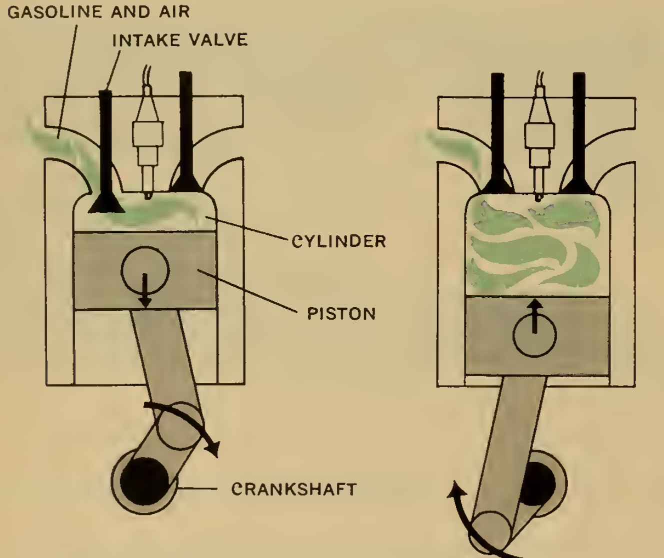
For Science Experts Only: The air from the fan would make an ice cube melt a lot faster. Air from a fan is not really colder; it just feels that way. (You could prove this with a thermometer.) As an ice cube melts, the air around it becomes cooler. A fan blows more warm air by the ice, making it melt faster.

HOW IT WORKS

Gasoline Engines

■ A gasoline engine works something like a gun. In a gun, gunpowder explodes and gases from the explosion push a bullet out of the barrel. The "barrel" of an engine is called a *cylinder,* and it is about three inches in diameter. The "bullet" is called a *piston,* but the explosion moves it only to the end of the cylinder. And the "gunpowder" is a mixture of gasoline and air. Here is how a typical four-stroke gasoline engine works:

First, the piston slides downward in the cylinder, leaving a partial vacuum. Tiny droplets of gasoline that have been mixed with air are sucked into the cylinder through an open *intake valve.* This is called the *intake stroke (see diagram).*

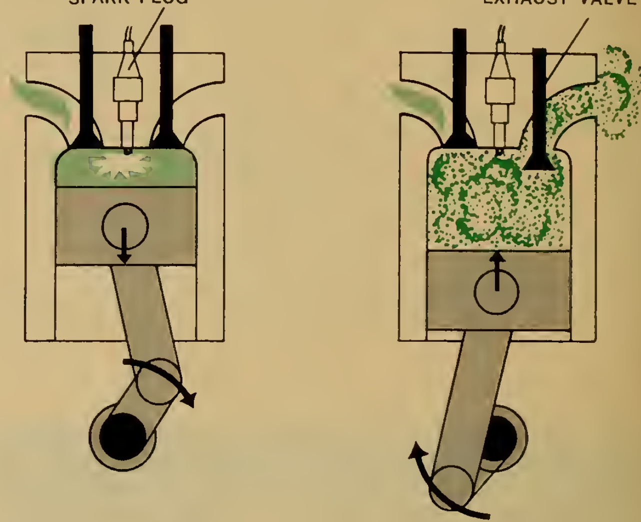


INTAKE STROKE   COMPRESSION STROKE

Next, the piston moves up in the cylinder and presses the gasoline-air mixture into a very small space. This is the *compression stroke.*

Then, a spark plug, in the top of the cylinder, makes an electrical spark that explodes the mixture of gasoline and air. The gases produced in this explosion push the piston downward. This is called the *power stroke.* A rod connects the piston to the *crankshaft,* making it turn as the piston moves down and up. The crankshaft turns gears that make the car wheels go around.

Finally, the *exhaust valve* opens and the piston moves upward, forcing the gases out of the cylinder. This is called the *exhaust stroke.*



POWER STROKE   EXHAUST STROKE

Then the exhaust valve closes, the piston starts downward again, and more of the gasoline and air mixture is let in to start the four-stroke operation all over again. This operation takes place many times each minute in each cylinder of the engine.

The piston in each cylinder supplies power only on the power stroke. At other times, it is being moved up and down by the crankshaft as it is turned by the power strokes of other pistons. An automobile engine may have from four to twelve cylinders. The more cylinders it has, the more force it applies to turning the crankshaft.

There are other devices that help the engine do its work. The *carburetor* changes liquid gasoline into tiny droplets and mixes it with air, the same way a sprayer vaporizes perfume. A *battery* stores electricity and supplies it to the spark plugs. The *exhaust pipe* carries waste gases away from the engine.

The next time you see a car with the hood up, try to identify the engine parts you can see. How many cylinders does the car have? How can you tell? ■

nature and science
TEACHER'S EDITION

VOL. 2 NO. 8 / JANUARY 18, 1965 / SECTION 1 OF TWO SECTIONS

The AAAS Science Curriculum for K-6—A Process Approach

by Mary M. Blatt

(Reports about new approaches to science teaching are published for your information and do not necessarily imply endorsement of these approaches by N&S *or The American Museum of Natural History.)*

■ The American Association for the Advancement of Science Commission on Science Education has completed the first phase of a new science curriculum program for the upper elementary grades. The Commission is now testing fourth- and fifth-grade materials written last summer. The materials are being tested in 50 classrooms in 10 states. Financial support for the project is provided by the National Science Foundation.

At the heart of the AAAS curriculum is the *process* approach to teaching. Members of the Commission believe that the essence of science is not *content,* but processes that are an orderly way of looking at the world.

GEORGE COPE, EDUCATIONAL SERVICES INCORPORATED

"Learning is most effective when the pupil discovers relationships himself. . . ." This youngster is examining pellets of fur and bone that were regurgitated by an owl, to find out what the owl eats.

The program, entitled "Science—A Process Approach," was developed through the efforts of AAAS science education specialists John R. Mayor and Arthur H. Livermore and teachers, supervisors, college professors, and other scientists who participated in seven major conferences and writing sessions over the past three years.

The AAAS curriculum writers have followed three basic tenets:

1. The processes of logical thought and action in the AAAS program must be presented again and again in different exercises of increasing sophistication.

2. The real test of pupil performance is what the pupil can do and how well he can think, not how well he can memorize. The word "process" implies doing.

3. Learning is most effective when the pupil discovers relationships himself rather than copying them from the teacher. Generalizations unfold for him instead of being imposed on him.

The exercises for grades 4 and 5 emphasize major processes such as:

FORMULATING HYPOTHESES. This process builds on the pupil's previous experience (in the K-3 curriculum developed in the summer of 1963 at Stanford University) with prediction and inference. For example, in the lower grades the pupil might be asked to predict how high a plant would be on the eighth day of growth after he had observed the plant for seven days. This is short-range prediction. But in the upper elementary grades, the pupil would be expected to devise a broader hypothesis: When plants get older, they get larger. The exercises are designed to give a pupil practice in making hypotheses and to help him recognize that a hypothesis becomes stronger as supporting evidence is collected.

CONTROL AND MANIPULATION OF VARIABLES. In studying science previously, the upper elementary pupil probably has

(Continued on page 4T)

IN THIS ISSUE

IN THE NEXT ISSUE

Collecting winter insects—where to look and tools your pupils can make . . . How mapmakers "flatten" the Earth . . . A WALL CHART shows how continents change shape and size on maps made in different ways . . . You can learn a lot about beavers when they live in your backyard.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 "Death Race"

In this article, Dr. Janis Roze describes the fate of the Orinoco River turtles known as "Arrau"—harmless creatures that are literally being eaten out of existence by man. By changing the names, locale, and a few other details, the story could be that of the Diamondback Terrapin of North America. In the past, both these turtle species were hunted for food with no thought given to their dwindling numbers. Fortunately, through studies such as this one in Venezuela, scientists are able to suggest ways which may save many species from extinction.

Topics for Class Discussion

• *How are turtles different from other reptiles?* Turtles are the only reptiles that have shells. They are also the only ones with no teeth. Instead, their jaws have sharp edges with which to tear their food. Contrary to the old folk tale, a turtle cannot be made to leave its shell. Its backbone and ribs are fused to the top shell, called the *carapace,* and its breastbone is fused to the bottom shell, called the *plastron.*

• *Do turtles take care of their young?* A mother turtle does a thorough job of preparing the nest for the eggs she lays, and of covering it up afterwards. But with that her responsibility ends; she never sees her offspring. The young turtles must fend for themselves, guided only by instinct. Have your pupils compare turtles with other animals in this regard. Most birds and mammals, and a few fish, exhibit some form of postnatal care. Does there seem to be a correlation between the number of young an animal produces and the amount of parental care it gives?

• *Why are the female Arrau larger than the males?* In many species of reptiles and amphibians, females are larger than males. This *may* be an adaptation for survival. The larger the female, the more eggs she can produce.

• *Why do the Arrau produce so many eggs?* The article points out an important ecological concept: Organisms that are heavily consumed must produce many young to survive. Your pupils can think of other examples, such as mice and rabbits.

• *Has anyone in the class ever eaten turtle soup or terrapin?* Have your pupils look up recipes for terrapin in a cook book at home. (Fanny Farmer's *Boston Cooking School Cook Book* contains several.) How is the meat prepared? What parts are eaten and what parts discarded?

PAGE 6 Keeping Turtles

Why keep turtles? Dr. James A. Oliver, Director of The American Museum of Natural History, gives this wry answer: "Amphibians and reptiles can be considered as curio-ornamental pets rather than companion-cuddly or economical pets. They are kept as objects of interest . . . with varying amounts of affection bestowed on them." Because of their hardiness and ability to live for several days without food, they are admirably suited to the vagaries of classroom care.

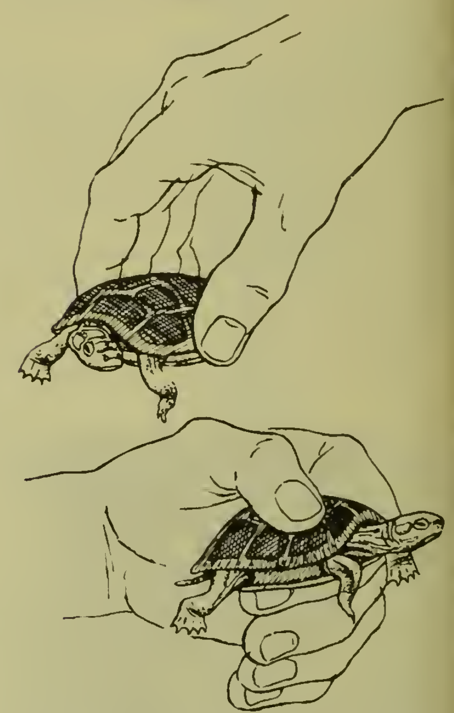
Suggestions for Classroom Use

Your pupils will want to know the best ways to pick up turtles. Large turtles with long tails may be picked up by the tail. Large turtles with short tails should be picked up by the back of the shell with two hands, with the turtle's body hanging down. Small turtles may be picked up by placing the thumb on the carapace and the fingers on the plastron or by the top shell only, with the thumb and middle finger on opposite sides of the shell (*see diagrams*). Either way, the children should be careful not to put pressure on the shells.

• *Have the children observe how turtles breathe.* Since their ribs are joined to their shells, they cannot expand them as other animals do. Instead, the bones and muscles of the shoulders and hips are moved to help fill and empty the lungs.

• *How sensitive is your turtle's shell?* Brush your turtle's shell with various things, such as a feather, a straw, and a stick. Note the animal's reaction.

• *Does your turtle make noise? Does it appear to hear?* Help your pupils see that when testing a turtle's hearing, they must avoid exposing it to other stimuli at the same time, such as the smell of food or the sight of nearby movement. For instance, to find out if it responds to the tapping of a ruler, they should tap where the turtle can not see the motion.



Here are two proper ways to hold a small turtle. Avoid squeezing the animal's shell.

PAGE 10 Codes and Ciphers

The science of cryptography has made great progress in recent years with the development of computers and of machines that encipher and decipher messages automatically when supplied

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition wth single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE & SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . .
(Continued from page 2T)
with the proper data. Modern military and diplomatic ciphers, while extremely complicated, are based, nonetheless, on the same principles as the ciphers described in this article.

Topics for Class Discussion

• *Are all codes used for secrecy?* No, many codes are used simply for brevity, to save money in sending telegrams and cables. Many business firms have their own codes for sending long distance messages. Others use the Western Union or Marconi codes.

• *What are some common substitution (invented alphabet) codes?* Semaphore, flags that represent different letters, Morse Code, and the use of numbers from 1 to 26 for the letters of the alphabet.

Activities

• *So that your pupils may get a better idea of how codes and code books work, bring in a French-English or other foreign language dictionary.* Point out that translating foreign languages is not much different from decoding a message in code.

• Knowing a cipher is not the same as knowing *about* ciphers. It takes much practice to encipher and decipher messages quickly. *Have the class pick a simple cipher to work on.* Assignments may be written in cipher for several days. You may also have races. Encourage the children to develop accuracy, then speed.

References

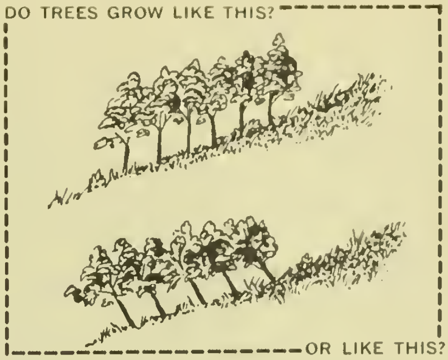
• *Codes and Secret Writing,* by Herbert S. Zim, William Morrow and Co., New York, 1948, $2.75.

• *First Book of Codes and Ciphers,* by Sam and Beryl Epstein, Franklin Watts, New York, 1956, $2.65.

PAGE 13 Plants Grow Up?

Your pupils may remember a mystery photo in Brain-Boosters (N&S, *Oct. 5, 1964)* that showed a group of seedlings growing on a disk with their stems leaning inward. This amazing sight was explained in the issue that followed as the result of growing the seeds on a spinning turntable. The plants had responded to the "pull" of centrifugal force by growing *away* from it.

In this workshop, your pupils will be able to demonstrate that plants react in like manner to the force of gravity—by growing *away* from the center of the Earth, which is the center of gravity. The effect of gravity on plant growth is called *geotropism,* or "turn to the Earth." Most plant stems are *negatively geotropic.*



Suggestions for Classroom Use

• *Have your pupils speculate on the probable outcome of the investigation.* Have they observed anything about plants growing on slopes which might give them a clue? They should recall that most trees on a hillside, for instance, do not grow perpendicular to the ground surface, but rather perpendicular to level *(see diagrams).* The angle that a tree forms with the slope usually approximates the angle formed by the slope and an imaginary line drawn to the Earth's gravitational center.

Be sure your pupils understand that the presence of light might alter the outcome of the investigation. Many factors influence the growth of plants; and to study the effect of one, we must eliminate the effects of others.

• *Ask your pupils if they can think of any plants that* do not *always grow up.* Many vines do not. Also, the limbs of trees can be considered stems, and many of them grow horizontally or downward. No one has any really good idea why they do not grow up.

Activities

• Just as stems usually grow straight up, the main roots of plants usually grow straight down *(positive geotropism). Your class may observe this by shaking the dirt off the roots of several of the plants after they have measured the angles of the stems.* The main roots will appear to be bent in the opposite direction from the stems. The plants can then be repotted and set upright as in the article. After two or three days, the roots will straighten out along with the stems.

• *Have your pupils notice the effect of gravity on the way they stand.* How far can they lean forward or backward without falling over? Have them stand on an inclined plane. They will notice they must bend at the ankles to remain upright.

HAVE YOUR PUPILS TRY TO BREAK A CODE

The dancing men on pages 10 and 11 carry a message in a simple substitution code. Each different dancing man stands for a letter of the alphabet. Breaking this code is an excellent group activity for your pupils after they have read the article on codes and ciphers.

The article lists the letters of the alphabet in order of the frequency of their use in the English language: E is used most, T next, A next, O next, and so on. That list will give your pupils a good start in breaking the code. For example, they will find that the figures  and  appear most frequently in the message, and stand for E and T, respectively, as the list predicts. Because our message is not long enough, the letters that make it up do not all occur in the same order of frequency listed in the article, but the list does serve as a useful guide.

Once your pupils have plotted in all the E's and T's, they will be on their way to breaking the rest of the code. For example, they will be able to guess the dancing figure that stands for H because they will find that there are four 3-letter words that begin with T and end with E. They will then be able to fill in other H's in the message.

In a similar way, they will be able to deduce that the two 4-letter words beginning with TH are completed by the letters IS.

They will probably be misled by the letter S, which appears more frequently in the message than the letter-frequency list would indicate. What they think is S will turn out to be A.

A little trial and error and some sound guessing should lead your pupils to the solution of the code. Here is the decoded message:

ATTEMPT TO READ THE ADVENTURE OF THE DANCING MEN BY SHERLOCK HOLMES THERE IS A CODE LIKE THIS IN THE STORY HOLMES SAYS THIS PROMISES TO BE AN INTERESTING CASE—THE EDITORS

The AAAS Science . . .
(Continued from page 1T)

only made observations of natural events. He probably has had no experience in controlling conditions. But if he wishes to study the effect of light on plant growth, he can learn to vary light intensity from darkness to extreme brightness while keeping other variables constant. The teacher poses the problem and the pupils propose variables to be controlled and varied. This activity leads to the performance of experiments.

EXPERIMENTING. With experience in the process approach, pupils can plan, execute, and communicate simple experiments. The most difficult part of this may be formulating the problem.

When the experimenters have completed an experiment, they should then formulate hypotheses to answer or explain the original problem or question. This may require mathematical interpretation of data, representation of observations in graphs and further experimentation to test predictions and inferences based on the first observations. Finally, the experiment should be communicated either orally, in writing, or both—stating the problem, experimental methods, results, interpretation of data, and conclusions (hypotheses, models, predictions, inferences).

MODEL FORMULATION. A model is often simply a tangible representation, such as balls and wire combined to form a model of the atom. But a scientific model may also be a "picture" of a complex concept—a word picture, a mathematical picture, or a tangible device based on a mental picture. For example, long before anyone had any idea of what a gene looked like, scientists formulated a gene "model," a concept that became useful because predictions could be made from it. If scientists find that predictions are incorrect, they modify the model. Formulating models gives a child a grasp of potentialities of the scientific approach to problems.

INTERPRETING DATA. All scientific reports include observations (results) and opinion (discussion). Correct observations depend on the design of the experiment and the honesty of the experimenter. Opinions are interpretations of results. A child should learn to distinguish between the experimental results and interpretation of them. He must avoid overgeneralizing and drawing conclusions not supported by data. Although pupils may not find it easy to become competent in these skills, they seem capable of attempting the exercises and seem to enjoy such activities.

Physical, Biological, Earth Sciences

In writing curriculum materials, the physical sciences committee dealt with energy forms and transformations and with the structure of matter, pointing up the distinction between heat and temperature and emphasizing the transformation of various energy forms into heat. Structure-of-matter exercises concentrate on the particulate nature of matter, the physical properties of mixtures, and changes in physical properties when substances interact.

The biological sciences committee developed exercises based on the unity and diversity of living things, reproduction and development, growth, metabolism, and behavior.

Another committee worked with Earth science. Rocks and minerals can be useful in teaching the processes of observation, communication, classification, and identification. Other areas covered by the exercises are gravitation, the Earth's magnetic field, and geologic change in terms of the hydrologic cycle.

A fourth committee was charged with orienting teachers who are using the new materials in tryout centers during the current school year. Participating teachers will report the strengths and weaknesses of every exercise on feedback forms. A careful testing program is an important feature of the AAAS curriculum ■

Mrs. Mary M. Blatt is Science Education Supervisor of the Pennsylvania State Department of Public Instruction. She participated in the AAAS project at Stanford University last summer.

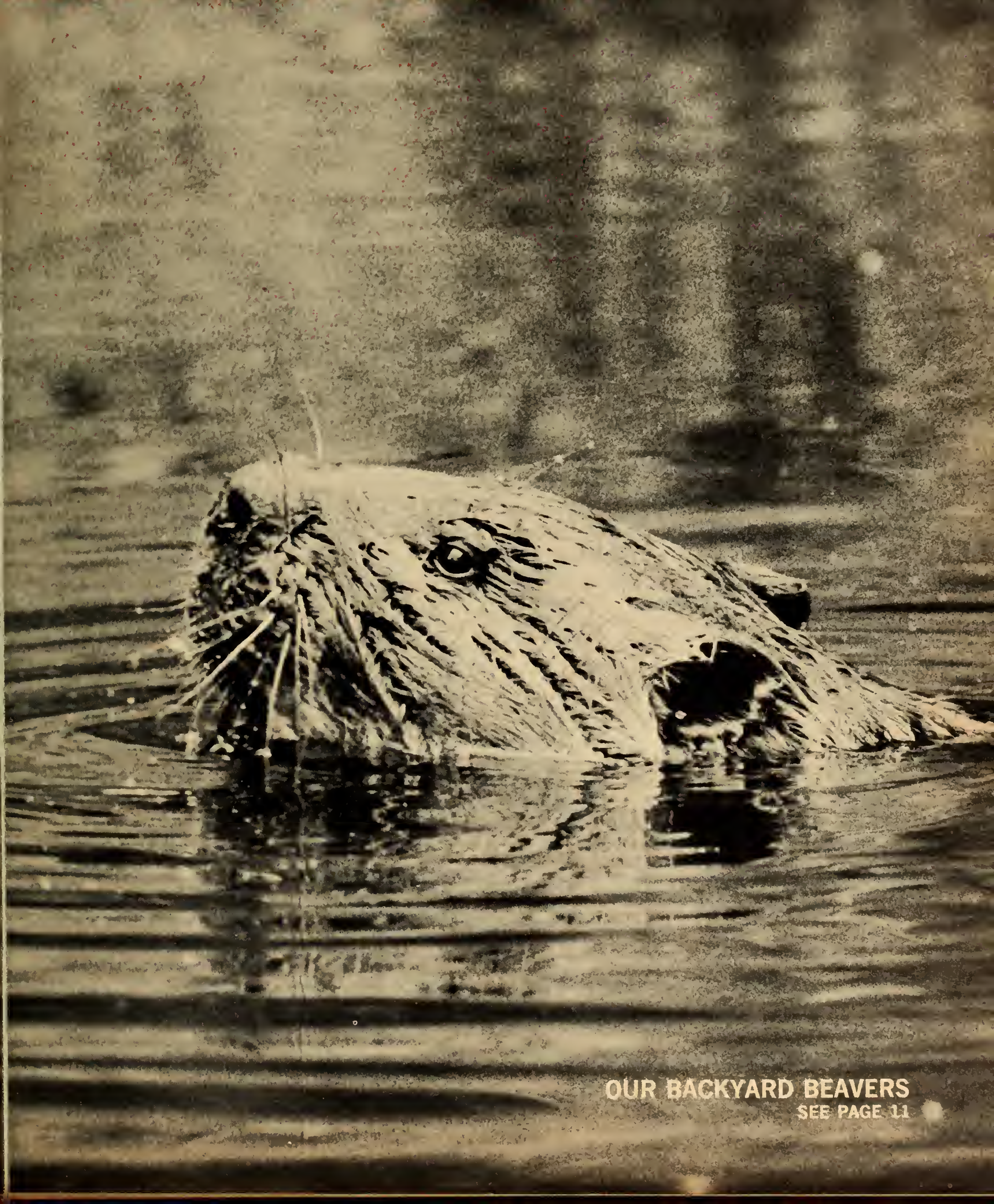
nature and science

VOL. 2 NO. 9 / FEBRUARY 1, 1965

Where have all the insects gone?
To find out—and to find them—

see page 3

HUNTING INSECTS IN WINTER



OUR BACKYARD BEAVERS

SEE PAGE 11

ABOUT THE COVER

When the Pilgrims landed on North America, they were greeted by Indians who wore clothing made of beaver skins. The Pilgrims wanted some of the warm furs for themselves. They told the Indians that they would trade blankets and other goods for beaver skins. This was the beginning of the fur trade that led to most of the early exploration of North America.

Pioneer trappers killed all of the beavers in some places. However, beavers survived in other areas and, with man's help, are now plentiful in many states. The article beginning on page 11 tells what happened when some beavers built their dams near a farm house in South Dakota.

Beavers are the largest rodents in North America. They are related to mice, squirrels, and other gnawing animals. They have powerful, webbed hind feet, which help them push through the water of the ponds, lakes, and streams where they live. Beavers breathe with lungs, but can stay underwater for as long as 15 minutes without coming up for air.

The photograph above shows a scene from the beaver habitat group at The American Museum of Natural History. To learn more about these fascinating animals, turn to "Our Backyard Beavers" on page 11.

nature and science

VOL. 2 NO. 9 / FEBRUARY 1, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; **SENIOR EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** David Whieldon; **EDITORIAL ASSISTANT** Linda Britton; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Don Cailliez; **CONTRIBUTING EDITOR** James K. Page, Jr.

CONSULTING EDITOR Roy A. Gallant

PUBLISHER Richard K. Winslow
CIRCULATION DIRECTOR J. D. Broderick; **SUBSCRIPTION SERVICE** Charles Moore

Contents

CREDITS: Cover, p. 13, left and center photo, by Leonard L. Rue, III; p. 2, photo from The American Museum of Natural History; pp. 3, 4, 6, 7, 10, 12, 15, 16, drawings by Graphic Arts Department, AMNH; p. 5, drawings by Gaetano di Palma; p. 6, photo by George Cope, Educational Services Incorporated; pp. 8, 9, drawings by R. G. Bryant; pp. 11, 12, photos by Willard and Elma Waltner; p. 13, right photo from Michigan Conservation Department; p. 14, photo by Fundamental Photos, Inc.

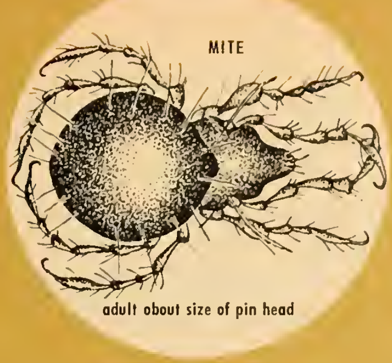
NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

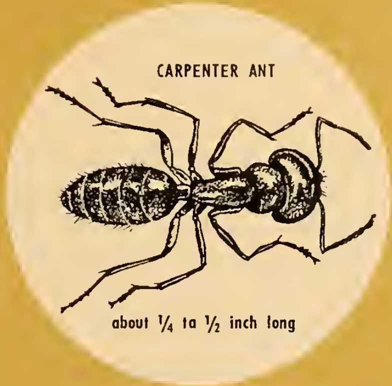
SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

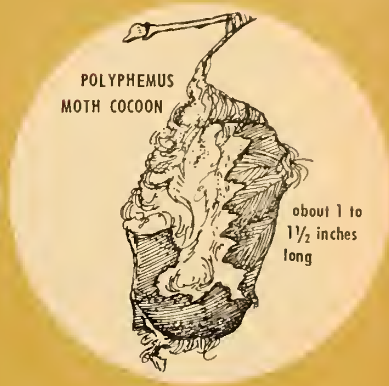
HUNTING INSECTS IN WINTER

by Alice Gray

Not all insects die when winter comes. You can find them in hidden places, and then watch their ways indoors.







■ Where do insects go in the winter? The Monarch Butterfly goes south, like a bird. Most of the insects, however, simply disappear with the coming of frost. With the first spring days we begin to see them again, so they haven't all died. Where have they been?

Insects are "cold-blooded" animals. Their body temperature changes with the air temperature. The colder the weather gets, the more sluggish they become. Most kinds of insects are completely helpless in freezing weather.

Insects are harder to find in the winter than in the summer. They are usually hidden inside or under something. You will not find many full-grown insects in the winter. More kinds of insects pass the winter as eggs, *larvae,* or *pupae (see diagrams),* than as adults. (Larvae are insects in the stage between eggs and pupae. You may know them as caterpillars, maggots, or grubs. Pupae are insects in an inactive stage just before they become adults.)

Equipment You Will Need

Why not make a field trip and see what insects you can find? Choose a day when the temperature is above freezing or not much below. If you live in an area where there is snow, do your collecting on a day when the snow is not too deep. Then you can find the logs, stones, and piles of dead leaves where so many insects are hiding. You will need some little boxes or plastic bags in which to carry home pupae for rearing; a pair of forceps, or tweezers, for reaching into cracks; and strong tools for prying up things that are frozen to the ground and for splitting dead logs to see what is inside.

My favorite tools are a case opener (a sort of miniature crowbar) and a hatchet, but a chisel and hammer also

(Continued on the next page)

work well. Everything may be frozen so hard that a knife is not much good. If you are collecting adult insects, you will want a killing jar for hard-shelled insects and a bottle of alcohol in which to preserve soft-bodied specimens. Use carbon tetrachloride or fingernail polish thinner on a blotter in the killing jar. Rubbing alcohol from the drugstore will do for the soft-bodied things. Since many of the animals you will find will be very small, an *aspirator* would be handy for picking them up *(see diagram on page 5)*.

Be sure to wear warm clothing, and don't forget your notebook to keep a record of the things you see.

Where To Hunt

The best places to hunt for insects in the winter are the places where these very small animals can hide. Look under loose boards and shingles on abandoned sheds, in and under cans on a dump, inside culverts, under bridges, under the eaves of low buildings, and in hollow trees. Be on the alert not only for insects but for the nests of mud-dauber wasps *(see page 3)*. Take the nests home and keep them in *emergence cages,* which are described later in this article. You will be astonished to see how many different kinds of insects come out. Some will be mud-daubers, others will be wasps or flies that have eaten the mud-dauber *larvae* and taken over their nests.

Look at the stems of dry weeds and the twigs of bushes and brambles. Here you may find the egg cases of mantids and a variety of *stem galls (see diagrams).* Galls are growths on plant leaves, stems, or roots that often have insects inside. If you are lucky you may find the cocoon of a moth or the chrysalis of a butterfly.

One of the likeliest places for finding lots of insects at any season is a big dead log. Some creatures, like ants and boring beetles, live there all year round. Others, like little green sweat bees, go there for the winter only, packing themselves into tunnels made by wood-boring insects. They are deep inside.

A great many insects spend the winter underground or under dead leaves piled deep in wooded hollows. These insects are usually small and so well camouflaged that it is almost impossible to see them while they are still. If you want them, the best thing to do is to take earth, leaves, and all, and warm them up indoors. Then the insects will begin to move and you will be able to see them more easily.

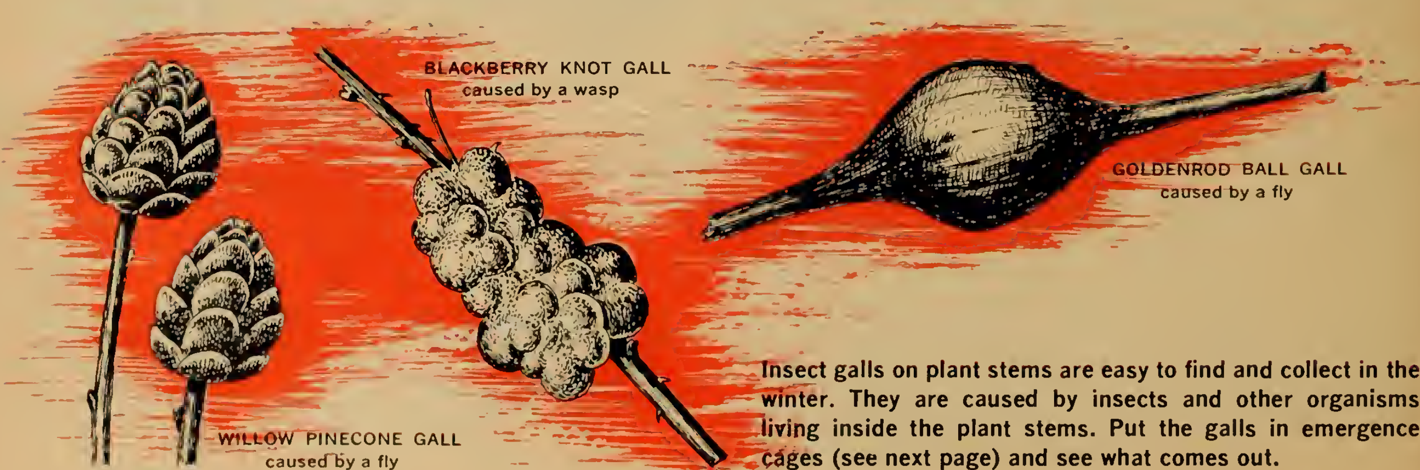
It isn't easy to collect soil when it is frozen solid. You will have to chop it out with your hatchet or chisel and carry home the chunks in a bag. There will be few animals in the top layers of soil, so dig as deep as you can. You can use a "collecting sieve" to shake insects out of leaf-litter and a "Berlese separator" to get them out of earth (*see diagram on page 5).*

Keep notes on where you collect different kinds of insects. Try to identify as many of them as you can, by using books on insects *(see list at end of this article)* and the drawings on page 3.

Most of the pupae you find will continue their development as soon as they are brought into a heated house, and will change into adults within a few weeks. (Keep the pupae in dark containers with moist earth or paper towels so that they do not dry out.)

As you sort over and identify the insects and other little animals you have collected, compare the kinds that came from leaves, soil, rotten wood, or other places. Is there any relationship between the form and color of the creatures and the kind of place in which you found them? (For example, white, thin-skinned animals almost always live in total darkness.) Do you think they always live where you found them, or are they just winter visitors? If they are visitors, what can you tell about the way they live during other seasons? Here is a hint: Would an insect with large, strong wings spend its whole life in a burrow? ■

These books will help you identify the insects you find: **Field Book of Insects,** by Frank E. Lutz, G.P. Putnam's Sons, New York, 1935, $3.95; **How To Know the Beetles,** by H.E. Jaques, Wm. C. Brown Co., Dubuque, Iowa, 1951, $3.50; **How To Know the Immature Insects,** by H.F. Chu, Wm. C. Brown Co., Dubuque, Iowa, 1949, $2.50.



Insect galls on plant stems are easy to find and collect in the winter. They are caused by insects and other organisms living inside the plant stems. Put the galls in emergence cages (see next page) and see what comes out.

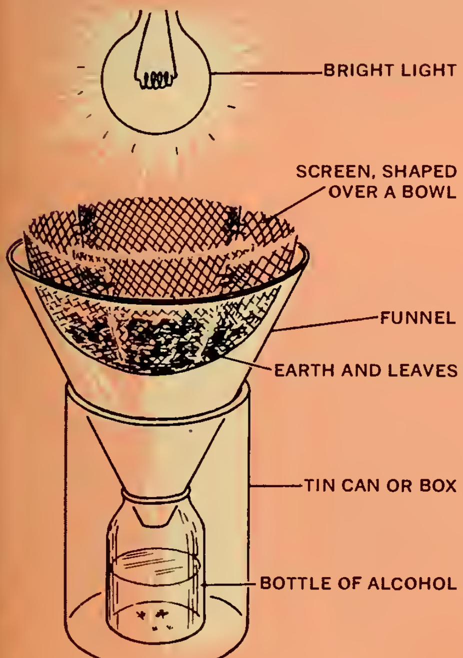
Use This Equipment for Your Insect Hunt

Berlese Separator

A Berlese separator is a device for making little soil animals catch themselves for you. To make one, you will need a piece of $\frac{1}{8}$-inch screening, a funnel that light does not shine through, a tin can or box to set the funnel in, a lamp, and a collecting bottle with alcohol in it.

Shape the screen to fit into the top of the funnel by pressing it over the rounded bottom of a bowl. If you have to fold it or cut it, overlap the edges and fasten them with staples, string, or wire.

To use the separator, put the bowl-shaped screen on a clean piece of paper and fill it about half full of earth. Jolt it a little so any earth that can drop through the screen will do so. Then gently set the bowl in the funnel. Set the funnel in the can or box with the mouth of the collecting bottle directly under the funnel spout. Add the earth which fell through to the screen bowl. A light over the separator is not really necessary, but it helps to dry the soil quickly. As the earth dries, the soil animals move down toward the bottom of the soil, through the screen, and into the collecting bottle. The insects will

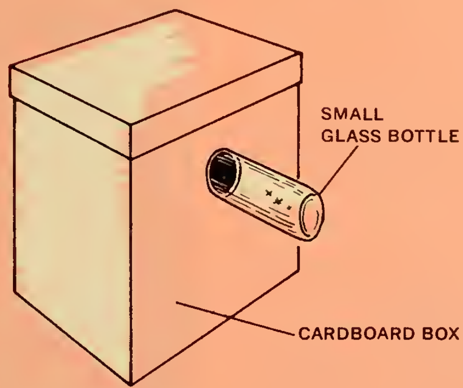


not fall into the bottle below until the soil gets really dry. This may take several days.

When the earth in the screen bowl is dry, lift the funnel carefully out of the can and empty the screen bowl. (If you jolt it, a lot of earth will fall into your collecting bottle.) Take out the alcohol bottle, swirl it around to stir up the contents, and pour the alcohol into a white saucer. The animals in it will be very little. You will need a magnifying glass to see what you have caught. There will probably be mites, little spiders, and many other creatures, as well as a variety of insects. Sort them out, taking each one up in a medicine dropper, and put each kind in a separate bottle of alcohol. Make labels telling when and where you collected the soil. Put the labels right into every bottle along with the specimens. (Outside labels may be lost.)

Emergence Cage

The little insects which come out of plant galls are attracted to light. If you put the galls into a dark box where the only light comes through a clear glass bottle, the insects will go into the bottle as soon as they leave the galls.



Cut a hole near the top of the box to fit the top of your bottle. If the fit is not good, seal the bottle into the hole with adhesive tape so the insects can't get out through the crack.

Before you put a gall into a box, look for holes in them where the insects may already have escaped. Have a separate box for each kind of gall, or you will not know for sure which gall and insect go together. Some galls are caused by animals other than insects—mites, for instance—and some by fungi or microbes. These will never produce any insects. The best way to find out if a gall is an insect gall is to wait and see.

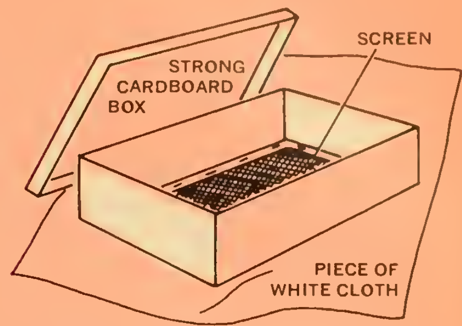
Most gall insects are either wasps or flies, but some are moths, aphids, or members of other groups. When more than one kind of insect comes out of one kind of gall, the extra ones are probably *parasites*, which live on the other insects in the gall. You can also keep small pupae and mud-dauber wasp nests in emergence cages to see what comes from them.

Collecting Sieve

A collecting sieve is used to shake little animals out of the bottom of a pile of dead leaves. (The top of a pile is usually too dry for most insects and in the winter it is too exposed.)

Get a large covered cardboard box and cut out most of the bottom, leaving a rim about an inch wide all around. Then cut a piece of $\frac{1}{4}$-inch wire screen to fit into the bottom of the box. Sew the screen to the rim of the box with a big darning needle and a piece of string. Take very big stitches. Strengthen the edges of the box with adhesive tape.

To use the sieve, fill it not more than half full of leaves, put on the cover, and hold it over a piece of white cloth, about a

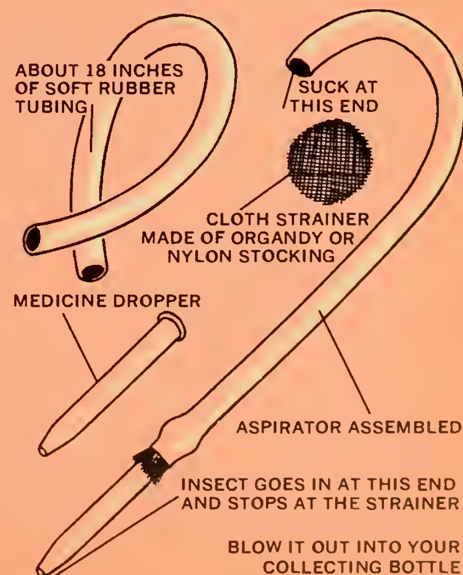


yard square. Then shake the sieve hard. A lot of little dark things will fall out onto the cloth. Watch for a few minutes. Anything that starts to move is an animal. An aspirator is the best tool for picking them up. If you don't have one, use a small watercolor paint brush. Moisten the brush with alcohol from your collecting bottle. Sweep up the insect with the tip of the brush and wash it off in the bottle.

When you think you have caught all of them, clear your cloth and give the sieve another shaking. Three or four shakings should get out all the insects that will pass through the screen. Then dump out the sieve and start over. Keep notes on where you found the leaves, the date, the weather, and so on.

Aspirator

An aspirator is a vacuum cleaner for sucking up insects so small that fingers or forceps would damage them. These drawings show how to make one. If you have trouble keeping the cloth strainer in place while you put the rubber tubing over it, glue it to the top of the medicine dropper with plastic cement first. Then you can trim the edges close to the glass and the tube will go on more easily. Be sure it is tight all around, or you may swallow your specimens.



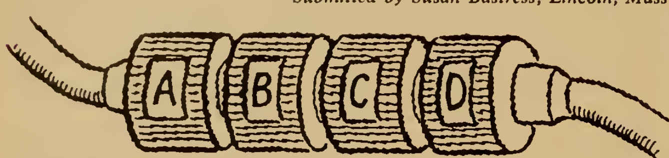
prepared by DAVID WEBSTER

Can You Do It?
Unscramble these letters and you'll have the names of two 4-footed animals and one 2-footed animal. When you finish unscrambling, you will have a 3-letter word-square that reads the same both down and across.

KEE
OLD
LOW

Fun with Numbers and Shapes
My bike combination lock has 4 numbers. If I told you that their sum is 14, that the sum of A and C equals B, and that the sum of A and B equals the sum of C and D, could you figure out the four numbers?

Submitted by Susan Bastress, Lincoln, Mass.



For Science Experts Only
Suppose some salt, iron powder, and sand were all mixed together. What could you do to separate them into three different piles?

MYSTERY PHOTO

What is it? A feather? A root? A rock crystal? A river? Or something else?

Answers to Brain-Boosters in the last issue

1. The plant stalks are a darker color than the snow. The heat that they absorb from the Sun melts the nearby snow.

2. The cooling system of a refrigerator takes heat from the inside of the refrigerator and releases it into the room. If the refrigerator door were left open, there would be no change in temperature.

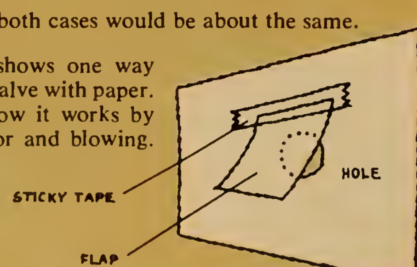
3. The bag of water acts as a lens and enlarges the words of a newspaper. The fatter lens magnifies more than the skinny one.

4. The bean plant Harry grew might have turned light green in the sunlight. If a bean plant were grown in the light, its color could have been compared with the color of the plant in the dark. It would also have been a better experiment if Harry had planted many seeds instead of just one.

5. The skeleton on the right is a human infant. Did you notice the shape of the skulls and the length of the arms?

6. The friction in both cases would be about the same.

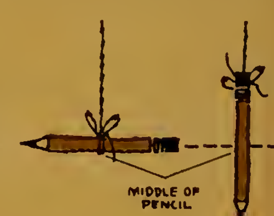
7. This drawing shows one way to make a simple valve with paper. You can watch how it works by looking in a mirror and blowing.



8. The iguanas are disappearing from the islands that have goats living on them. The goats destroy the underbrush, leaving young iguanas with no place to hide from large, meat-eating birds.

9. Both animals would have been going from left to right. When a rabbit hops, he places his small front paws between and slightly behind his large hind feet. The open part of a horseshoe is at the back of the horse's hoof.

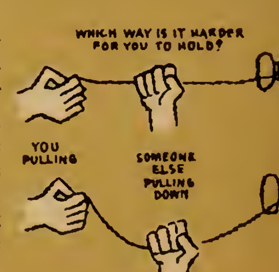
10. The pendulums will not go back and forth with the same frequency. The pendulum with the pencil tied at the eraser end will go back and forth slower. To make it the same, its string can be shortened until the middle of the pencil is about in line with the other pencil.



11. Lines drawn east from the mountain top and north from the big rock intersect on the north shore of Birch Pond. This is where the deer would be.

12. Carbon dioxide gas will be given off when the vinegar is mixed with the baking soda. The carbon dioxide will inflate the balloon a little.

13. To find out why the towers of suspension bridges are so high, try this experiment. Tie a short piece of rope to a door knob and pull tight. Have someone else pull down on the rope in the middle (*see diagrams*). Is it hard for you to keep the rope from going down? Now try the same thing with the rope looser. Why are bridge towers high?

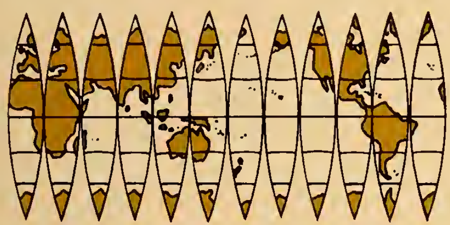


14. There are more bones in the wrist of the 10-year-old boy.

MAKING THE EARTH FLAT

We have to flatten out our planet whenever we make maps. To find our way from one place to another, or to show the shapes of land masses and where they are, we use many different kinds of maps. **by David Linton**

■ The Earth is round, yet to find our way from one place to another we treat the Earth as if it were a flat surface. One way to get a flat view of our planet would be to strip the paper off a globe. If you did this carefully, then spread it out, you might see something like this:



But it wouldn't be a very useful map, because it has too many holes in it.

To make a map we have to make a flat picture of the curved surface of the Earth, or whichever part of the Earth interests us. Such a picture is called a *projection.* There are hundreds of different projections. This article describes the three main kinds of projections, and the WALL CHART on pages 8 and 9 shows a map of the same part of the Earth made in each of these three ways.

The kind of projection you use depends on what you want the map to show. You may want a map to show the *shape* of a continent. Or the *direction* from one place to another. Or *distance,* so that you can measure it accurately on the map. Or *area,* so you can see how large a country is. No one projection can show all of these things correctly. Different projections are needed for each of them.

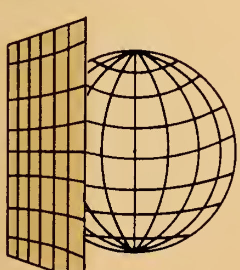
How Projections Are Made

Suppose you had a clear plastic globe of the Earth with a light bulb inside. If you held a piece of paper next to the globe, each line on the globe would make a shadow on the paper *(see diagram).* The shadows would be a *projection* of the lines on the globe. By bending and twisting the paper this way and that, you would see many different kinds of projections and each one would be a different kind of map. All of them would be "right" in some respects, but "wrong" in others.

You can see what the different projections do by looking at the *meridians* and *parallels.* The meridians are the lines that run north and south on a map or a globe. On a globe, these lines meet at the poles and are farthest apart at the Equator. They are also called "lines of longitude." On maps and globes the meridians are numbered from 0 to 180 degrees east and west. The "prime meridian," or 0°, runs through Greenwich, England. Measuring west from Greenwich, you can see that the longitude of Omaha, Nebraska, is exactly 96°W. Measuring east from Greenwich, the longitude of Alexandria, Egypt, is about 30°E.

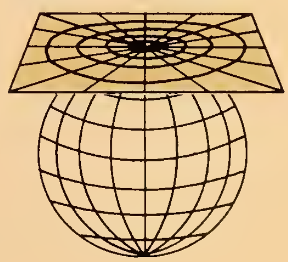
The parallels are the lines running east and west on a map or a globe. They form circles around the Earth, the Equator being the largest circle. Going toward the North and South Poles, the circles become smaller and smaller. (The circles formed by meridians are all the same size.) The parallels are also called "lines of latitude." Latitude is also measured in degrees, but north and south of the Equator. The South American city Montevideo is about 35°S. Los Angeles is 34°N. Look in an atlas and find the longitude and latitude of where you live.

If you held a piece of paper flat so that the center of the paper just touched the clear plastic globe, you would see a *plane projection.* Suppose you made the paper touch the globe at the North Pole. On the paper, the meridians would be straight lines stretching out from the pole, and the parallels would be circles, as they are on the globe *(see diagram).* But the parallels would not be spaced equally. Those near the outside of the map would be farther apart *(Continued on page 10. On pages 8 and 9, North America is shown in three different projections.)*



A light inside a globe throws shadows of meridians and parallels on a flat sheet of paper held up against the globe. This kind of projection is most accurate at its center. Land areas are "stretched" around the edges of the map.

Holding a flat sheet of paper against a lighted globe at the North Pole produces a polar plane projection. The meridians are straight lines and parallels are circles. Sizes and shapes are most exact at the center of the projection.

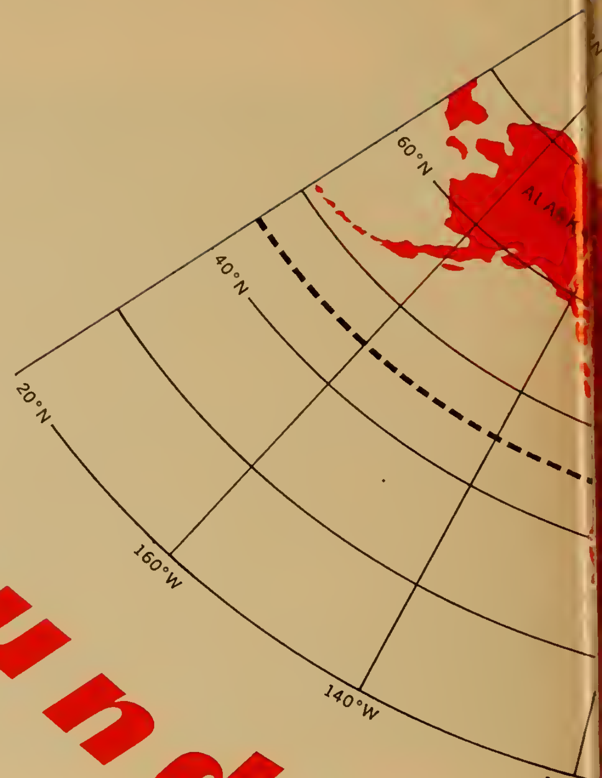


■ It is impossible for a map to show the *true* shape of any *large* area of the Earth. If you think about this for a moment, you should know why this is so. It is because the Earth's surface is curved, while a map's surface is flat.

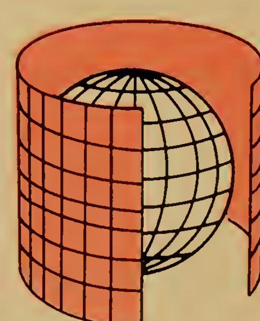
The kind of *projection (see pages 7 and 10)* a mapmaker uses to picture a curved surface on a flat map will determine the shape of a continent on his map. Each of the three maps on this WALL CHART shows the same area—North America. Although the continent has a different shape in each projection, each of the maps is "correct." Sometimes a mapmaker wants a map that shows *distances* accurately. Other times he wants a map that shows the *shapes* of small areas accurately. And still other times he wants to show *directions* accurately. Because no one projection can do all of these things, the mapmaker must choose the projection that best suits his needs.

The small sketches beside each map show how each of the three projections is made. In each sketch, imagine a clear plastic globe with a light bulb inside. The light bulb and globe act as a projector that shines the outlines of the continents onto the "screen"—a piece of paper wrapped around the globe or held against it in a certain way. When the paper is spread out, it becomes a map like those you see here ■

around the



Notice that the shaded area is about the same size and shape on these three maps. But what happens to sizes and shapes north and south of the shaded area? For instance, is Canada the same size and shape on all three maps? Compare the shapes of Canada and other land areas on these maps with their shapes on a world globe.



MERCATOR MAP—This map is made on a cylindri projection (see *diagram*). The shapes of small areas correct and all directions are true compass directio The Mercator is a sailor's map. Harbors and coastli have the correct shapes, and you can read on the n the true direction from where you are to where you w to go—but not by the shortest routes.

Although small shapes and directions are correct o Mercator map, sizes and distances are wrong. farther north or south of the Equator you go, the m the distances are stretched. For example, on a Merca map Iceland looks about the same size as Borneo. Ac ally, Borneo is more than twice the size of Iceland. M people think that Siberia, Greenland, and Australia much larger than they really are because they have s them on Mercator maps. The polar regions cannot shown at all on a Mercator map.

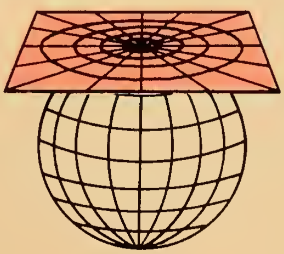
SIMPLE CONIC MAP—This map is made on a conic, or cone, projection *(see diagram).* It is most accurate along the middle, or *standard*, parallel. This map has a "balance of errors"—meaning that the errors do not become extreme toward the top and bottom of the map. The errors in direction, distance, and shape are about the same all over the map.

A straight line on this map will show almost, but not quite, the shortest distance between two points. A simple conic map works best at latitudes near 30°N and 30°S. Notice that the meridians are all straight lines, and that the parallels are equally spaced.

orld in 80 ways

LAR STEREOGRAPHIC MAP—This map is made on a plane ojection, centered on the North Pole *(see diagram).* The rallels, or lines of latitude, are spaced in such a way that the apes of small areas are correct. A straight line drawn from any e place to another on the map traces the shortest route be- een those two places.

A map using a plane projection does not have to be centered the North Pole or South Pole. It can be centered on any nt on the Earth's surface. This is the best kind of map for owing distances from one place. For example, you would e this projection centered on New York for a map showing line distances from New York to cities around the world.



PROJECT

Find a Mercator map of the world and look at Greenland. With a tape or ruler, measure how many inches long and how many inches wide Greenland is. Now measure the length and width of South America. Which land mass seems to be the larger?

Now find a large globe and measure Greenland and South America on the globe. Which land mass seems larger now?

Go to an atlas and find out how many square miles Greenland covers, and how many square miles South America covers. Which is larger?

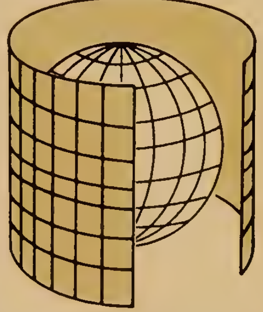
than those nearer the center of the map. The Equator and the Southern Hemisphere, of course, would not show at all.

When maps are made on plane projections, the parallels at the outer parts of the map are spaced so as to make either shapes, distances, or areas correct. But what about directions? If the map is centered on the North Pole, a line from north to south will be a straight line on the map, but a line from east to west will be a curved line. (A parallel is such a line.) This means that directions can not be read directly from this kind of map.

A projection does not have to be made on a flat sheet. It can be made on any surface that can be unrolled into a flat sheet, such as a cylinder or cone.

The Greenland Puzzle

Suppose that you rolled a sheet of paper into a tube or cylinder shape and slipped it over our plastic globe so that the paper touched the globe all around the Equator. This would give a *cylindrical projection*. It is also called a Mercator projection, because the first map of this kind was made in 1569 by Gerhard Mercator, a maker of globes and instruments who lived in what is now Belgium. On the Mercator projection, all the meridians become parallel straight lines *(see diagram)*. Since the meridians never meet



On a cylindrical Mercator projection, "shadows" of meridians and parallels are straight lines. The farther land areas are from the Equator, the more they are spread out. The distance between parallels also increases.

on this kind of map, it is impossible to show the polar regions, and the map usually ends at 70°N and 70°S.

The lines of latitude are also parallel straight lines on a Mercator map. But they are not evenly spaced as they are on a globe. They are squeezed together near the Equator, but they are spaced farther and farther apart toward the poles. This makes a Mercator map like a globe map near the Equator. The farther north or south you go on a Mercator map, the more everything—land masses and oceans—are spread out.

The Mercator map has an important property. Although the sizes and distances shown on the map are wrong, all directions are correct. Draw a straight line joining any two places on a Mercator map, and the line will give you true compass direction from either place to the other. This is why the Mercator map is so widely used.

If you roll a sheet of paper into a cone and put it over the clear plastic globe, you will get something called a *conic projection*. The cone will touch the globe along one parallel. The meridians will be straight lines that meet at the pole. The parallels will not be straight; they will be curved, but they will be parallel *(see diagram)*.

A "paper-cone," or conic projection, shows meridians as straight lines, joining at the North Pole. Parallels are curved. Distances and shapes are fairly accurate, but it is hard to measure directions.

Directions can not be read directly from a conic projection map, but distances, small shapes, or areas can be made true. This depends on how the parallels are spaced when the map is made.

Different projections, then, give the world different shapes. From now on, when you look at a map, see if you can find out what kind of projection it is. The name of the projection is usually printed on the map ■

PROJECT

On a globe, tape one end of a piece of string to Sydney, Australia. Stretch the string over the curved surface to Valparaiso, Chile, and tape the string to the globe there. Now, write down the latitudes where the string crosses each meridian between the two cities. Each place where you take a latitude and longitude reading is called a "fix."

Next, on a Mercator world map make a pencil dot at each of the fixes you took on the globe. After you have dotted in all four or five fixes, connect them by drawing a line through them. What shape is the line? Is it straight? Is it curved?

The line you have drawn is called a "great circle route." A great circle route is the shortest distance between any two points on the Earth's surface. Suppose an airline pilot followed a straight line on a Mercator map from Sydney to Valparaiso, rather than the line formed by your fixes. Which of the two lines would represent the shortest route?

OUR BACKYARD BEAVERS

by Willard and Elma Waltner

When beavers moved into a creek near our home, we set out to learn about the lives of these fascinating animals.

■ Many, many moons ago, according to an old Seminole legend, Indian children captured some young beavers and took them home as pets. The children grew so fond of the little animals that they did not wish to give them up, so the "Beaver King" and the Seminole chief made an agreement. The beavers would make fish-stocked lakes for the Indians by building dams across small streams. In addition, each year two young beavers would be sent to be playmates for the Indian children. In return, the Indians promised not to bother the beavers.

For many years the animals and Indians lived peacefully side by side. Then the old chief died. The new chief broke the treaty and declared war on the beavers. Gathering all of his warriors, he began a march on the animals to destroy them. Seeing that the Seminoles were about to attack, the "Beaver King" gave a mighty slap with his tail. At once the beavers set to work. They ripped out the dams they had built and a great flood spread over the land. The Seminoles had to flee for their lives.

To this day the great Okefenokee Swamp in northern Florida and southern Georgia—the result of the flooding—remains a watery haven for beavers. And to this day, beavers still use the same tail slap as a danger signal.

This is only a legend, of course, but the tail-slapping danger signal really is used by beavers, as we discovered for ourselves. In the summer of 1963, some beavers moved into a creek that flows through a grove of trees on our 240-acre farm in South Dakota. About the middle of summer, we discovered the beginnings of a dam built across the shallow stream. It was just an eighth of a mile from our house. At first the dam was just a few large tree limbs, sticks, and brush, tightly laced together and plastered with mud to keep them from washing downstream. At this stage the dam didn't look very substantial. However, when we tried to pull out one of the smaller sticks, it was so firmly anchored that we could not budge it.

The water began backing up behind the dam, forming a pond. As summer went on, more and more material was added to the dam and the pond rose higher. The creek flowed on, running out a spillway at one end of the dam.

Photographing a Beaver

Every few days we checked the progress of construction to see how much had been added. However, no matter how long and how quietly we sat on the stream's bank, we never did see the beavers at work in the daytime. We had read that beavers work mostlv at night. That seemed to be what ours were doing. We were determined to get a picture of them at work, so one evening we stationed ourselves with camera and flash equipment on the bank near the dam.

Dusk deepened into dark. The robins finally stopped singing and all was quiet. We waited, perfectly quiet, not even whispering. It was one of those velvety black nights with no moonlight.

About 10 o'clock we heard rustlings on the opposite bank, then sloshings just above the dam. When we thought the creature was in about the right place, the camera shutter was tripped and there was a quick bright flash of light. The beavers paid no attention. Apparently the bright light from the flash was like a bolt of lightning to them. They went right on with their work.

Several more times the camera shutter was tripped. Then one of us shifted position a bit and made a slight

(Continued on the next page)

This photo shows some young neighbors of the authors, looking at a beaver dam. The dam is made of branches and mud. When complete, it was nearly five feet high.

Our Backyard Beavers (continued)

sound. There was a moment of silence, then a sudden loud "splat" as a beaver smacked the water with his flat tail. There were some frantic splashings, then dead silence. We waited for almost an hour but the beavers did not return.

When the film was developed and the pictures printed we had a good look at a beaver at work. He had just crawled up out of the water onto the dam with a stick in his mouth and was about to place it in the dam *(see photo on page 11)*.

Lodges and Tunnels

Beavers live either in lodges made of limbs, branches, and mud, or in tunnels dug in the bank of a stream or lake. A lodge may be up to 40 feet across and as high as 14 feet. Each lodge has at least one underwater entrance which slopes up to a main room within the lodge that is above water level (*see diagram*).

The beavers that moved into our stretch of creek dug a tunnel into the stream bank. How far back the tunnel runs we do not know. It may be many feet if the experience of one of our neighbors is any evidence. He once had a beaver colony on his land. One day he was harvesting grain in a field about 300 feet away from a creek bank. Suddenly a wheel of the harvesting machine broke through the surface into what seemed to be the "hallway" to the beavers' home. The tunnel was about 2½ feet in diameter, and was partly filled with water from the creek. It was impossible to tell how much farther the tunnel ran before it reached the animals' living quarters.

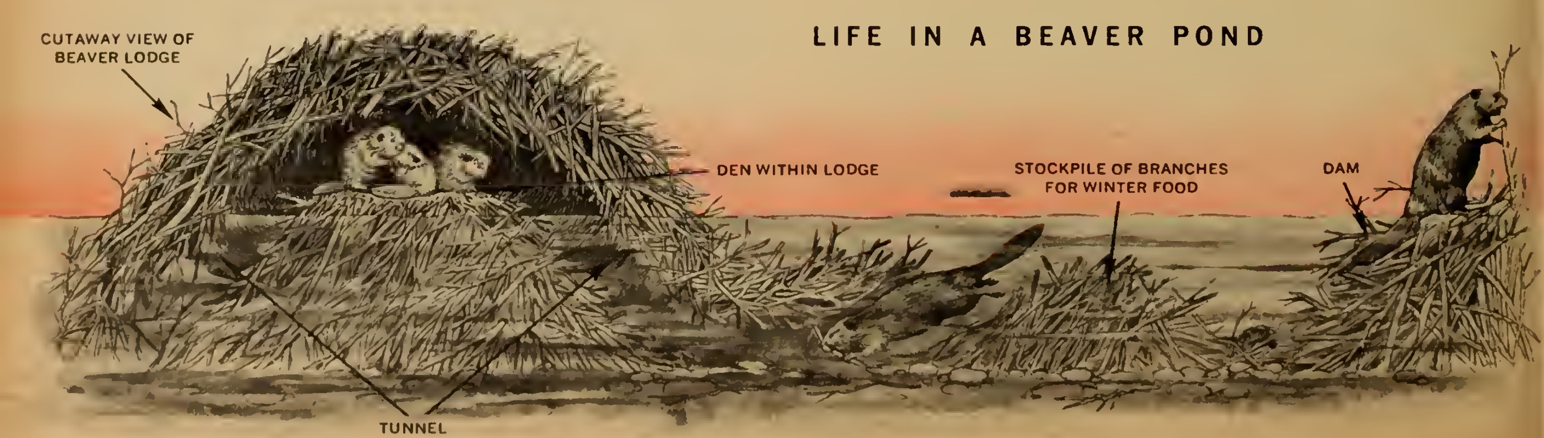
Beavers eat the bark, twigs, and buds of trees, as well as water plants. They cut down trees to get most of their food, gnawing around the trunk in a broad band with their sharp, chisel-like teeth. Chip by chip, they cut the trunk into an ever-thinner cone, until the trunk snaps and the tree falls. Sometimes a tree is felled in the wrong direction. Once we found a cut tree that had fallen into the forked trunk of another tree. There it teetered, several feet above the water and no good at all to the beaver. Sometimes a beaver is killed by the falling tree it has gnawed through.

Building Dams and Storing Food

The spot that our beavers chose for a dam had no trees nearby. So they cut small limbs from upstream trees and floated them down to the dam site. Through August and early September, the animals worked only irregularly and the dam rose slowly. As summer drew to a close and cooler days came, we noticed that the tempo of work picked up. We also discovered that the beavers had more than one dam. There was a smaller dam about 100 feet downstream from the main one, and another still smaller dam about the same distance beyond the second.

By the time the nights began to be frosty, the main dam was as high as the stream bank. Next the spillway was closed so that the water trickled over the top evenly across the entire width of the dam. The pond behind it was four or five feet deep.

As the dam neared completion the beavers began stocking a winter food supply. At one place in the pond we discovered an ever-growing pile of green branches and limbs which they had dragged under water and anchored to the bottom. For about a half mile upstream we could see where



the limbs had been cut off the ash and willow trees that grew at the water's edge. These were floated downstream and added to the food pile. All through the fall the beavers kept cutting down trees along the creek. Finally the weather got so cold that the creek froze and the work of tree-cutting stopped.

Beavers spend most of the winter months in their brush or bank homes. When a beaver is hungry, it swims out of the house to the underwater food supply. There it grabs a limb in its teeth and swims back to the lodge or tunnel to feed. Ordinarily beavers don't come above the ice, but we had a warm spell in February. Then we noticed that there were holes in the ice at the creek bank where the openings to the tunnels were located. One day after a fresh snow we could see where a piece of brush had been cut off and dragged for quite a distance to the mouth of the tunnel. Perhaps the beavers' underwater food supply was getting low.

Beavers usually mate in February, and the young—called *kits*—are born in May. There are usually four kits. We are not sure if any young were born in our colony this past spring. The only clues we have are some photographs taken during the summer. We were determined to get pictures of the beavers as they gnawed on trees. They were working on several trees, and by setting up a camera and flash as before, we did manage to take two pictures. One photo was of a large beaver, and the other was of a much smaller beaver, perhaps a kit.

When Beavers Are a Nuisance

When beavers build dams they affect the lives of many other animals. Mice and rabbits had to flee from our grove to higher ground as the water in the pond rose. We found that water animals, such as muskrats, minnows, and frogs became more plentiful. Some trees were killed by the rising water, while water plants thrived in the new pond.

Because beaver fur is valuable, these animals were wiped out in many areas as the United States was settled. However, they are now protected by law except during trapping seasons, and have become common in many areas. There are beaver colonies within 45 miles of New York City.

Beavers can become nuisances. Their dams may flood valuable farm land or wash out roads. Men from state conservation departments use special traps to catch the beavers alive and move them to areas where they will do no harm.

Even our beavers have become a nuisance. We want to save our biggest trees from being cut down. To keep the beavers away, we painted the tree trunks with roofing tar. This stopped the beavers for a time, but now they no longer seem to mind the tar flavor. Now we are wrapping a woven wire fence around the trees we hope to save. Beavers can be a bother, but we hope that our backyard colony will stay so we can learn more about these fascinating animals ■

PROJECT

Are there beavers living near you? To find out, look in library books for information about beavers in your area. Also look along streams for dams, lodges, and other beaver signs. If necessary, call or write to the game warden, conservation biologist, or other local representative of your state conservation department. Try to visit a beaver colony and see for yourself how they build dams and cut down trees.

■ Two books about beavers are **The World of the Beaver,** by Leonard L. Rue III, J. B. Lippincott Co., Philadelphia and New York, 1964, $4.95; and **Beaver Business: An Almanac,** by Glen Rounds, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1960, $3.

Beavers get most of their food by gnawing down trees (left). You can recognize a beaver-chewed tree by the tooth marks on it and the rectangular wood chips on the ground (center).

When beavers are nuisances, men from state conservation departments trap them alive and release them (right) in other areas where they will do no harm.

SCIENCE WORKSHOP

With a few pieces of simple equipment, you can make and measure your own

"LITTLE LIGHTNING"

How can you put "little lightning" on a comb and pick up bits of paper like this?

■ Have you ever scuffed your shoes along a fuzzy rug, then touched some object or a person and seen sparks jump from your finger? Or have you heard crackling sounds when you combed your hair? If so, you have made "little lightning," or *static electricity.*

Unlike the electricity that flows through the lamp cord in your home, static electricity does not flow evenly. ("Static" means still.) Static electricity forms on objects made of things such as rubber, glass, or plastic. The object is then *electrically charged.* If the charge is big enough, it makes a spark when it flows away to some other object.

Here are some ways that you can make static electricity. Static electricity experiments will not work very well on damp days, so pick a dry day for your experiments. Get some rubber balloons, a piece of wool cloth, a glass rod or tube, and a piece of silk or nylon.

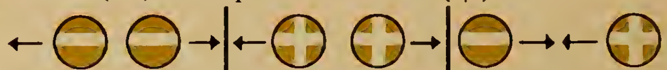
Blow up one of the balloons and tie it at the neck. Stroke the balloon with a piece of wool cloth about a dozen times. Move the cloth all around the balloon. As soon as you finish, hold the balloon against a wall and let go. Why do you suppose that it clings to the wall? Rub the balloon again and see if you can pick up some small pieces of paper with it.

How the Balloon Clings to the Wall

All things are made of tiny particles called *atoms.* Atoms are so small that we cannot see them with the most powerful microscopes. A cube of air this size has 10,000,000,000,000,000,000 atoms.

Atoms themselves are made of even smaller particles. Two of the particles that make up atoms are called *electrons* and *protons.* These are the particles that interest us when we talk about static electricity.

Electrons *repel,* or push away from, each other. Protons also repel each other. But an electron and a proton *attract,* or pull toward, each other. In this diagram, an electron is marked (—) and a proton is marked (+):



Atoms have the same number of protons and electrons. But an atom that is electrically charged has either some extra electrons or a shortage of electrons.

You can move electrons from one atom to another quite easily. When you rub a balloon with a wool cloth, for example, electrons move from atoms in the cloth onto atoms in the balloon. This gives the balloon extra electrons. When you hold the balloon against the wall, its extra electrons are attracted to protons of the wall. The balloon clings to the wall as long as the balloon stays charged. As soon as the balloon loses its extra electrons—to the wall or to the air—it is no longer charged, so it falls to the floor. To charge the balloon again, all you have to do is rub it with the wool cloth. This gives it extra electrons.

What do you think would happen if you let two charged balloons hang side by side? To find out, tie two balloons together with a piece of string and loop the string over something so the balloons hang side by side. Now rub each balloon with a piece of wool cloth and see what happens.

Extra Electrons or a Shortage of Electrons?

You can charge a glass rod by rubbing it with a piece of silk or nylon. But have you rubbed extra electrons onto the glass rod? Or have you rubbed electrons off the glass rod, leaving it with a shortage of electrons? To find out, charge a balloon by rubbing it with a wool cloth and let the balloon hang in the air on a string. Now hold the charged glass rod close to the balloon. If it repels the balloon, the glass rod also has extra electrons, like the balloon. If the balloon clings to the glass rod, then the rod has a shortage of electrons. You rubbed electrons off the rod when you charged it.

When you rub things made of different substances with a wool or silk cloth, what happens? Do they gain electrons or lose electrons to the cloth? Here's a way to find out. Charge a hard-rubber comb by rubbing it with wool, then hold it close to a charged balloon to see if it repels the balloon or attracts it. Write the results in the table above. Then charge the comb by rubbing it with silk and test it the same way. Other objects you can test this way are a plastic ruler, wooden ruler, a piece of plastic dry-cleaning bag, and a strip of paper. (Rub the paper as you hold it against a flat surface.) If a charged object repels a charged balloon, it has gained extra electrons; if it attracts a charged balloon it has lost some electrons.

	RUBBED WITH WOOL	RUBBED WITH SILK
HARD-RUBBER COMB	REPELS BALLOON ( ) ATTRACTS BALLOON ( )	REPELS BALLOON ( ) ATTRACTS BALLOON ( )
PLASTIC RULER	REPELS BALLOON ( ) ATTRACTS BALLOON ( )	REPELS BALLOON ( ) ATTRACTS BALLOON ( )
WOODEN RULER	REPELS BALLOON ( ) ATTRACTS BALLOON ( )	REPELS BALLOON ( ) ATTRACTS BALLOON ( )
PLASTIC BAG	REPELS BALLOON ( ) ATTRACTS BALLOON ( )	REPELS BALLOON ( ) ATTRACTS BALLOON ( )
STRIP OF PAPER	REPELS BALLOON ( ) ATTRACTS BALLOON ( )	REPELS BALLOON ( ) ATTRACTS BALLOON ( )

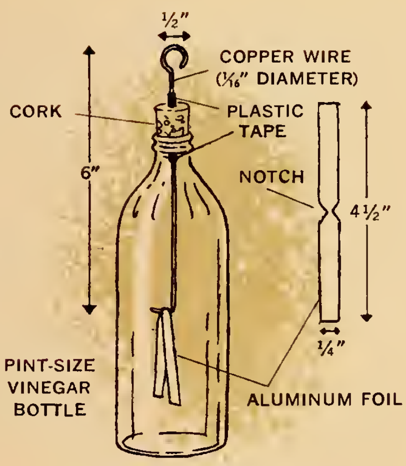
Big lightning is also caused by static electricity. A thundercloud is made of tiny particles of water, ice, and dust moving rapidly up and down. Some scientists believe that the larger particles rub electrons off the smaller particles, then the larger particles tend to gather in the lower part of the cloud. This gives the lower part of the cloud an electrical charge, and the extra electrons jump to the ground, or to a nearby cloud, in a tremendous spark ■

How To Make and Use an Electroscope

You can make an electroscope to detect and measure static electricity *(see diagram)*. In making it, be sure that the vinegar bottle is clean and dry. Push the end of the wire through the hole in the cork before making the right-angle bend in the wire.

When the electroscope is completed, hold a charged balloon near the loop of wire—*without touching the loop*. What happens? When you take the balloon away, what happens to the aluminum leaves?

When you hold the balloon close to the loop, extra electrons on the balloon push electrons from the copper wire onto the aluminum. This happens even though the balloon's electrons don't move off the balloon. The electrons collect on the leaves and cause the leaves to push apart. When you move the balloon away from the loop, the loose electrons on the leaves scatter through the copper wire. The leaves are no longer charged, so they hang down again.



Now rub your glass rod with silk and slowly bring it near the loop, but don't touch the loop. The glass rod has a shortage of electrons. It attracts loose electrons to the top of the wire—although they don't actually leave the wire. This causes a shortage of electrons on the aluminum leaves. Again, the leaves push apart—but this time because they both have a shortage of electrons.

Charge the balloon again, but this time *touch* it to the loop, then pull it away. Some of the balloon's electrons moved onto the wire, giving the wire and leaves extra electrons. The extra electrons stay on the leaves. That's why the leaves stay pushed apart. One way to make the leaves hang down again is to drain off the extra electrons by touching the wire loop with your finger. Can you think of another way?

Your electroscope may do two things: 1. It shows that a charged object is nearby. 2. It also gives you some idea of how strong the charge is. Rub a hard-rubber comb once or twice lightly with a wool cloth and bring the comb *near* the loop. How far apart do the leaves move? Now rub the comb several times and hold it at the same distance from the loop as before. How far apart do the leaves move now? Can you think of other ways to use your electroscope?

HOW IT WORKS

Telephone

■ How does a telephone "carry" your voice many miles, to other cities or even across the oceans to other countries?

When you want to call a friend, you pick up your telephone *handset (see diagram).* As you do this, two small buttons pop up in the cradle, closing a switch. Electricity then begins to flow through the handset. When you speak into the mouthpiece, sound waves from your throat and mouth move through the air and push against a very thin metal plate, called a *diaphragm.* As you talk, the sound waves that you make cause the diaphragm to wiggle in and out many times each second. You can't see the difference, but a high-pitched sound makes the diaphragm wiggle, or vibrate, faster than a low-pitched sound does.

The diaphragm is the cover of a small round box that is filled with powdered carbon. Two wires are connected to the box, so that a little electricity is flowing through the powder whenever the button switch is on. When a sound wave pushes against the diaphragm, it squeezes the powder together tightly, so that electricity flows through it easily. The amount of electricity that flows through the box changes with each wiggle of the diaphragm.

From Electricity Back to Sound

This changing electricity flows through wires to the telephone in the home of your friend. When it reaches the earpiece of his telephone, the electricity flows into a wire that is *coiled,* or wound, around an iron core to make a special kind of magnet, called an *electromagnet.*

When a lot of electricity flows into this coil of wire, the magnet is made strong; when only a little flows in, the magnet is weak. So, as the amount of electricity flowing into your friend's telephone changes, the strength of the magnet in his earpiece changes.

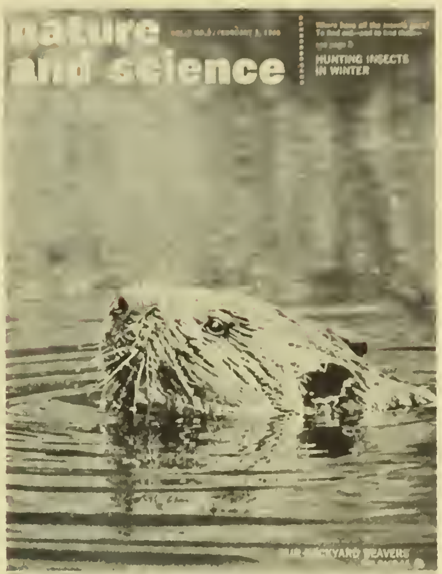
Just in front of the magnet is a thin metal diaphragm. Whenever the strength of the magnet increases, it pulls harder on the metal diaphragm. As the pull of the magnet becomes weaker, it pulls less on the diaphragm. These changes in the magnet's strength and the movements of the diaphragm take place many times each second. As a result, the diaphragm vibrates back and forth very rapidly. As it does this, it makes the air in the earpiece vibrate too, making sound waves. The sound waves strike your friend's ear and he hears your voice.

In a telephone, sound waves change into electric current, then the electric current is turned back into sound waves again.

There are about 400 million miles of telephone wires linking towns, cities, and villages in the United States. This includes undersea telephone lines to other countries. Whenever you make a long distance telephone call, changing amounts of electricity carry your words through many miles of wire. Ship-to-shore telephones and telephones in automobiles operate as radios do. If a friend telephones you from an automobile, his call goes out as a radio signal to a switchboard of the telephone company, then to you by telephone wire ■

nature and science
TEACHER'S EDITION

VOL. 2 NO. 9 / FEBRUARY 1, 1965 / SECTION 1 OF TWO SECTIONS



Using Audio-Visual Aids To Expand the Science Classroom View

by Richard J. Hurley

■ When I walked into a sixth-grade classroom of one of our Fairfax County schools not long ago I saw a group of youngsters bent over a large chart. Beside them was a model of the Bohr atom made of balls of chewing gum and candy. There was also a copy of Heinz Haber's *Our Friend the Atom*. On the teacher's desk were filmstrips about the atom. The chart the pupils were using was an atomic weight chart that they had made to show characteristics of different kinds of atoms.

By using filmstrips — along with other materials — this teacher had managed to excite her pupils about a subject that can be painfully dull.

In a class of fifth-graders I visited the teacher was showing some filmstrips about space. She was preparing her pupils for a visit to the planetarium.

The "magic" that youngsters find in audio-visual aids has been well expressed by Dr. Edwin Peterson of the University of Pittsburgh: "There is something sacred to this generation about a screen. They [the youngsters] seem to operate on the basis: When there is something on a screen, you sit up straight, stay awake, pay attention, and watch it. If it's on a screen, it must be important."

Films, filmstrips, and slides can be made to fill many important teaching roles. For one thing, they can help span the gap between direct experience and verbalizing the experience. One of the chief advantages of A-V materials, of course, is that they can present things and processes that are seldom directly observable to the youngster—be it irrigation of the Sahara or micro-organisms revealed by the electron microscope. Such materials can also be used to speed up the teaching process—or, sometimes equally important, to slow it down to a manageable pace.

How To Find A-V Materials

In science, from astronomy to zoology, you can find guidance in textbook units, the school curriculum, and dozens of catalogs supplied by state and local film libraries, museum education departments (*see page 4T*), government agencies, and film producers, such as Jam Handy, McGraw-Hill, Encyclopedia Britannica, Society for Visual Education, and Coronet, to mention only a few. McGraw-Hill has published a new 14-volume *Educational Media Index*, which lists 28,000 items other than conventional-type books. The Educators Progress Service has the *Educators Guide to Free Slidefilms* and a companion guide to films. The H. W. Wilson Company publishes two indexes, the *Filmstrip Guide* and *Educational Film Guide*.

How To Use A-V Materials

You, the teacher, need to know the psychological and logical time to use films, filmstrips, or other A-V materials in the classroom—and how to prepare the class for the viewing. The teacher should also know how the film or filmstrip can be integrated with subjects other than science.

All of this begins when you preview a film or filmstrip. For example, here are some questions to ask yourself: Are my pupils prepared for technical vocabulary that might be difficult? Do I want to show all of the film in one showing? What questions are my pupils likely to ask? And am I prepared to answer them? Do I want to use the film to summarize a unit just completed? To introduce a unit? To climax a unit? How can I introduce supplementary reading and other materials?

(Continued on page 4T)

Richard J. Hurley is Supervisor of Libraries for the Fairfax County Schools, Fairfax County, Virginia.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● Hunting Insects in Winter
This SCIENCE WORKSHOP article tells where and how to search, what to look for, and how to make simple equipment for collecting and rearing these tiny creatures.

● Making the Earth Flat
Mapmakers must picture the curved surfaces of a sphere on flat sheets. Here are some of the ways they do it, and what happens in the process.

Around the World in 80 Ways
Your pupils can compare the size and shape of the same land mass on maps of North America made on each of the three basic simple projections.

● Our Backyard Beavers
The activities of beavers on a South Dakota farm show how these non-hibernating animals are adapted for survival in the cold months.

"Little Lightning"
Using simple equipment, your pupils can make, detect, and measure static electricity.

How It Works—Telephone
This article explains how the telephone changes sound into electrical impulses and back into sound.

IN THE NEXT ISSUE

How do gorillas live and act in the wild? You might have your pupils write down their ideas before they read "Gorilla Watching in the Congo." . . . A visit to Flatland—a two-dimensional world where people are geometrical figures . . . A SCIENCE WORKSHOP tells how to measure how much water you eat.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Hunting Insects

By going on a winter insect hunt, your pupils will observe some ways in which animals are adapted to survive seasonal changes. The children may be familiar with this concept chiefly in respect to mammals and birds. This workshop activity will extend their awareness of the concept to insects.

Suggestions for Classroom Use

- When keeping insects in an unnatural environment, such as the classroom, it is important to give them the right amount of moisture. Too much moisture may make pupae moldy. Thus the paper toweling or sponge used in the emergence cage should be well squeezed out and re-treated frequently.
- To tell if a cocoon has a live pupa inside, shake it gently. A soft bumping can be heard or felt. A dry rattle usually indicates an empty cocoon. Keep empty cocoons for a collection. Try to identify them.
- Watching insects hatch is a rare treat. Observe your insects every day for signs of wetness or movement. Most moths usually emerge in the morning. Insects emerge in different ways. Try to note exactly what happens. If hunting winter specimens is difficult in your area, you may wish to purchase some cocoons so that your class can have the experience of watching them hatch. One source is the General Biological Supply House, 8200 S. Hoyne Avenue, Chicago 20, Ill. (Cocoons are available between November 15 and April 15.)

Topics for Class Discussion

- *What is the difference between a cocoon and a gall?* A cocoon is an insect home made by the insect itself, out of silk or a combination of silk and leaves or twigs. A gall is an insect home made by a plant. Briefly, this is how a gall is formed: An insect deposits an egg in the plant's tissues. The larva hatches and starts to feed. As it feeds, it secretes chemicals that stimulate plant growth so that a gall is formed. Your pupils may compare this to the formation of a pearl within an oyster.

A specific insect is responsible for a particular type of gall on a particular type of plant. For instance, a goldenrod spindle gall is caused by a moth, while the goldenrod ball gall is caused by a fly.
- *How do some small animals react to winter?* Have your pupils consider garter snakes, turtles, frogs, toads, snails, and spiders. Help them understand that cold-blooded animals, in order to survive, reduce their rate of living, or *metabolism,* by some type of winter hibernation.
- *Do household pets change with the season?* Have your pupils report on their observations. Would they expect pets kept in heated houses to undergo much change? Cats and dogs that spend much time out of doors will often grow a thicker coat of fur.

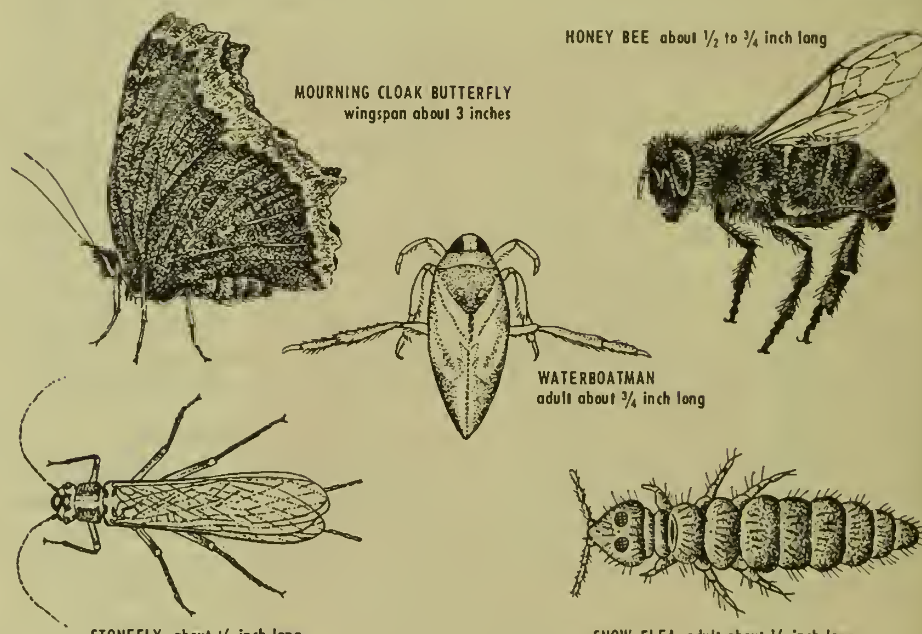
PAGE 7 Making Earth Flat

Cartography, or the making of maps and charts, is a precise science that is continually developing and expanding. This article and the accompanying WALL CHART will introduce your pupils to some of the problems facing map-makers.

Suggestions for Classroom Use

- To emphasize the difficulty of making a round surface flat, cut an orange in half and squeeze out the juice. Have one child make rings or some other design on it with a Magic Marker. Let another child attempt to flatten the hemispheres by pressing down on them.

(Continued on page 3T)



During warm winter days, some kinds of insects will begin to move about, even when there is snow on the ground. They include stoneflies (found near open water), honey bees, mourning cloak butterflies, snow fleas *(Collembola)*, and waterboatmen (aquatic insects that can be seen in open water or under thin ice). In the deserts of the southwestern United States, winter is the time of greatest insect activity. In summer, the dry season, insects are usually inactive. For information on collecting and studying insects, see *N&S*, April 17, 1964, and Summer Edition No. 1, 1964.

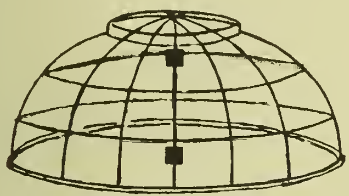
NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N .Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

Using This Issue...
(continued from page 2T)

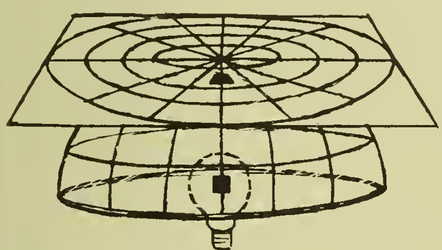
The class will note how the edges tear and how little humps keep popping up. What happens to the design? A hollow rubber ball, preferably a painted one, may be cut from top to bottom and then slit at regular intervals to make it lie flat *(see diagram on page 7 of map stripped from globe).* Again, note how the design is broken up.

• You can demonstrate the three basic types of projections to your pupils by using a round glass bowl to represent the Northern Hemisphere of the Earth. With a Magic Marker, draw two circles around the outside of the bowl, evenly spaced between the rim and the bottom edge of the bowl, like this:



These represent parallels, or lines of latitude. Next, draw lines from the center of the bowl to points spaced equally, about 1½ inches apart, around the rim. These represent meridians, or lines of longitude. You might also draw two black squares, as shown in the diagram, to represent land masses near the "Equator" and near the "pole."

Now, have a pupil hold the bowl upside down over a light bulb and hold a sheet of white paper over the bowl, touching it where the "meridians" meet like this:



The image on the paper is a plane projection. By bending the paper into a cylinder that touches only the rim of the bowl, you can make a cylindrical projection of the "hemisphere." And by making a "dunce cap" of the paper and setting it over the bowl you can make a conic projection.

Have your pupils describe what happens to the meridians and parallels in each of the different projections. By comparing the shapes and sizes of the two black squares in each of the projections, they can get a good idea of what happens to a land mass when it is projected each of these ways.

Explain that maps are no longer made directly from visual projections, but instead the projections are drawn from mathematical calculations. Maps made this way can be adjusted to reduce distortions in shape, size, distance, and direction that appear in a visual projection.

• The meridians and parallels of the globe form a *grid system.* Help your pupils to see that a grid is very useful in locating places on a map. Do they know of a nearby city that has numbered streets and avenues arranged in a grid? How does this help people find their way around?

Topics for Class Discussion

• *What is the most nearly perfect map we have?* The globe is the preferred map for many purposes. It is useful for planning air and sea routes and is the best way to learn about basic world geography. Its disadvantage is that it is awkward to use. To get a road map of your state, you would need a globe 100 feet in diameter. Flat maps can be folded up and carried around, and parts of the world can be drawn to any convenient scale.

• *Which can be more accurate—a map of the Western Hemisphere, of West Virginia, or of West Branch, Iowa?* West Branch. The smaller the area, the more accurate the map can be in all respects. One square mile is relatively flat. To give some idea of the amount of curvature in a mile of the Earth's surface, you may tell your pupils that if their eyes were at the surface of the ocean, a ship 10 miles away would have to be 57½ feet high for them to see the top of it.

• *What is a "great circle"?* A great circle is a circle that cuts the globe in two equal parts. It has its center at the center of the Earth. Thus, all the meridians and the Equator are great circles, but none of the other parallels are. The shortest distance between two points on the Earth lies on a great circle passing through those points. There are an infinite number of great circles.

When sailing or flying a great circle route, compass direction must be constantly changed. Have the class consider what obstacles may prevent ships from following an exact great circle route (islands or larger land masses).

Activities

• Have your pupils examine a good atlas. On each map the name of the projection is usually printed near the scale designation. Your pupils might make a list of the different projections used in the atlas.

• Someone may investigate the use of satellites for map-making.

PAGE 11 Backyard Beavers

Animals that do not hibernate have many difficulties during the winter months. This story explains how beavers, through their unique behavior, are adapted to survive this difficult period.

Topics for Class Discussion

• *What are the special problems of animals that remain active during winter?* They must keep warm, find food, and protect themselves from enemies in a cold, barren world.

• *How does a beaver lodge protect beavers?* A beaver house is like a castle with a big moat around it. It offers protection from animals that cannot swim. The pond water provides a uniform climate, since the water below the ice never drops below 32°F. Their underwater food supply makes it unnecessary for beavers to plow through snow to find food.

• *What makes an animal a pest? Are beavers always a nuisance?* An animal is considered a pest if it has some adverse effect on the prosperity and welfare of man. It has been said that beavers are second only to man in changing plant and animal communities. Have your pupils consider the changes that would occur if beavers dammed a nearby stream. What effect would it have on plants and animals, including humans? Would the changes be good, bad, or both?

Beaver dams help control spring floods. In mountainous western states, cold stream water is warmed enough in beaver ponds to be ideal for the growth of trout. In eastern states, the water often warms too much in beaver ponds and trout do not fare well.

• *Why does the beaver have a flattened tail?* The tail serves as a rudder while a beaver swims. It also serves as a prop—somewhat like a kangaroo's tail—while a beaver sits upright to gnaw on a tree. It is *not* used to carry mud used in dam or lodge building. Beavers carry mud by holding it against their chests with their forepaws.

Using A-V Materials . . .
(continued from page 1T)

There are several textbooks that give excellent teacher guidance on the evaluation and use of films, filmstrips, and slides. Among them are: *Audio Visual Instruction: Materials and Methods,* by James W. Brown et al., McGraw-Hill, 1964; *Audio Visual Methods in Teaching,* by Edgar Dale, Holt, Rinehart and Winston, rev. ed. 1954; *Integrated Teaching Materials,* by R. Murray Thomas and Sherwin G. Swartout, David McKay Co., Inc., rev. ed. 1963; *Audio Visual Materials and Techniques,* by James Kinder, American Book Co., 2nd ed., 1959.

While there are hundreds of excellent science films and filmstrips available, make sure that the ones you use are not out of date. A lot of them are.

Following are a few films and filmstrips that some of our Fairfax County teachers keep coming back to. For the space minded there is NASA's *The American in Orbit,* the story of John Glenn's flight. One sixth grade class uses the Audubon Birds of America filmstrips from Encyclopedia Britannica Films for information about birds not native to Northern Virginia. Another school has found the Disney filmstrips (available from EB), such as *The Living Desert, The Vanishing Prairie,* and *The Arctic Wilderness,* just right for the study of the ecology.

Other films cited as very useful in science—natural resources—are the *Making of Steel,* by the Bethlehem Steel Company; the U.S. Bureau of Mines film, *Story of Copper;* and General Motors' the *ABC of Diesel Engines.*

In our county-wide school system, A-V materials are distributed by our Teaching Materials Center to school librarians, who coordinate requests from teachers. Available A-V material is indexed on colored cards in each school library, and the librarians introduce new materials to the teachers at weekly staff meetings. Each school library also has a number of film strips and records for individual use.

This system encourages and facilitates the use of A-V materials in teaching and fulfills the concept of the library as an *information*—not just a print—center ■

American Museum of Natural History Slides and Filmstrips

■ One of the largest museum stocks of science audio-visual aids in the United States is in The American Museum of Natural History. Here are thousands of 2-by-2-inch (35mm) color slides—nearly all of them suitable for teaching—on botany, zoology, anthropology, paleontology, astronomy, and primitive art. A few color filmstrips are also available.

Among these color slides are photographs of the Museum's famous exhibits showing animals in natural habitats. Other slides show living animals, fishes, reptiles, insects, spiders, birds, marine life, dinosaurs, prehistoric man, Indians, trees and plants, and art objects of tribes around the world.

The Museum also has prepared sets of slides, complete with scripts or charts, on various themes. Some representative titles are "The Story of Ancient Man," "Digging up the Dinosaurs," "North American Mammals," "Flowering Beauties of Spring," and "Some Common Rocks and Minerals." Filmstrips cover such topics as fossils, reptiles, dinosaurs, and mammals.

The Museum's Slide Library will send slide catalogs and filmstrip listings free on request. Individual slides sell for 70 cents each. On orders of 10 or more, the cost is 60 cents each. On quantities of 300 or more, a five per cent discount applies; on 500 or more, a discount of 10 per cent.

Sets of 15 to 34 slides vary from $9.60 to $20 in cost. The color filmstrips are $4 and $6. Slides and filmstrips are no longer available for rental.

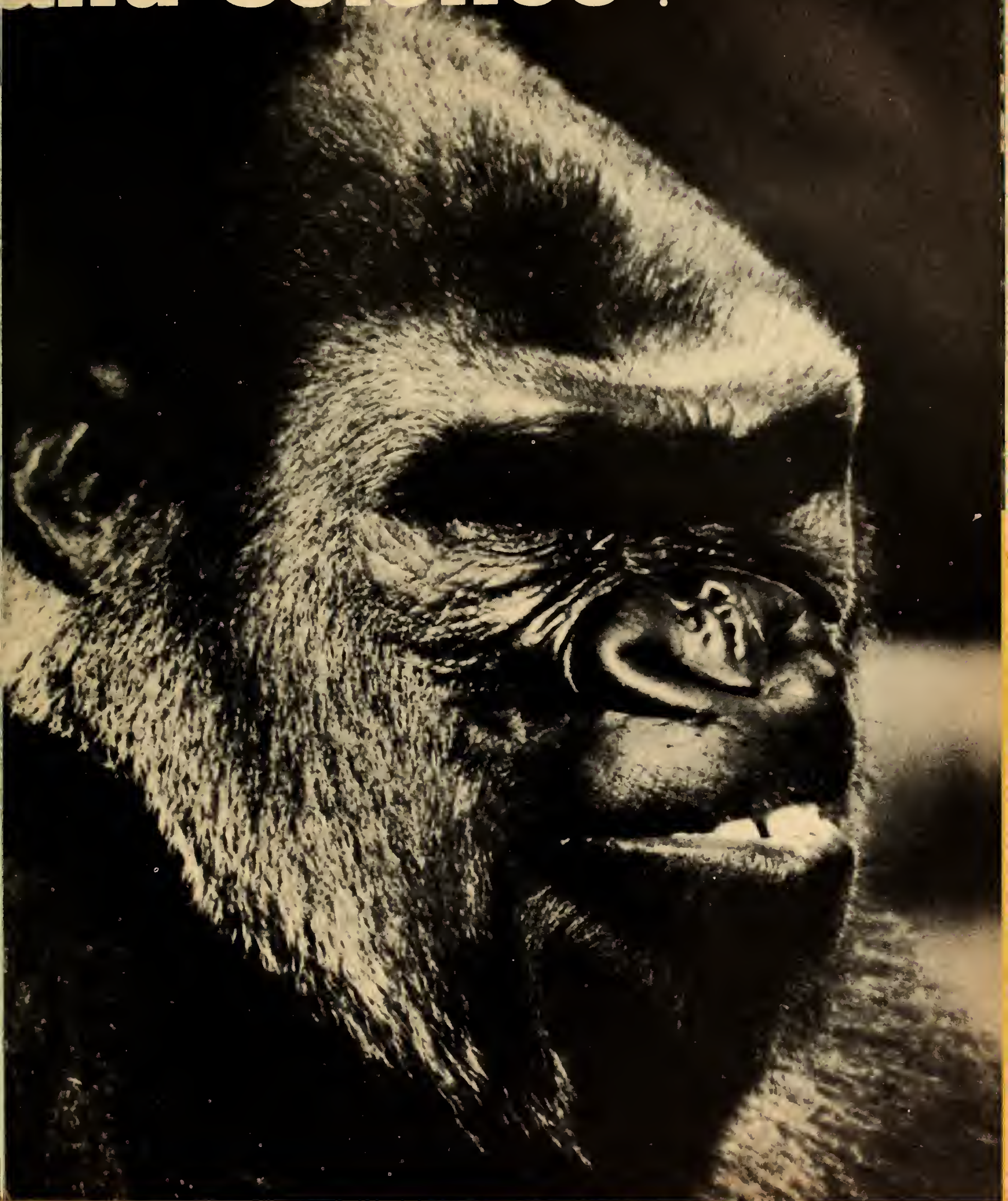
Orders filled from stock are usually on their way by return mail. A few special items may require two weeks for processing and delivery.

Orders and requests for catalogs should be addressed to the Slide Library, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024 ■

nature and science VOL. 2 NO. 10 / FEBRUARY 15, 1965

Man Meets Gorilla
see page 3

IN THE REALM OF THE MOUNTAIN GORILLA



ABOUT THE COVER

What are gorillas really like? Are they fierce, meat-eating animals that chase and crush humans? You have probably seen that sort of gorilla in "jungle" movies and on television. However, those animals are really men in "gorilla suits." Their actions are based on what some people *think* gorillas are like.

The article that begins on page 3 tells what a young scientist discovered about real gorillas—the Mountain Gorillas of central Africa. What he discovered may surprise you.

The photograph above shows a male Mountain Gorilla beating his chest. The animal is part of an exhibit in the African Hall at The American Museum of Natural History.

Chest-beating is part of a wild display that includes hooting, ripping up and throwing plants, and running. Gorillas usually beat their chests with their palms, not their fists. They beat not only their chests, but their bellies, thighs, nearby trees, and even other gorillas. Apparently chest-beating serves to warn other gorilla groups and humans away, and helps gorillas to "let off steam."

To learn more about the secret world of these huge animals, see "In the Realm of the Mountain Gorilla" on page 3.

nature and science

VOL. 2 NO. 10 / FEBRUARY 15, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

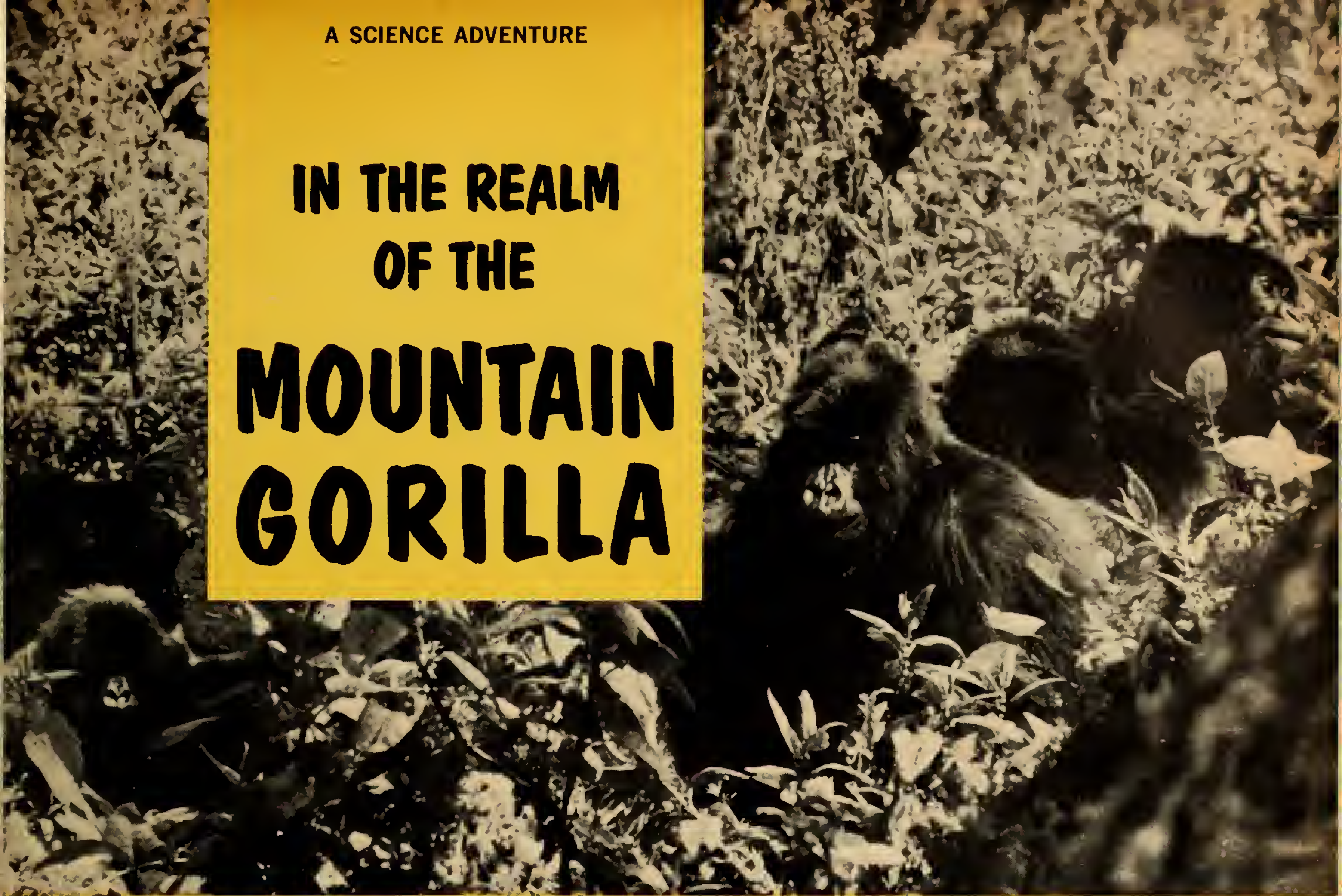
CREDITS: Cover photo by Russ Kinne, from Photo Researchers, Inc.; p. 2, photo from The American Museum of Natural History; pp. 3, 4, 5, 7, photos from George B. Schaller; pp. 4, 10, 11, 12, 13, 14, 15, 16, drawings by Graphic Arts Department, AMNH; pp. 8, 9, maps by R. G. Bryant, valley glacier photo from Annan Photo Features, ice sheet photo by Mark W. Huntley from U.S. Navy, pack ice photo from Wide World Photos, iceberg photo by Bradford Washburn; p. 13, photo by George Cope, Educational Services Incorporated.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

A SCIENCE ADVENTURE



IN THE REALM OF THE MOUNTAIN GORILLA

For two years, I followed groups of mountain gorillas. What I discovered about these huge animals may surprise you.

by George B. Schaller

■ The musty, somewhat sweet odor of gorilla hung in the air. Somewhere ahead and out of sight, a gorilla roared and roared again, *uuuauuua*! It was an explosive, half-screaming sound that shattered the stillness of the forest and made the hairs on my neck rise. I took a few steps and stopped, listened, and moved again. The only sound was the buzzing of insects. Then another roar. I continued on, and finally I saw them—gorillas. There were males, females, and young ones. They were about 200 feet away, some sitting on the ground, others in trees.

After seeing the drab gorillas in zoos, with their hair dull and scuffed by the cement floors of their cages, I was little prepared for the beauty of the beasts before me. Their hair was not merely black, but a shining blue-black, and their black faces shone as if polished.

I fixed my attention on one huge adult male that was sitting among some vines. He had spotted me and was watching me intently. He rose again and again on his short, bowed legs to his full height of about six feet. He then whipped his arms up to beat a rapid tattoo on his bare chest, and sat down again. He was the most magnificent animal I had ever seen. His mouth, when he roared, was like a cavern, and his large canine teeth were stained black. He lay on the slope, propped on his huge shaggy arms, and the muscles of his broad shoulders and silver back rippled. I had a strong urge to speak to the animal—if only he could speak—or by some kind of signal let him know that I intended no harm, that I wished only to be near him. Never before had I had this feeling about an animal.

Suddenly from the forest behind me came a shout: "George! George!" It was Doc—Dr. John T. Emlen, professor of zoology at the University of Wisconsin. I was one of his graduate students.

We were in the African forest together, making a survey of Mountain Gorilla country. He had gone off to search in one direction, I in another. On hearing the many roars, and then the long silence, Doc had become worried about me.

(Continued on the next page)

This article has been adapted from parts of the book, The Year of the Gorilla, *by George B. Schaller, published by the University of Chicago Press, Chicago, Illinois. The article is printed by permission of the publisher.*

At the sound of his voice the gorillas rose and disappeared silently at a fast walk. This and other meetings with groups of gorillas convinced me of one thing. To approach and observe gorillas at short range was possible.

For the greater part of two years I was to live in the African forest with my wife, Kay, and observe Mountain Gorillas. We soon came to cherish the peace, quiet, and sheer beauty of the untamed forest and the magnificent man-like apes that inhabit it.

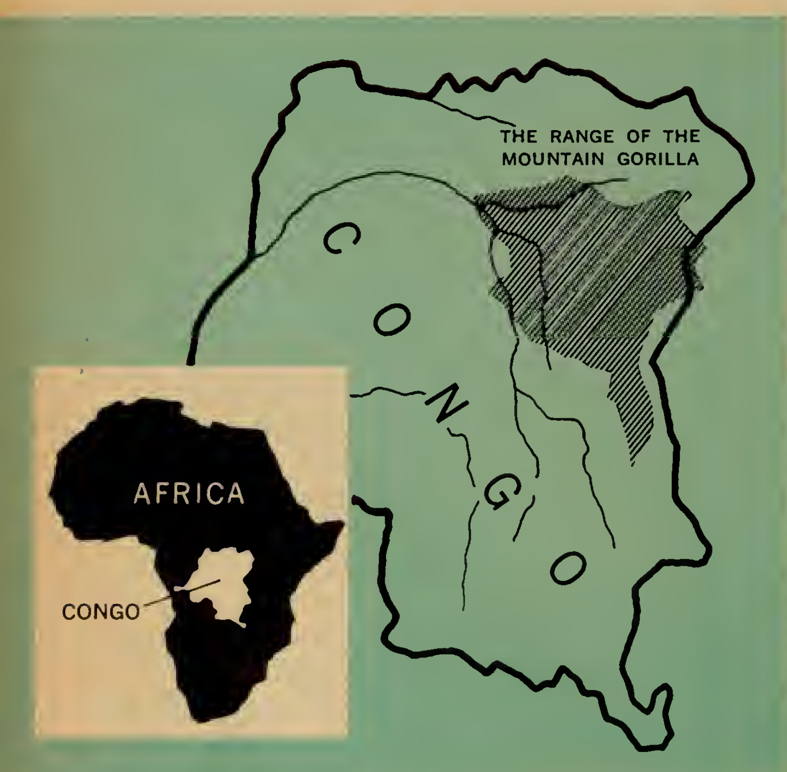
As the author studied groups of gorillas, he learned to recognize many of them by the way they looked and acted. He called this male "Junior."

Ferocious or Peaceful?

The idea most people have of gorillas is hardly an accurate one. Perhaps "jungle" movies and poorly written television shows have helped make us think of gorillas as fierce, blood-thirsty animals that will attack men, crushing them in a death-hug, for no apparent reason. Nothing could be further from the truth. By nature gorillas are shy. They are not meat-eaters, but live on a diet of plants. Whenever they can do so, they avoid human beings.

But there is an exception to every rule. Sometimes gorillas raid banana fields. They do not eat the fruit, but the soft, inner part of the stem. This, of course, ruins the trees of a banana plantation and angers the owners.

Sometimes the natives band together, surround a group of gorillas and net, spear, and slash at anything that moves. Once the male leader is killed or driven away, the natives then go after the females and infants. The West African hunter Fred Merfield once wrote: "I have seen the native hunters, having driven the Old Man away, surround the females and beat them over the head with sticks. They don't even try to get away. It is most pitiful to see them putting their arms over their heads to ward off the blows. They seldom attempt to fight back."



When they do, however, it is usually the males who do the fighting. An attack by a gorilla usually is in the form of a lunge forward, a brief contact during which the gorilla bites, then runs away. The bite of a gorilla can be a serious wound, but usually it is not fatal.

Many observers say that a gorilla will seldom attack a person who stands his ground and faces the animal. But as soon as the person turns and flees, the gorilla follows on all fours and, like a dog, bites. To members of an African native tribe in the Cameroon, it is a disgrace to be injured by a gorilla. These people believe that a gorilla would not have attacked if the man had not fled.

How To Observe Gorillas

Before I could hope to learn anything about Mountain Gorillas, I first had to learn how to approach them without frightening them. I also had to learn to put them at ease so they would not flee—or attack—when I watched them from as close as 30 feet. Over my two years in the forests I studied 10 different groups of gorillas. Sometimes I would follow a group for several days, watching them by day and sleeping near them by night. Many of the animals had such strong personalities, or were so striking in appearance, that I gave them names.

I would begin to study a group of gorillas by visiting the place where I had seen the group the day before. Then I

Sometimes a male gorilla puts a single leaf between his teeth before he begins beating his chest. This is "Mr. Dillon."

Sometimes a male gorilla would beat its chest and roar, then look at the author to see his reaction.

A gorilla often breaks and bends tree branches into a rough platform for its nest.

would follow the trails of the animals through the trampled vegetation. I could never be sure if they were a hundred yards ahead, a mile, or had doubled back so that now they were somewhere behind me.

The trails always had an interesting story to tell. In many ways, I enjoyed my wanderings as much as the sight of the apes themselves. I found myself falling into the same unhurried pattern of living as that of the gorillas. Sometimes a musty odor, like that of a barnyard, filled the air. I knew that it was a place where the animals had slept the night before in their nests.

Whenever I overtook a group of gorillas, I usually walked slowly and in full view of them. Then I would climb up on a stump or tree branch and watch them. It was important that they could also keep an eye on me. I felt certain that if I moved around calmly and alone near the gorillas, without dangerous intent, they would soon realize that I was harmless.

As could be expected, gorillas were more annoyed and excited on seeing two persons than one, so Kay remained home much of the time. Once they had moved from my sight, I decided not to follow the animals. Pursuit could easily frighten them and increase the chance of attack.

As with man, sight is the most important sense in gorillas. The apes are very quick at spotting slight movements. Often they watched my approach before I was aware of them. They also have keen hearing, but their sense of smell seems to be rather poor.

How the Gorillas Observed Me

One day I was watching a group of about 24 gorillas. I had come to know the animals in this group from observing them before. Big Daddy, a powerful male, was their leader. One I named D.J., an "executive" type who one day might become a leader of his own group, was second in command. D.J. eyed me; he seemed to have a plan. He left his resting place and cautiously worked his way toward me, all the time keeping behind a screen of shrubs. Every now and then he glanced over the top for a look at me. As soon as I looked directly at him, he ducked and sat quietly before working his way a few feet closer.

When he was about 30 feet from me, he gave out a terrible roar and began beating his chest. Before the echo of the sound died away, he peered out to see how I had taken it all. I felt like running, but decided it might be better to climb part way up a tree instead, which is what I did. Slowly, as if daring each other, the whole group came toward my tree. I felt a brief panic. The gorillas had never done this before. Three females and two juveniles climbed a nearby tree to get a better look at me.

Over the next several minutes we played a game of peekaboo: Whenever I craned my neck to see the gorillas more clearly, they ducked their heads, only to pop forth again as soon as I looked away. One gorilla was in a tree next to mine, only 15 feet away from me. We sat there nervously glancing at one another. Both of us were curious, but did not want to stare at each other. Constant staring is a threat to a gorilla. Apparently satisfied that I wasn't up to any mischief, and meant them no harm, the gorillas wandered away and began feeding again.

Another time I was observing a different group, also

(Continued on the next page)

old friends. I had been watching them feeding and resting for two hours or so from a branch about five feet from the ground. Suddenly one of them spotted me, and all 21 began walking toward me. To my relief they stopped about 30 feet from me and looked me over carefully. One female, looking at me out of the corner of her eye, came to within 15 feet of me. She reached up and gave my branch a sharp jerk. She then glanced at me as if to see my reaction. Then she did something even more remarkable. She pulled herself up onto the branch and sat with me. Both of us squatted on the limb, giving each other fleeting looks like a pair of strangers on a park bench. When her curiosity had been satisfied she swung down. To my surprise, another gorilla took her place beside me, and when he left, another one joined me. Gradually they lost interest in me and returned to their rest area. There they went about their daily routine as if I did not exist.

Head Shaking and a Staring-down Contest

Several times a gorilla would approach me shaking its head from side to side. It was an odd gesture, one that seemed to say: "I mean no harm." To see what gorillas would do if I shook my head at them, I waited until one was 30 feet away and paying close attention to me. He was watching me steadily. As soon as I began to shake my head, he immediately turned his face away. Perhaps he had thought that I had mistaken his steady gaze for a threat. Then when I in turn stared at him, he shook his head. We continued this for 10 minutes until he lost interest and went away.

From what I was able to observe, gorillas seem to go to great lengths to avoid fighting with each other. Once two different groups found themselves face to face. I wondered if a great battle was about to begin. The two leaders gazed at one another, then one of them began to hoot softly. The hoots became faster until the sound slurred into a harsh growl. He then beat his chest and finally he gave the ground a hollow thump with the palm of his hand. The other leader walked rapidly toward the growler. The two stared into each other's eyes, their faces a foot apart. These giants of the forest, each with the strength of several men, were settling their differences not by fighting but by trying to stare each other down. They stared at each other threateningly for from 20 to 30 seconds, then parted. One of them made an effort to win this war of nerves by throwing a handful of weeds into the air, as he stood bolt upright to show his full power. Suddenly he raced at the other male and the two stared at one another again. This time their faces were only an inch apart. The bluff failed. The weed-thrower turned and walked away, followed by his group.

Gorillas are *social* animals. Like human beings, they live in groups, hardly ever alone. Each group has a "head man," and all down the line to the infants there is a definite order of rank. This rank order does not cause strife, but leads to peace within the group. It puts each member in a certain position so that every animal knows exactly where it stands in relation to every other animal.

Who's Who in a Group

Silverbacked males boss all other members of the group. Their size and strength seem to determine their rank to some extent. Females are above juveniles, and the juveniles are above those infants which have strayed from their mothers. A gorilla expresses his rank in many ways. Once when it was raining, I saw a juvenile give up its shelter to a female. Then as soon as the female had taken over the dry spot, a silverbacked male sat down beside her. With one hand he pushed her gently but firmly until she was out in the rain and he under cover.

The leader, which is always a silverbacked male, decides the basic daily routine of the group—when and where to rest, how far to travel, where to go. He does this with rather simple motions and sounds. When, for example, he rises suddenly and walks rather stifflegged in a certain direction, the others know not only that he is leaving but also the direction he is about to take. The females and youngsters then crowd around him, ready to follow his bidding. Sometimes the leader stands motionless, feet spread, looking straight ahead. Again, the others know that this posture means "We are moving on." Sometimes, when the group was widely scattered, I heard a call that sounded like a rapid *ho-ho-ho* or *bu-bu-bu*. Both calls seem to mean "Here I am."

If the leader suddenly runs, to the others it means that danger might well be near, and they race after him. In times of danger, any member of the group may take leadership. Once a juvenile saw me, and with a high-pitched scream of fear he bolted down the slope. All the others in the group fled after him even though they were not aware of the nature of the danger. Once, when I suddenly met up with a group, Big Daddy, the leader, grabbed a juvenile around the waist. Holding it against his hip, he carried it to safety.

A Day in the Life of a Gorilla

A day in the life of a gorilla is unhurried and as relaxing as you could imagine. The groups I observed awoke between seven and eight in the morning. They did so gradually and unhurriedly. Then their day consisted of feeding and resting, then moving on to a new feeding area, eating and resting again. Ten to 11 hours after awakening, the animals were again ready to bed down. They would sit around, seemingly not knowing what to do, or waiting for someone else to make the first move. Then, about six o'clock, or as early as five o'clock if the sky was heavily overcast, the leader of the group would begin to break branches for his nest. The other members would begin to do the same.

Nest building is a simple activity, one that rarely takes more than three to five minutes, and sometimes as little as 30 seconds. The apes build nests either on the ground or in trees. Many ground nests were simply three or four handfuls of weeds packed down around the animal to form part of a rim. When building a ground nest, the gorilla merely bends and breaks weeds, twigs, and vines in from all directions. There is no interlacing, weaving, knot-tying.

Nests in trees have to be sturdier. If they should collapse, the resulting tumble could well be dangerous to the animal. Tree nests are usually built in forks and along horizontal limbs for support. Surrounding branches are bent and snapped inward until a fairly stable platform has been made.

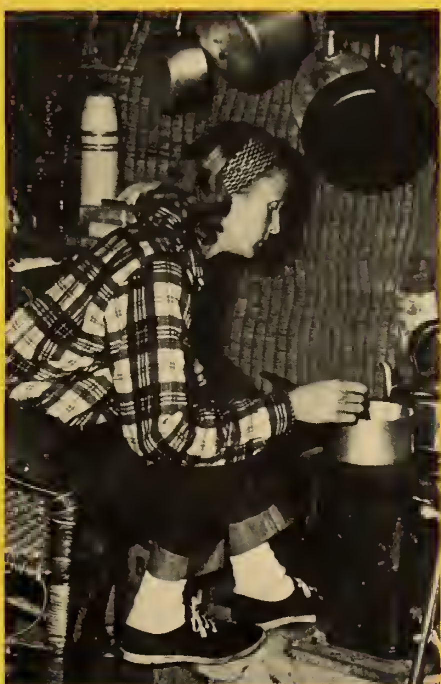
When I saw crude gorilla nests on the ground, I often wondered what possible use they could have. They seldom provided shelter or offered protection from the cold earth, for the nests were more rim than bottom. Nests in trees, on the other hand, have a very definite use: They are a secure platform on which the animal can sleep without danger of falling. It is, therefore, probable that the nest-building habit developed in trees, when the gorillas' ancestors still spent most of their time in trees rather than on the ground.

Gorillas and Man

When I began to study gorillas, I was at first struck by their human appearance. The body positions and gestures of gorillas resemble those of man rather than monkeys. They stretch their arms to the side and yawn in the morning when they wake up. They sit on a branch with legs dangling down, and they rest on their back with their arms under the head. The ways they express their emotions are also like man's. They frown when annoyed, bite their lips when uncertain, and youngsters have temper tantrums. Gorillas in the same group are close and affectionate, much like that of a human family.

These and many other likenesses are to be expected, for man and the apes came from a common ancestor—the monkey-like apes that lived millions of years ago. The gorillas and other apes developed in one direction; man developed in another. Ever so slowly, over millions of years, man became man by degrees. Still, to this day he retains in his mind and body many signs of his beginnings.

In an age when man more than ever before is wondering about his origins and worrying about his behavior, in an age when he is reaching for the Moon, he is just beginning to study his closest relations and himself ■



AMONG THE GORILLAS

The author and his wife, Kay, lived in a wooden hut for two years while studying Mountain Gorillas. Their meals were cooked on a small, wood-burning stove. Sometimes Dr. Schaller was away for several days, following groups of gorillas by day and sleeping near them at night. Dr. Schaller is now studying deer and tigers in India and teaching at the University of Calcutta.

the changing world of ICE

■ Most of us live where we can see snow and ice for only a few months of the year, or perhaps not at all. Yet about one-tenth of the Earth is covered by ice all year around (*see maps*). This Wall Chart shows different kinds of ice that cover the land and oceans. It also describes how the ice is constantly changing shape and size and constantly moving over land or through the sea.

As recently as about 20,000 years ago, great sheets of ice thousands of feet thick spread over a larger part of the Earth. At different times, these huge masses of ice called *glaciers* have moved down from the north into much of what is now Europe, Asia, and North America (*see map*). The glaciers scraped and moved rocks and soil from the land in some places and left them in other places. These mountains of ice carved many new valleys and made old ones deeper. They also destroyed plant and animal life. The ice was so heavy that some of the land beneath it sank 200 feet or more.

Will the world of ice ever invade the warm areas of the Earth again? Some scientists believe that this may happen thousands of years from now. Others suspect that the Earth may be slowly warming up, and that people might some day be able to live comfortably in Greenland and Antarctica—both nearly covered now by thick ice. Before we can be sure, we will have to learn much more about how the world of ice is changing over long periods of time ■

VALLEY GLACIERS form on cold, high mountains, like this one on Mount Robson, in British Columbia, Canada. Snow piles up and squeezes the snow beneath it into a solid mass of ice. The heavy ice moves slowly

downh
moves
as mu
warm

ICE COVERS the land and sea all year around in the areas shown in white on these maps. Pack ice floats in most of the ocean over the North Pole and surrounds the continent of Antarctica at the South Pole. In winter, the floating ice spreads outward and covers the areas shown in gray on the maps. Greenland and Antarctica are both almost completely covered by ice sheets. Smaller ice sheets, sometimes called ice caps, cover other land areas in the north. Valley glaciers are found in mountain areas. The dotted white line shows how far south the ice sheets moved in the last Ice Age.

AN ICE SHEET is a glacier that forms on fairly level land. As new snow presses down on old snow and turns it to ice, the glacier gets thicker at the middle. The weight of this ice spreads the glacier slowly outward, between and around mountains, and even uphill in some places. This picture shows part of the Antarctic ice sheet, which is about 14,000 feet thick in some places.

gh valleys. The ice in some glaciers w inches a day; in others the ice moves 0 feet a day. When a glacier reaches nelts, pouring into lakes and streams.

AN ICEBERG breaks off from the front edge of Miles Glacier in Alaska. This process is called *calving.* It takes place where a mountain glacier or an ice sheet spills over from land into the ocean. Icebergs may be as large as a mile across and may stick up above the water 300 feet. Nine-tenths of an iceberg floats under water. Some float to within 30° latitude of the Equator before melting completely.

PACK ICE, or frozen sea water, sometimes raps a ship, like this one off Greenland. These slabs of ice are constantly being ammed together, broken up, and moved round by the ocean currents and winds. n summer pack ice may get as thin as ive feet or so; in winter, it freezes to hicknesses of 12 feet or more. The currents in the Arctic Ocean slowly carry the pack ice in a circle around the North Pole.

HOW WE LIVE IN FLATLAND

WHERE ALL PEOPLE ARE GEOMETRICAL FIGURES AND WOMEN ON THE MOVE ARE VERY DANGEROUS

ADAPTED BY ROY A. GALLANT

In 1884, an English clergyman and school headmaster named Edwin A. Abbott wrote an amusing book with the title Flatland. *The people in his story are geometrical figures—triangles, squares, pentagons, and so on. They live in a world of two dimensions, and to understand how they live as flat figures on a flat surface will make you do some hard thinking. You will have to leave your Spaceland world of three dimensions and imagine you are a Flatlander in order to see the world from their point of view.*

■ I call our world Flatland, although that is not its real name. Perhaps the word "Flatland" will help you, who are lucky enough to live in Spaceland, to understand something about our people.

Imagine a great sheet of paper on which are Triangles, Squares, Pentagons, Hexagons, and other figures. Imagine also that these figures are free to glide about on the surface of the paper, but they do not have the power to stand up, rise above, or sink below the paper. They are very much like shadows—only they are hard and have bright edges. Oh, how difficult it is to describe all of this to you.

You who live in Spaceland would find it easy to tell a Square from a Triangle. All you would have to do is look "down" on the figures. But in Flatland there is no "down," no "up," no such thing as "depth." Our people would not know what you meant if you used the expression "solid" object. In Flatland, a Square and a Triangle appear very much the same to us. They appear as Straight Lines. In fact, in our world everything appears to us as Straight Lines. Let me try to explain.

Place a penny on a table and lean over it, looking down upon it. It will appear as a circle *(see diagram)*. But now, move back to the edge of the table and gradually bring your eyes down level with the penny. Half way down you see an oval, then, when your eyes are level with the edge of the penny, you see a Straight Line. Perhaps now you are beginning to understand how we see things in Flatland.

The same thing would happen if you took an edge-on view of a Triangle, Square, or any other figure. It ceases to appear as a figure and to your eye is a Straight Line.

The inhabitants of Flatland are all figures, such as Triangles, Squares, and so on. But more about them in a moment. I would like to finish making my point about how we see each other. Imagine that you are a Flatlander and that a Circle friend, or a Triangle friend, is coming toward you. What do you see? Since there is no Sun in Flatland, or any kind of light that casts a shadow, we have none of the helps to sight that you have in Spaceland.

As your Flatlander friend comes closer to you, you see only a straight line. Imagine a yardstick, held flat and at eye level, moving toward you through your Spaceland air from the far end of a long corridor. The closer it floated toward you, the longer it would appear to grow. In the same way, as your Flatland friend approaches you, his line appears to become longer. And as he leaves you, it becomes shorter. All the while he looks like a Straight Line—be he Triangle, Square, Pentagon, Hexagon, or Circle. A Straight Line he looks, and nothing else.

At first thought you might wonder how we are able to tell one friend (a Square, say) from another (a Pentagon).

The People of Flatland

As I said earlier, in Flatland there is no such thing as "up," "down," or "depth." In Spaceland, you say that a

This article has been adapted from parts of the book Flatland, *by Edwin A. Abbott, available in paperback edition for $1 from Dover Publications, Inc., 180 Varick Street, New York 14, N.Y.*

friend is so many feet and inches "tall." In Flatland, we cannot measure ourselves in height, only in length. A full-grown Flatlander may be as long as about 11 inches.

All our women are Straight Lines *(see diagram).*

Our soldiers and laborers are Triangles with two equal sides about 11 inches long. Their third side, or base, is rather short—often not more than half an inch, sometimes only a quarter inch. Soldiers and laborers are so very pointed that sometimes it is hard to tell them from women. A woman is a *one* dimensional figure, for she is all length.

Our middle class citizens are also Triangles—but each of their sides is the same length.

Our professional people are Squares; or sometimes they are five-sided figures called "Pentagons."

Next above these come the nobility, who have several shapes. The lowest in rank are six-sided figures, or "Hexagons." People higher in rank have more than six sides and are called "Polygons." Some people have so many sides, and each side is so short, that it is hard to tell them from a Circle. The Circle, of course, is the highest rank of all.

Our Dangerous Citizens

A Spacelander reading this might well think that the soldiers are the most "dangerous" members of Flatland, since they are highly pointed Triangles. Imagine bumping into a soldier at high speed. His sharp point could be very painful. Actually, women are much more dangerous—for they are *all* point, at least at their two ends. To add to the danger, they can make themselves all but invisible at will. A few words will make this clear.

Place a needle on a table. Then, with your eye on the level of the table, look at the needle sideways. You see the whole length of it. But look at it end-on and you see nothing but point. It has become nearly invisible. It is just so with a Flatland woman. When her side is turned toward us, we see her as a Straight Line. When she faces us, we see her only as a bright point; and when she walks away from us, we see nothing but a very dim point.

If running into a soldier produces a gash, imagine the danger of running into a woman! It means instant death. In some of the states of Flatland there is a law saying that women must not walk or stand in any public place without keeping their backs moving from right to left. To any one approaching a woman from the front or rear, this motion makes the woman visible as a line constantly becoming longer and shorter.

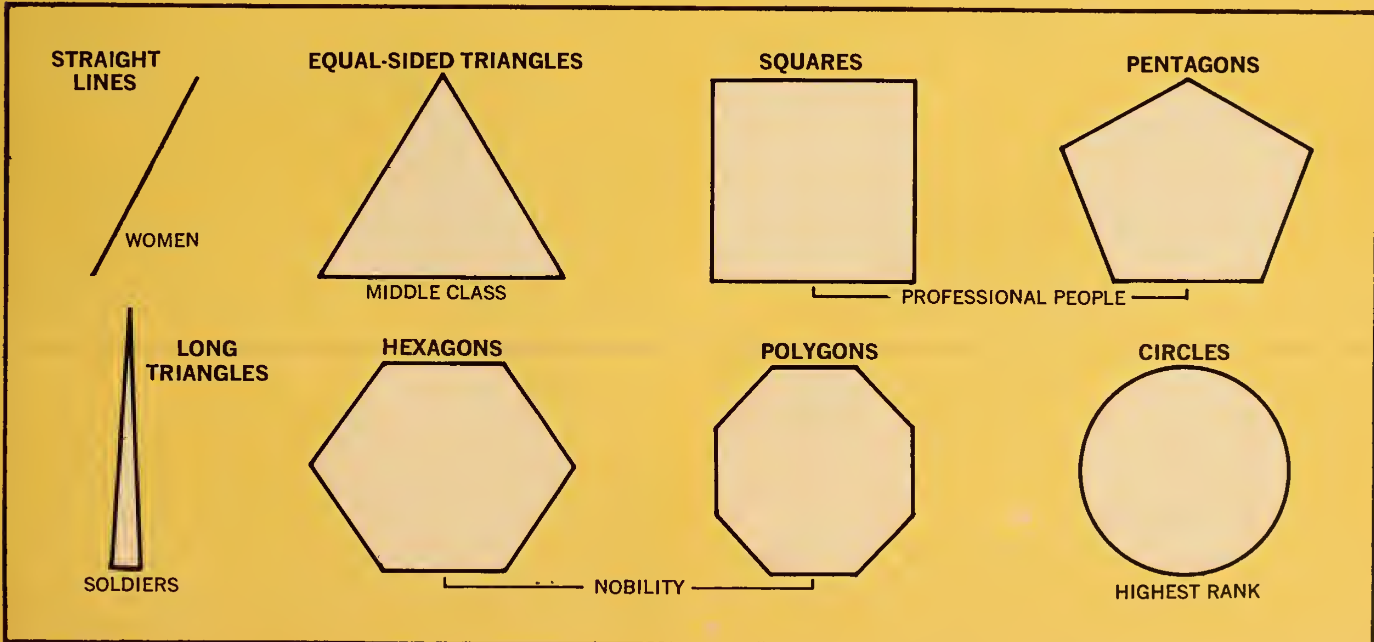
In one Flatland state, women are thought to be so dangerous that the following law was written: *Any Female suffering from St. Vitus's Dance, fits, violent sneezing, or any disease bringing on violent motions which she cannot control shall be instantly destroyed.*

How We Recognize One Another

You in Spaceland, who can see a whole circle, who can actually *see* an angle—how can I make clear to you the trouble we in Flatland have recognizing one another?

Recall what I told you earlier. All people in Flatland, no matter what their shape, *to our view* appear as a Straight Line. Fortunately, in addition to seeing, we have another way of recognizing one another. In a manner of speaking, we "shake hands," but it is really more like touching one another. If a Triangle and a Square are introduced and touch one another, each can tell the shape of the other. But

(Continued on the next page)

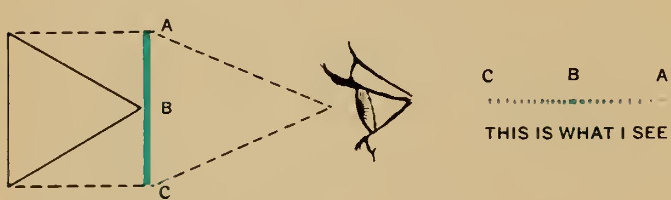


this becomes harder to do with people who have many sides. Imagine the difficulty of telling a 20-sided Polygon without touching the person all the way around!

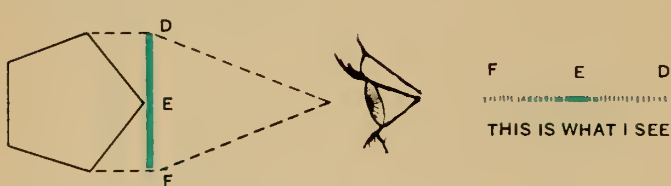
Even though each Flatlander appears to any other Flatlander as a Straight Line, still we can tell a Triangle from a Pentagon by sight. The reason we are able to is because there is nearly always fog in Flatland. Let me explain by giving you an example:

Suppose I see two people coming toward me and I want to know what shape they are. One is an Equal-Sided Triangle, and the other is a Pentagon. I see the Triangle as a Straight Line A,B,C *(see diagram).* The mid-point B will be bright because it is nearest to me, but on either side—from B to A, and from B to C—the line will shade away rapidly into dimness because of the fog. So point A and point C, which are the Triangle's rear portions, will be very dim indeed.

I see the Pentagon also as a Straight Line, D, E, F. As in the case of the Triangle, I see the mid-point (E) of the Pentagon as a bright point. As I saw points A and C of the Triangle dimly because of the fog, I also see the Pentagon's points D and F dimly, because of the fog. But I see the Pentagon's far points *less* dimly because its sides do not go so deeply into the fog as the Triangle's sides do.



HOW I SEE THE TRIANGLE



HOW I SEE THE PENTAGON

Recognizing each other by sight is not always easy. Suppose, for example, that my neighbor's son, who is a young Triangle, approaches me. But instead of presenting me with one of his angles, he happens to present one of his sides to me. I must then ask him to turn around, or I myself, have to edge my eye round him in order to see his shape. If I see him only from the side, I cannot tell if he is a Straight Line, in other words, a Woman.

A Visitor from Spaceland

Perhaps you have been wondering how I, an inhabitant of Flatland, am aware of your Spaceland, and have found the words to describe our world to you.

HOW I SAW THE SPHERE AS HE ROSE FROM MY SIGHT. HIS CIRCLE BECAME SMALLER AND SMALLER, UNTIL FINALLY HE VANISHED.

One evening—it was the last day of the 1999th year of our era—I was sitting in my study and felt a Presence in the room. A stranger suddenly appeared, as out of nowhere. I touched him and found him to be the most perfect Circle I had ever met. Clearly he was from another land, for he also talked of a world of *three dimensions,* meaning a world of length, width, *and* height.

Try as he did, the Stranger could not make me understand by words alone what he meant by "height." It is beyond our experience in Flatland. Finally, he said, "Now, sir, listen to me.

"You are living on a vast level surface, without ever rising above it or falling below it. I am not a flat figure, but a *Solid.* You call me a Circle. Actually I am many Circles of different size, but you can see only one of my circles at a time because you have no power to raise or lower your eye out of Flatland. In Spaceland I am known as a Sphere—a solid object.

"Now prepare for proof positive of the truth I speak. See now, I will rise. The effect upon your eye will be that my Circle will become smaller and smaller till it dwindles to a point and finally vanishes." *(See diagram above).*

There was no "rising" that I could see, but he grew smaller and smaller and finally vanished. I winked once or twice to make sure that I was not dreaming. But it was no dream. For from nowhere came a hollow voice: "Am I quite gone? Are you convinced now? Well, now I will gradually return to Flatland and you shall see my Circle become larger and larger."

It was through that action, and others performed by the Sphere, that I came to know about the wonders of Spaceland. It is now many years since that visit from the Stranger, and I am in prison, where I am to remain for the rest of my life.

I tried to tell our people about Spaceland, but they would not believe me. It was "dangerous" talk, they said, for the wisest among our Flatland thinkers say that there are only *two* dimensions—length and width. Perhaps someday, someone else from Flatland will learn the truth of Spaceland, as I have. Perhaps, also, that person will succeed in enlightening our people, where I have failed ■

BRAIN-BOOSTER CONTEST

prepared by **DAVID WEBSTER**

A CHALLENGE TO ALL READERS OF NATURE AND SCIENCE

Your answers to the Brain-Boosters below may win a prize—

- **For each of the five winners, choice of a 10-power or a 100-power student microscope or a telescope *(see photographs)*, courtesy of Bausch & Lomb Incorporated.**
- **For each of the ten runners-up, a fascinating science book.**

To enter, just write down your answers and send them to:

David Webster
RFD #2
Lincoln, Massachusetts

They must be mailed by February 25, 1965. It is not necessary to answer all of the questions to enter the contest. You may draw pictures to help explain your answers. The names of the winners and the best set of answers will be published in the May 3rd issue of *Nature and Science*.

TEACHERS AND PARENTS—You Can Enter, Too!

Adult entries will be judged separately. Each of the five winners will receive a boxed set of *Astronomy Highlights*. To enter, follow the procedures outlined above, and *indicate that you are an adult*.

1. *What was done to make the fish in this doughnut-shaped tank swim around in the same direction?*

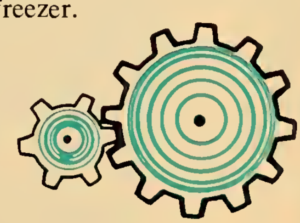
2. If the middle loop of string is cut, all three pieces of string will come apart. But if the loop on either side is cut, two loops will still be together. *Can you make three loops of string so that all three will come apart if any one of the three is cut?* (Send your loops of string with your other answers if you don't want to draw them.)

3. Two candles are put on one side of a stick to balance a single candle on the other side. Then all three candles are lighted. *Will the stick still balance after the candles have burned for awhile? Why?* (If you try this to find out what happens, make sure to have a grown-up person with you.)

4. Suppose you put several heavy books on your bathroom scale and you stood on top of them. The scale would, of course, show your weight plus the weight of the books. But suppose you then took the books off the scale and held them in your arms. *What weight would the scale now show?* You can try this if you are not sure.

5. *Does ice ever get colder than 32°F?* To find out, you might want to put a thermometer in a jar of water and freeze it outside or in your freezer.

6. Imagine the larger gear turning clockwise once a minute. *How would the smaller gear be turning?*



7. Below is a description of an experiment. *What is wrong with the experiment and how would you do it better?*

> I tested my dog to see his reaction to music. Every night after his dinner, for two weeks, I put him in my room and turned on some music. On almost every night he was asleep in 10 minutes. It seems that music makes my dog go to sleep.

Answers to Brain-Boosters in the last issue

Mystery photo: The thing that looks like a feather or root was made by electricity. Millions of volts of electricity were shot into a piece of plastic. When a nail was stuck into the edge, the electricity jumped to the nail. As it moved, it made holes in the plastic in the shape of a root.

Can you do it?

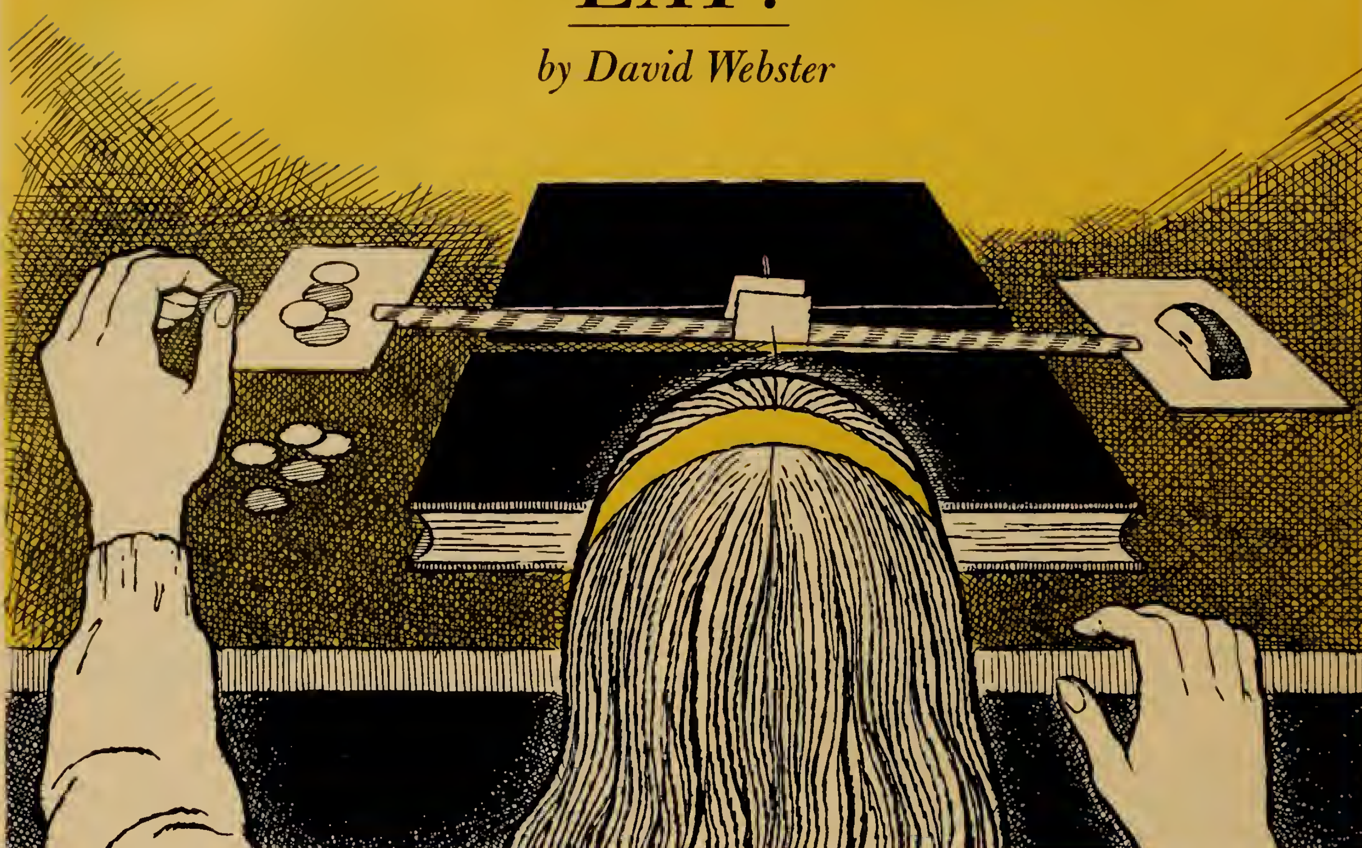
D O E
O W L
E L K

Fun with Numbers and Shapes: 2 5 3 4 is the combination.

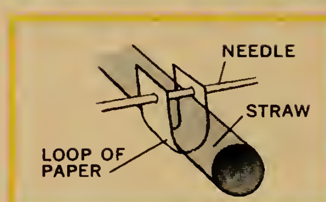
For Science Experts Only: The iron powder could be removed from the mixture with a magnet. The sand and salt which are left can be put into some water so the salt dissolves. The sand will be left when the salt water is poured off. To recover the salt, the salty water can be evaporated. Suppose the mixture had some sugar in it also. What could you do to separate the sugar from the salt?

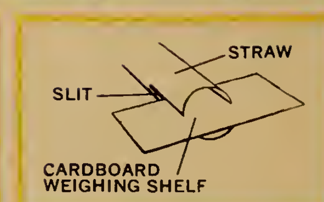
HOW MUCH WATER DO YOU EAT?

by David Webster



You'll be surprised by how much water some foods have in them. Here is how you can find out by building a scale.





■ Everyone needs water to stay alive. If you had to go many days without water, you would become very sick. Once several men were locked inside a railroad car and lived for almost a week without anything to drink or eat. No one has ever stayed alive much longer than this without having food or water.

Because you *eat* water every day, you could go many weeks without drinking any water. Milk, orange juice, and ginger ale are mostly water. If all the water were taken out of a glass of milk, only a little bit of solid stuff would be left at the bottom. There is also water in many of the solid foods you eat, such as apples and hot dogs. How can you find out which solid foods contain water? Do the juiciest foods have the most water?

Think about other things you have seen with water in them. You know that a wet towel is heavy, but the towel gets lighter as it dries. How could you measure how much water is in a wet towel? You could squeeze some of the water out, but not all of it. If you had a scale you could weigh the towel. How many weighings would you have to make to see how much water the towel held?

By weighing food — an apple, say — before it has been dried, then after it has been dried, you can figure how much water it contains.

It is easy to make a scale for weighing small pieces of food. All you need is: (1) a long paper straw; (2) a needle; (3) some thin cardboard; (4) two books the same thickness; (5) a pair of scissors; (6) a paper punch; (7) a piece of stiff paper to form the cradle for your scale.

Make a slit in both ends of the straw with the scissors. Next, push two small squares of thin cardboard, each about the same size, into the slits *(see diagram)*. These are your weighing shelves. Now loop a strip of the stiff paper under the straw. Put the needle through the strip so that it just touches the top of the straw *(see diagram)*. This will help keep the straw in place. Rest each end of the needle on a book, and the scale is ready to use.

For weights, you need a lot of little things all the same size. Circles of thin cardboard cut out by a paper punch work well. Staples or small paper clips can be used instead.

How to Use Your Straw Scale

Slide the needle back and forth on the straw until the scale becomes balanced with both ends off the table. Now put what you want to weigh on one shelf and add the little weights (cardboard punchings) to the other shelf until there are enough to make the scale balance. The number of cardboard punchings needed to do this is the weight. So with your straw scale something might weigh eight cardboard punchings rather than eight ounces or eight pounds or eight tons.

Practice using your scale by weighing several small things around the house—a dead fly, or a safety pin. What do you think would happen if you balanced a small piece of wet paper towel on the scale and watched it as it dried out? Try it. After that you will be ready to carry out the experiment on the water in foods. What food do you want to test first? Cut off a little piece and weigh it on the scale. The piece you use should be very small, probably weighing no more than 15 or 20 cardboard punchings. Write down the weight so you can remember it.

Now leave the piece of food for a few days so it will begin to dry out. There are things you can do to the food to make it dry faster. Can you think of one? If so, you might want to try it.

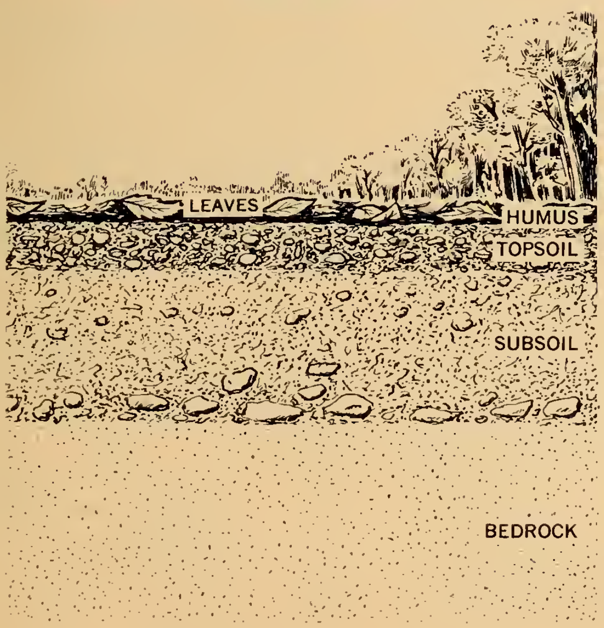
When you weigh your food after it has dried out some, you can guess that it will be lighter than before. Of course, the more water that goes away, the lighter the food becomes. Maybe you can let the piece of food dry out even more, then weigh it again. How will you know when there is no water left?

You probably will want to test many foods to see how much water is in them. You might try some of these: jelly, peas, tomatoes, fried eggs, lettuce, and bacon. Or you could use a little piece of each thing you eat in a day.

Which foods are almost all water? Which are just about half water? Do any have no water in them? Do you eat more water than you thought? ■

AN INVESTIGATION

HOW MUCH WATER CAN SOIL HOLD?



Soil can have water in it too. The ground soaks up rain water like a sponge. Then the soil gradually dries out again until the next rain. Plants use the water which is stored in the soil.

How much water can soil hold? Do different kinds of soil soak up different amounts of water? You can find out by doing another experiment with your soda straw scale.

First collect some soil. You can see in the diagram that humus (a layer of dark, decayed plant material) and topsoil are near the top of the ground in the woods so these two may be easy to get. You might have to dig to find subsoil. If you are lucky you may find subsoil piled up by a bulldozer where a new house or road is being built. Maybe you live near a swamp, a lake, or a clay pit where you can get other types of soil. See if you can collect four or five kinds.

Take one kind of soil and make a little wet mud ball about as small as a pea. Weigh it on your scale. A tiny piece of aluminum foil on the paper shelf will keep the shelf from getting wet. Now dry the mud ball out until all the water is gone, and weigh it again. Should you use the piece of aluminum foil this time too? Make pea-sized mud balls with the other soils and figure out how much water each one holds.

Which soil held the most water? In which soil would you expect to find plants which need only a little water to grow? Why do you think some soils hold more water than others?

BLOTTER BIRDS

by Richard L. Kimball

■ Would you like a pet bird that needs little or no care, wants only water to keep healthy and needs no cage? This bird does not make noise but can grow and do tricks.

If you would like to be a lazy kind of bird-watcher, then get a piece of white blotter paper, a few paper clips, a quart milk carton and a paper cup. For your first bird, cut a piece of blotter paper the same shape and size as this diagram:

Next, cut the milk carton for a stand as shown in the diagram above. Unbend one paper clip to make it straight, push it through the bird's "neck", and set it on the stand.

Weight the bird with paper fasteners, clips, or Plasticine clay until its head dips slightly. The beak of the bird should stick into the water when the head is down.

As soon as the cup is placed under the bird's beak, it will begin to drink. When it is finished drinking, it will rest for some time before later returning for another drink. Don't be surprised if it does not return for an hour. Sometimes it may not be very "thirsty." Your bird will continue to move as long as the cup is filled with water.

What happens if another liquid such as rubbing alcohol, salt water, or water with sugar mixed into it is used instead of plain water? What happens if the balance point is changed or if the beak is not slightly dipped at the start?

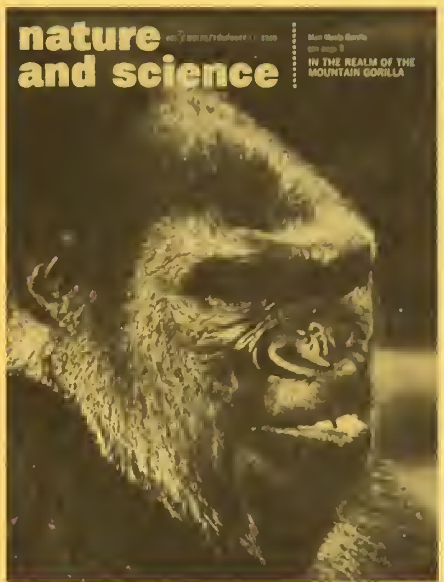
What do you notice about birds of different shapes and sizes? Try a wide bird made of three or four birds of the same shape glued together with rubber cement. When this bird is allowed to drink, do you see any difference between it and the first bird you made?

When you make a new blotter bird, try putting some spots of ink, or water-color paints of different colors, on it. Put some spots on the head, some on the neck, some on the body, and some on the tail. What happens to these spots as the bird is drinking? Why does it happen?

Do you know why blotter birds drink? Remember what kind of paper you used. Can you explain why your bird lifts its head after drinking? Recall what happens to a see-saw when a fat boy gets on. Why does the bird later dip its beak back into the water? Where does the liquid go that was in the bird's body? Does it evaporate into the air? Have you noticed if the bird gets wet all over? Will a blotter bird work if its head is bigger than its body?

You can buy birds from toy shops and some scientific supply houses that drink and return more rapidly than the blotter birds do. These birds are also good for bird-watching. The way they work is different from the way blotter birds work. It is exciting to discover how these birds work. If you have any suggestions for other birds to watch, please let us know ■

nature and science
TEACHER'S EDITION
VOL. 2 NO. 10 / FEBRUARY 15, 1965 / SECTION 1 OF TWO SECTIONS



◀ N&S REVIEWS ▶

Recent Science Books for Your Pupils

■ Of the several hundred science books published each year ostensibly for the young reader, only about one in four is appropriately written for the age group of *N&S* readers. From the current crop, *N&S* editors have selected the 25 books reviewed below as among the best—with promise to be widely read if made available in the school or classroom library.

Life Sciences

Two of the best children's books of the past year in this field are about ants. **An Ant Is Born,** by Harald Doering and Jo Mary McCormick (Sterling Publishing Co., Inc., 1964, 96 pp., $2.95), gives an accurate account of ant life history, with many excellent black and white photographs. The text is sometimes too difficult for the middle elementary grades, but children will be fascinated by the photos and captions.

The Story of Ants, by Dorothy Shuttlesworth (Doubleday & Co., Inc., 1964, 60 pp., $3.25), is packed with interesting detail about many kinds of ants and is beautifully illustrated in color by Su Zan Swain.

Rain in the Woods, by Glen Rounds (World Publishing Co., 1964, 95 pp., $3), relates some of the author's observations of a variety of animal life. The chief value of the book is that it encourages the reader to look around —in roadside ditches, backyards, weed-grown lots—and discover something about the many animals that lurk there unnoticed. Illustrated with the author's charming drawings.

Birth of a Forest, by Millicent E. Selsam (Harper and Row, 1964, 44 pp., $2.95), is concerned with the fascinating subject of plant succession, and specifically, how some forests actually have their beginnings in a pond. The text is clear and accurate; the photos and drawings are plentiful and helpful.

Naturalists and Explorers, by Wyatt Blassingame (Franklin Watts, Inc., 1964, 145 pp., $3.95), is a bit difficult for the middle elementary grades, but is still a treasure, ideal for "story hour" reading. Seven explorer-naturalists, from Carl Linnaeus to John Muir, come alive as the author describes some of the highlights of their lives.

Two good books on spiders are **Spiders and How They Live,** by Eugene David (Prentice-Hall, Inc., 1964, 72 pp., $2.95), and **The Web of the Spider,** by Laura Barr Lougee (Cranbrook Institute of Science, Bloomfield Hills, Mich., 1964, 44 pp., $3.50). Both are well illustrated. *Spiders and How They Live* is more simply written and includes more information than *The Web of the Spider.*

A useful guide for investigating the lives of common pond and stream animals is **Adventures with Freshwater Animals,** by Richard Headstrom (J.B. Lippincott Co., 1964, 217 pp., $4.25). There are 47 "adventures" in all. The text is sometimes too technical for middle elementary grades and the author's drawings are rather primitive. No index.

Tide Pools and Beaches, by Elizabeth Clemons (Alfred Knopf, Inc.,
(Continued on page 3T)

IN THIS ISSUE

(For classroom use of articles preceded by ■, see pages 2T and 3T.)

IN THE NEXT ISSUE

This is a special-topic issue on scientific aspects of time: The biological clocks that enable animals and plants to "tell" time...How scientists use geological clocks to measure time in the past...Telling time by the stars...How we set our clocks ...Time-keeping machines...A water clock your pupils can make.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Mountain Gorilla

This enjoyable first-hand account of a scientist's unique experiences with gorillas in the wild contains many opportunities for extending your pupils' understanding of animal behavior. The gorilla's resemblance to man makes him an object of lively interest to children, as the popularity of gorilla masks, King Kong, and Magilla Gorilla attest. By capitalizing on this, you may lead your pupils into a serious consideration of some forms of social behavior and relationships among animals.

Suggestion for Classroom Use

Before your pupils read the article, have them express whatever ideas they may have about gorillas. List them on the blackboard: What do gorillas eat? Where do they live? Do they live alone or in groups? And so on.

After reading the article, the children might review the list, crossing out what now seems false. A brief discussion of the sources of their misconceptions (comics, TV, movies) may help them set standards for judging the reliability of information.

Topics for Class Discussion

■ *What can we learn from Dr. Schaller's experiences about how to behave around large animals?* Have any of your pupils had frightening encounters with dogs, bulls, bears, or horses? In many cases, the animal in question may have felt threatened. In general, it is wise to keep calm and quiet, avoid quick motions, and face the animal as you back away.

■ *How do gorillas defend themselves against enemies?* The gorilla's chief enemies are leopards and humans. Since gorillas are not predatory, they react by running away or by biting, if it comes to a fight. The chest-beating and the fierce noises they make are also a kind of protection, as they tend to frighten away other animals.

■ *Why do gorillas build new nests each night?* This may seem like unnecessary behavior. Bring out that the search for food keeps gorillas on the move.

■ *What makes staring contests and other threats work to keep peace among the gorillas?* Animals within a species are frequently able to settle disputes with threats if they know the fighting capacities of their rivals. This implies that they can also tell one individual from another. With gorillas, as with chickens, a *peck order* is established, in which each animal knows his position. A "threat code" may be used in which certain signs of submission are recognized. In gorillas, such a sign would be turning and walking away from the dominant member. These rigid social patterns help keep animals of the same species from attacking one another.

Have your pupils ever observed this sort of behavior among people or nations? A perusal of the morning newspaper might reveal several examples of the "threat code" being applied by both individuals and nations.

Activity

■ The techniques used by Dr. Schaller to study gorillas—following their trails, moving slowly, observing patiently for hours—are techniques that anyone can use to find out how animals live. Individual pupils might be interested in studying squirrels, birds, and other animals in nearby woods or parks this way. They should keep notes and can report to the class. Have them try to figure out why animals do certain things—why birds sing, for example.

PAGE 10 Life in Flatland

This unusual and amusing article will surely stretch the imaginations of your pupils. Like any good gymnastics program, it offers more than entertainment. Hopefully, your pupils will come away with an appreciation of the meaning of three-dimensional space and, perhaps, a respect for the limitations of their particular view of the world.

Topics for Class Discussion

■ *How does the fog in Flatland help the inhabitants recognize one another?* It is their only way of perceiving depth. Can your pupils think of paintings where the artist created the illusion of distance by making mountains or trees in the background hazy?

■ *What would happen if the atmosphere in Flatland were to clear up?* The far edges of figures would appear as close as the near edges, giving everything the appearance of a straight line. Can perspective, which is another way artists depict space on a two-dimensional surface, be employed in Flatland? No, because the edges seen in Flatland have no thickness that can be diminished.

■ *Does everyone in "Spaceland" see things from the same point of view?* Would an ant's view of the world be the same as that of a ten-year-old-boy or girl? How might the world look to a baby in a playpen, or to a flagpole sitter? Can your pupils conceive of what it would be like to be blind?

Activities

■ To further demonstrate the peculiarities of a world without height, have your pupils look at a photograph in a book. What happens to the image as they bring the edge of the book up to eye level? At what point does the picture become unrecognizable? Would living in Flatland be anything like looking at a room through the crack under the door?

■ Have your pupils try to imagine a world without weight, or time, or death, or taste, and so forth. For instance, in a world without light, would we still have artists, or writers, or be able to drive cars? How would we have to change our ways of doing things? With such a discussion as a starting point, encourage your students to write a fantasy of their own.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue...
(continued from page 2T)

PAGE 14 How Much Water?

Through this SCIENCE WORKSHOP activity, your pupils can discover that much water is contained in some common foods. Your classroom experience with this article would be of interest to the author. Write to David Webster, The Elementary Science Study Project, Educational Services Incorporated, Watertown, Mass.

Your pupils should have no difficulty constructing the scale and learning how to use it. Be sure, however, that they understand that they are not measuring in pounds or ounces, but in units of paper punchings, staples, or paper clips. They will be concerned not with absolute weights, but with *relative* weights. The amount of water found in a certain kind of food will be expressed as a fraction. For example, they may find that a piece of bread, no matter what size, will be about ⅓ water by weight, a piece of hamburger meat about ½ water, and so forth. Be sure they know how to tell when no water is left. (Successive weighings will be identical.)

Further Activities

■ Weigh onion flakes before and after moistening. How much water do they absorb? Your pupils should notice that moisture makes food soft, and that dehydration makes things more solid.

■ Weigh a slice of raw carrot before and after it has been soaked in cold water, and again after it has been cooked in water. Did the carrots absorb water from soaking or from cooking?

PAGE 16 Blotter Birds

Your pupils will enjoy making and watching blotter birds, as well as figuring out how they work. The blotting paper soaks up water by capillary attraction. The body holds more water than the head because the body is larger. The extra water in the body pulls it down, lifting the head out of the cup. When the water evaporates from the body into the air, the head drops back into the cup and begins soaking up water again.

You might tear a piece of blotting paper and have your pupils examine the torn edge with a magnifying glass. They can see the tiny fibers that make up the blotting paper and the spaces between them through which the water moves.

Have them look at torn edges of other kinds of paper (construction paper, newspaper, slick magazine pages and so on), and try to predict whether a bird made of each kind of paper will work like a blotter bird.

W. A. WOOD FROM AMERICAN GEOGRAPHICAL SOCIETY

THE CHANGING WORLD OF ICE—Canada's Kaskawulsh Glacier shows how moving ice changes the surface of the land. A glacier scrapes rocks, sand, clay, and soil from the land and valley sides and carries it along with the ice. Where two glaciers run together, the debris along the edges of each merges into a ribbon of rocks between the ribbons of ice. Wherever some of the ice melts, some of the debris is left on the land.

Recent Science Books...
(continued from page 1T)

1964, 30 pp., $2.95), is an attractive, useful book for those near an ocean. It gives brief life history information about some common seashore plants and animals, along with hints on how to identify and collect them.

The vision of animals and how it is adapted to their different ways of living is described in **Watchers, Pursuers and Masqueraders,** by Edith Raskin (McGraw-Hill Book Co., 1964, 160 pp., $3.50). The author also describes how scientists have learned about animal vision. The subject is fascinating and the text is well written.

A big, handsome book is **Exploring the World of Fossils,** by William H. Matthews III (Children's Press, 1964, 157 pp., $3.95). Beside telling how fossils are formed and describing the most common kinds of fossils, the book tells how to collect, identify, and care for fossils. The text is rather difficult, but the book is a good classroom reference. Indexed.

Two other attractive books, for enrichment, not reference, are **Wonders of the Animal World,** by Vezio Melegari (Golden Press, Inc., 1964, 175 pp., $4.95), and **Natural History Adventures,** by Marion B. Carr (Golden Press, Inc., 1964, 105 pp., $2.95). *Wonders of the Animal World* features about 150 color photographs of wild animals around the world. Many of them are not well known, and this is one of the book's virtues. The excellent photos are supplemented with clear, simply written text. Indexed. *Natural History Adventures* is a collection of 60 articles that originally appeared in *Junior Natural History* magazine. The subjects range from the radar of bats to insect-eating plants. The illustrations are colorful and appealing, but the text is sometimes difficult for the suggested reading ages of 9 to 13, and there are a few inaccuracies. No index.

Three small books devoted to a single group of animals are **Moths,** by Dorothy Childs Hogner (Thomas Y. Crowell Co., 1964, 70 pp., $2.75); **Swallows,** by Charles L. Ripper (William Morrow and Company, 1964, 64 pp., $2.75); and **Wonders of Hummingbirds,** by Hilda Simon (Dodd, Mead and Co., 1964, 62 pp., $3). All three are simply written, accurate, and well illustrated.

—LAURENCE PRINGLE

(Continued on page 4T)

Recent Science Books...
(continued from page 3T)

Physical Sciences

In **The Rise and Fall of the Seas,** by Ruth Brindze (Harcourt, Brace & World, Inc., 1964, 96 pp., $3.50), young readers will find far more than just the mechanics of the tides. Tide hazards to mariners, the cause of tidal bores—those walls of water that periodically surge up several of the world's rivers—tides in the Earth's atmosphere, and other tidal phenomena are described and explained simply and clearly. How the rhythm of the tides affects animal life in the sea is also described, as are man's attempts to harness the tides as a source of energy. Fourth and fifth graders may find some of the vocabulary and concepts tough, but sixth graders should be able to cope.

Nature's Clues, by Walter C. Fabell (Hastings House, 1964, 119 pp., $3.50), selects nearly a dozen people of outstanding talents and tells us how they achieved what they did. Among them: a Japanese peddler who reputedly started the cultured pearl industry; Ben Franklin flirting with death at the end of a kite string; Mendel's work on heredity, the Wright brothers, and Mr. Birdseye of frozen food fame.

Each of these men is remarkable for many reasons. In addition to their sheer inventiveness and persistence to see a thing through, each took certain "clues" from nature, according to the author, and applied them in a new context. The book is readable and should interest most science-minded youngsters, although every now and then the science seems questionable.

The Curious World of Crystals, by Lenore Sander (Prentice-Hall, 1964, 64 pp., $3.25), is too expensive for its size and makeup, but the author does a better than average job of introducing the kinetic molecular theory, the number one ingredient in any discussion about crystals. Unlike many crystal "recipe books," this one does more than simply list six or seven quick steps that are supposed to result in a crystal garden but too often don't. The reader who stays with this book to the end will emerge with some understanding of order and disorder on the atomic-molecular level and should, therefore, have a good idea of what crystals are.

Magnet, by E. G. Valens, photographs by Berenice Abbott (The World Publishing Co., 1964, 58 pp., $3), is a gem of a book. The author and photographer lead the reader through several demonstrations and investigations that are great fun to do. Unlike so many young people's science books

that simply spoon-feed, this one concerns itself—and will concern its readers—with the process of discovery. Mr. Valens' text is excellent, and Miss Abbott's photographs are things of beauty. —ROY A. GALLANT

All About Fire, by Raymond Holden (Random House, 1964, 142 pp., $1.95), explores fire from myth and magic to its use in rocketry in a lucid and interesting style. The illustrations by Clifford Stead, Jr., are well done. Although Mr. Holden tells us "the Sun's fire is not the same as fire on the earth," we wish he had pointed out more strongly the mis-use of the term "Sun's fire," and the wide range of the Sun's energy over the electromagnetic spectrum — from radio energy through to gamma rays. But these are minor matters. If you don't have a good book about fire, get this one.

The Moon, by Angelo Rocca, illustrated by Fedini (Duell, Sloan and Pearce, 1963, 60 pp., $2.95), discusses briefly the Moon in ancient times, mapping the Moon, the Earth and Moon, the Moon in space, eclipses, tides, Earth from the Moon, Moon in the space age. The writing is adequate, though suffering a bit by the translation from the Italian version which appeared in 1961.

In full color illustrations, Fedini, the artist, has caught the desolation of the Moon. He has effectively diagrammed tides, density, and some lunar vehicles. If you have other books on the Moon and want one that shows information in bright colors, you will be pleased with this volume.

—FRANKLYN M. BRANLEY

Biographies of Scientists

Out of Silence into Sound, by Roger Burlingame (Macmillan Co., 1964, 146 pp., $2.95), is a warm, sympathetic, and generally pleasing biography of Alexander Graham Bell. The author presents the conflicts and challenges of the inventor's life in a way that should appeal to young people. The illustrations are many and pertinent. However, the explanations of electrical phenomena are few and rather vague. Two chapters dealing with achievements of the modern-day Bell companies seem unnecessary in a biographical work.

Great Experimenters, by William Bixby (David McKay Co., 1964, 182 pp., $4.25), presents biographies of nine important scientists, ranging in time from Isaac Newton to Enrico Fermi. All nine are depicted as great scientists, possessed of keen minds and imaginations, but at the same time as fallible men. In fact, the author makes a plea that the reader not glorify science or deify its investigators. Scientific explanations are very sound; the author is a teacher of physics. This book will appeal to young people with some grounding in science.

Robert Goddard, Trail Blazer to the Stars, by Charles Michael Daugherty, illustrated by James Daugherty (Macmillan Co., 1964, 44 pp., $2.95), is intended for a very young audience. This short book is a blend of well written text, complete with explanations of difficult words, and clever, whimsical line drawings. In spite of anecdotes and the element of whimsey, Goddard emerges here as a serious space pioneer, who could see far beyond his own time and his own considerable achievements. All in all, it's a good biography and a good rocket primer.

—DAVID WHIELDON

Anthropology

Makemá of the Rain Forest, by Nancy McIvor Webb (Prentice-Hall, 1964, 64 pp., $3.25), is a fine book about an Indian boy who lives in the tropical forest of Brazil. The anthropological data presented is sound and the author has chosen good sources for her writing. The author's style is pleasing and the story moves rapidly. A glossary of terms is provided and the woodcuts that illustrate the book are very nice. This book should delight those children who are interested in how other people live.

—LINDA BRITTON

nature and science

VOL. 2 NO. 11 / MARCH 1, 1965

SPECIAL-TOPIC ISSUE

TIME

- How plants and animals keep time
- Past ages of the Earth
- How scientists measure time
- Make your own clock

nature and science

VOL. 2 NO. 11 / MARCH 1, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

ABOUT THIS ISSUE

You may have seen clocks something like the one on our cover. It's the face of an old grandfather's clock. How many other kinds of clocks can you think of: alarm clocks, wristwatches, electric clocks, others?

In this special issue on time, you will discover that there are many kinds of clocks, including a water clock that you can make yourself *(see page 16)*. There are "clocks" in rocks and "clocks" in the sky. All living things—including you—have not one but *two* kinds of clocks inside them.

Living things have *biological* clocks that measure days, or months *(see page 3)*, and they also have *radioactive* clocks that measure longer periods *(see page 7)*. Many of these clocks don't measure hours or minutes or seconds. One measures a period of one billion years. By using such clocks, scientists have pieced together a history of the "Ages of the Earth" *(pages 8 and 9)*.

In "How Long Is a Day?" *(page 10)*, you will find out that the length of a day depends on how you measure it. The article on page 12 tells how scientists all over the world know what time to set their clocks, and how clocks work is explained on page 14.

Editor of this special-topic issue was James K. Page, Jr.

Contents

CREDITS: Cover, p. 2, photo by Harold M. Lambert, from Frederic Lewis Photographs; p. 3, drawings by R. G. Bryant; pp. 4 (lower right), 6, 7, 8, 9, 11, 14, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, photo by Dr. Max Renner. Fiddler Crab drawings by Gaetano di Palma; p. 6, photo by George Cope, Educational Services Incorporated; pp. 10, 16, drawings by Joseph M. Sedacca; pp. 12, 13, photos from the United States Navy.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

THE CLOCKS INSIDE US

by Diane Sherman

■ Birds wake up at dawn and go to sleep at night. The leaves of plants rise towards the Sun and droop when it is dark. Earthworms creep out at night. People, too, have 24-hour schedules. We work and play in the daylight hours and at night we go to sleep. Everyone knows that. To ask why all this happens seems a silly question. We and other living creatures simply follow the day-and-night rhythm of the world around us.

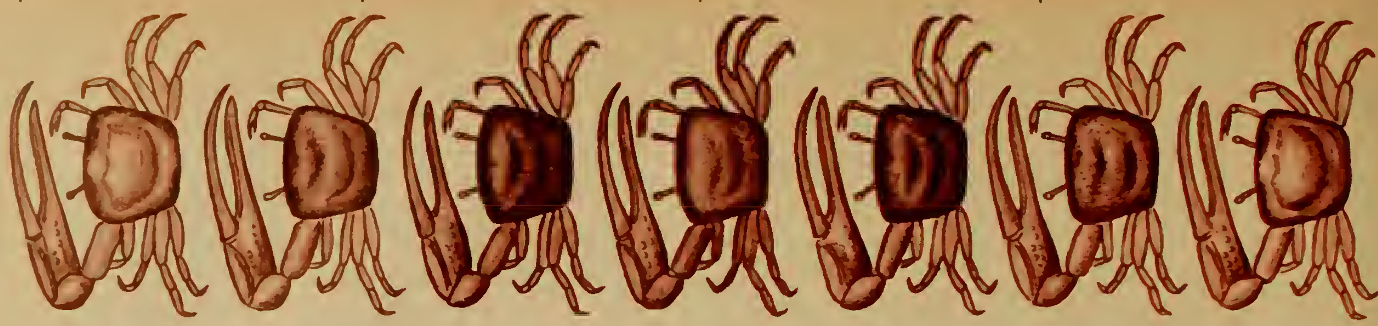
But biologists have wondered about it. Maybe we keep a 24-hour schedule because that is the way we are made. Suppose that plants and animals were kept in a laboratory where the temperature and light never changed. Would they *still* act one way at night and another way in the day?

As long ago as 1729, a French scientist named Jean-Jacques de Mairan decided to find out. He kept plants in constant darkness and at an even temperature, and he found that the plants still went through a day-and-night cycle. The leaves still drooped when it was evening. It was as if the plants could tell time by themselves.

A modern scientist named Wilhelm Pfeffer experimented in much the same way with bean seedlings. His results also showed that plants "knew" when it was night even when they were kept in darkness.

Animals as well as plants seemed to measure the passage of time for themselves. In 1955, at the Marine Biological Laboratory at Woods Hole, Massachusetts, two scientists named H. Marguerite Webb and Frank A. Brown, Jr., began to study Fiddler Crabs. These little seashore animals change color twice each day. At dawn their skins get very dark. At sunset, they grow pale. The two scientists kept some of these crabs in darkness for many weeks, in the laboratory. Even then they went on changing color. They changed from light to dark and back again, just as if they were still out on the beach. The crabs seemed to have clocks inside them—biological clocks.

(Continued on the next page)



Fiddler Crabs change color twice each day. They turn pale at dusk and dark at dawn. When scientists kept some crabs in darkness, the animals changed color as before, even though they could not see the sunrise or sunset.

The Clocks Inside Us (continued)

The Case of the Oyster

Dr. Brown tried another experiment, this time with oysters. Oysters at the seashore open their shells widest to feed at high tide, when they are covered with water. The two scientists took some oysters from a bay in Connecticut and shipped them to a laboratory in Evanston, Illinois. The oysters were kept in a pan of seawater, in a dark room.

Supposedly, oysters in a Midwestern laboratory would have no way of knowing about tides in the ocean 800 miles away. Yet for almost two weeks they went right on opening their shells widest at the times when the tides were high in the bay in Connecticut.

Then the cycle changed. The oysters began opening their shells widest at a somewhat different time each day. Finally they were opening their shells widest when the Moon was high over Evanston, and they stayed on that schedule. This is the time when it would be high tide in Evanston if there were an ocean in Illinois.

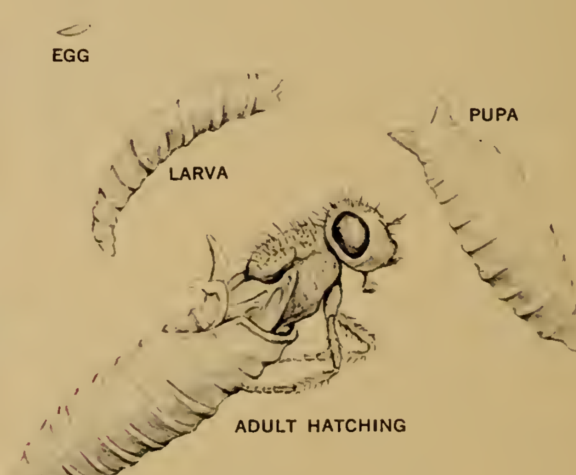
How could this be? The oysters had adjusted their schedules to the time zone *(see* N&S, *October 19, 1964, page 14)* in the place to which they had been moved. But they were kept in a dark room in a pan of sea water, so how could they know about ocean tides and the position of the Moon? In Connecticut, the oysters' clocks had been set in time with the tides: They were "lunar clocks." But the Moon pulls on the Earth's atmosphere, too, causing regular changes in air pressure. Dr. Brown suggested that the oysters may feel the changes in air pressure and regulate their timetables accordingly.

Dr. Brown had thought that by controlling light and temperature he was keeping the oysters from finding out the time from any outside source. But if oysters could feel the pull of the Moon, they *were* getting outside signals. Perhaps their clocks were not built-in at all.

The Case of the Bees

In 1955 a German scientist, Dr. Max Renner, did an experiment with bees. Scientists already knew that if food is available at a certain place at only one time of day, bees soon learn to visit that place at only that time each day. Dr. Renner had two identical testing rooms built in Germany. He sent one to Paris and the other to The American Museum of Natural History in New York. Everything

These bees were trained to eat at the same time each day. When they were moved from Paris to New York, their "clocks" told them to eat as though they were still in Paris.



A fruit fly changes from an egg to an adult in a few days. When a light is flashed on a fly larva, its inner clock is "set." The fly hatches at the same time a few days later.

about the two testing rooms was the same including temperature and light. Then, in the room in Paris, he trained bees to take sugar water each night from 8:15 to 10:15.

One night, after the bees had fed in Paris, they were put in a closed container, rushed to New York by plane and placed in the second, identical testing room. The question was, when would they come to feed? Would they stay on their 24-hour cycle? Or would they come at 8:15 New York time? If they did that, it would mean that some outside influence was responsible for their sense of timing. But if they stayed on French time, it would mean that they had internal clocks.

At 3:15 New York time (8:15 Paris time), exactly 24 hours after their feeding in Paris, the bees began looking for food in their testing room in The American Museum. The bees were telling time by their own clocks.

The Case of the Fruit Fly

Suppose there is a clock in every room of your house. They all measure the time exactly in units of 12 hours. But suppose the one in the living room reads 7:00, at the same time that the one in the kitchen reads 8:00, while your alarm clock reads 6:00. You wouldn't know when to get up, when to go to school, or when to go to bed. Of course, this usually doesn't happen, because you set the hands of all the clocks in your house to the same hour. You know what time to set them from the radio, perhaps. When the alarm in your bedroom goes off at 7:00, the clock in the living room chimes seven times.

If living creatures have internal clocks that measure 24-hour periods, what is it that determines when they will "chime?" How are the "hands" on these clocks set?

The tiny fruit fly is a very good animal for certain kinds of experiments, because it "grows up" very fast. It goes from an egg to its larval stage, to its pupal stage, to adult in only a few days *(see diagrams)*. Dr. Colin Pittendrigh of Princeton University found that fruit flies normally crawled out of their cocoons only in the early morning.

He raised some fruit flies, from egg to adult, in complete darkness in a laboratory. These flies crept out of their cocoons at all hours of the day.

Then he raised some more flies in complete darkness except that when they were in the larval stage, he flashed a single light. In the days that followed, all emerged at *the same time of day that the light had been flashed.* Dr. Pittendrigh suggested that fruit flies are born with internal clocks that measure off 24-hour periods without any help from outside forces. But an outside force is needed to "set the hands" of these clocks—either the first light of day, or a single flash of light in the laboratory.

Many other experiments have been done on biological clocks. And many more will be done. Scientists know that practically all living creatures have some sort of biological clock. Even people. With all of our other watches and clocks, *we* seem to have inner clocks, too. Scientists have found that many of the things going on in our bodies follow a 24-hour schedule. For example, our temperature, our breathing, and our blood circulation change with the time of day or night.

Our *adrenal glands* follow a schedule of their own. Several hours before we wake up, these glands start pouring a substance into our blood. This substance acts on the rest of the body, getting us ready for an active day. Then, late in the morning, the glands slow down.

But how do our adrenal glands start working at a certain time? What makes them begin at three o'clock in the morning for the man who usually rises at five? Why do they start at five o'clock for the man who usually gets up at seven? It would seem that we have built-in clocks, too. They are not the kind of clocks that tell us if we'll be late for school, but they keep our bodies running on schedule.

What happens when our schedules are disturbed? Often jet plane passengers cross many time zones as they fly over the oceans. When this happens, their bodies are thrown off schedule. It may take three or four days before they feel like sleeping when everyone else in the new part of the world does. It may take several weeks before all their body rhythms are adjusted to the new time. But, like oysters, they do adjust. The clocks inside living creatures are marvelous indeed, and we still have much to learn about how they work ■

PROJECT

Raise a bean plant in a pot. Watch it closely to see whether the position of its leaves changes over a 24-hour period, and keep a record of what time of day any changes happen. Then put it in a dimly lit closet, or someplace else where you can keep the light and the temperature the same, night and day. Do the plant's movements still take place at the same time each day? If so, how long do these movements continue—1 day, 3 days, a week?

PROJECT

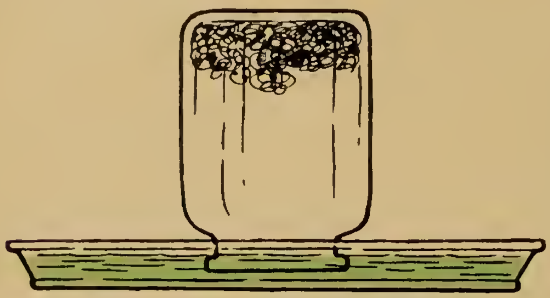
This summer, catch a few fireflies if you can. Put them in a jar and keep them in a closet where the light is kept very dim 24 hours a day. When do the fireflies start to flash? Do they have biological clocks? If they do, can you think of a way of resetting them?

brain boosters

prepared by **DAVID WEBSTER**

Can You Do It?
Can you place an ice cube in a glass of water and make it float for a minute in the center without touching the glass?

What Do You Think Would Happen?
Some wet steel wool is put in a jar which is turned upside down in a pan of water. What would happen after a few days? Try it to find out.



For Science Experts Only
A girl was born in summer, but now her birthday is during the winter. How could this happen?

submitted by Tia Ballantine, New City, New York

TRY THESE IN YOUR SPARE TIME

How Long Will It Take?
If a clock takes 5 seconds to strike 6 o'clock, how long will it take to strike 12 o'clock?

submitted by Steven German, South Orange, New Jersey

What Time Was It?
Two microbes were placed in a quart jar at exactly 2 o'clock. The number of microbes doubled every minute. The jar was full of microbes at exactly 3 o'clock. At what time was it half full?

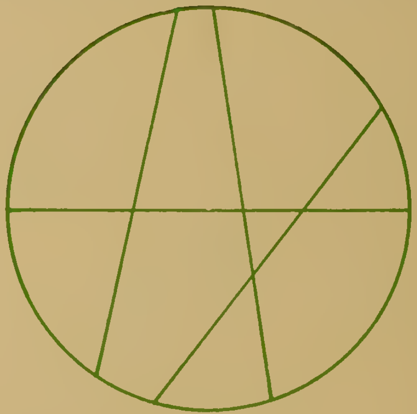
submitted by Mike Hansen, St. Davids, Pennsylvania

This Takes Time
Hang a heavy object from a piece of string so that it will swing freely. By shortening the string you can make the object swing faster. Can you make it swing back and forth once each second, or 60 times in a minute?

MYSTERY PHOTO

About how old was this tree? Why are the rings different thicknesses?

Fun with Numbers and Shapes
Four lines have been drawn to divide the circle into 9 parts. Can you divide a circle into 11 parts with four straight lines? Can you divide a circle into 16 parts with 5 lines?



The best answers submitted to Brain-Boosters in the contest appearing in the last issue will be published in the May 3rd issue of *Nature and Science*.

MEASURING PAST AGES

■ Ever since men invented writing about 5,000 years ago or more, they have left records of the things they did. But how do we know what happened before men started to write? And even earlier, before there were people on the Earth?

Suppose it is millions of years ago. A volcano erupts, sending molten ash high up into the air. Later the ash settles down to the ground in a thin layer. Sands and clays, carried by wind and water, cover the ash. Animals die and their bones are added. Then, many years later, the volcano erupts and another layer of ash falls to the ground, covering up everything. As thousands of years go by, more sand and clay cover the second layer of ash, and other kinds of animals leave *their* remains behind. Meanwhile, the first layers of sand and clay have changed to rock *(see diagram)*. Still later, a river flows through the land for thousands of years, *eroding,* or slowly wearing down, the soil and rocks. Today the layers formed over millions of years are exposed to view.

Scientists who study these layers can see that a volcano erupted twice. From the remains of the animals, called *fossils,* they can tell what the animals looked like when they were alive. They can also tell that the animals buried in the lower layer lived before those in the upper layer.

Over the past hundreds of millions of years, the Earth's surface has changed in many other ways *(see pages 8 and 9)*. By studying layers of soil and rock, scientists have long been able to tell the *order* in which these changes took place, and to figure out roughly *when* they took place. About 15 years ago, Dr. Willard Libby of the University of Chicago discovered a way of finding out more exactly when certain events happened in the past. He found that all plants and animals are radioactive "clocks."

How Radioactive Clocks Work

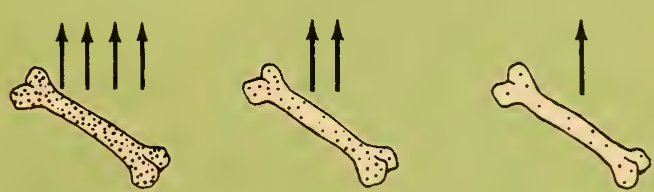
Living plants take in from the Earth's atmosphere a rare type of carbon, called *carbon-14.* Carbon-14 slowly but constantly changes into another element, nitrogen-14. As the carbon-14 in a living plant changes into nitrogen-14, it is replaced by more carbon-14 from the atmosphere. Animals also take in carbon-14 from the plants they eat.

When a plant or animal dies, it stops collecting carbon-14. The amount of carbon-14 in the remains of the plant or animals gets smaller as it changes into nitrogen-14. No matter how much carbon-14 a dead plant or animal may have, it takes 5,760 years for half of its carbon-14 to disappear. (This period of time is called the *half-life* of carbon-14.) It then takes another 5,760 years for half of the remaining carbon-14 to disappear, and so on *(see diagram below)*. By measuring how much carbon-14 is left in a piece of dead wood, for instance, scientists can figure out how long ago the wood was a living plant.

This method only works for plants and animals that have lived within the past 50,000 years or so. So far, scientists cannot measure the age of older fossils because there is not enough carbon-14 left in them. And rocks never were alive, so they never absorbed carbon-14. But rocks contain other radioactive elements.

One radioactive element that is found in some rocks is called *potassium-40.* Potassium-40 has a half-life of 1,300,000,000 years. In that period of time, half of the potassium-40 in a rock changes to calcium and a rare element called argon-40. A scientist can measure how much potassium-40 and argon-40 a rock contains. Since he knows how long it takes for potassium-40 to change into argon-40, he can figure out how long ago the rock was formed. If there are fossils of plants or animals in the rock, he knows that they must be at least as old as the rock itself.

—James K. Page, Jr.



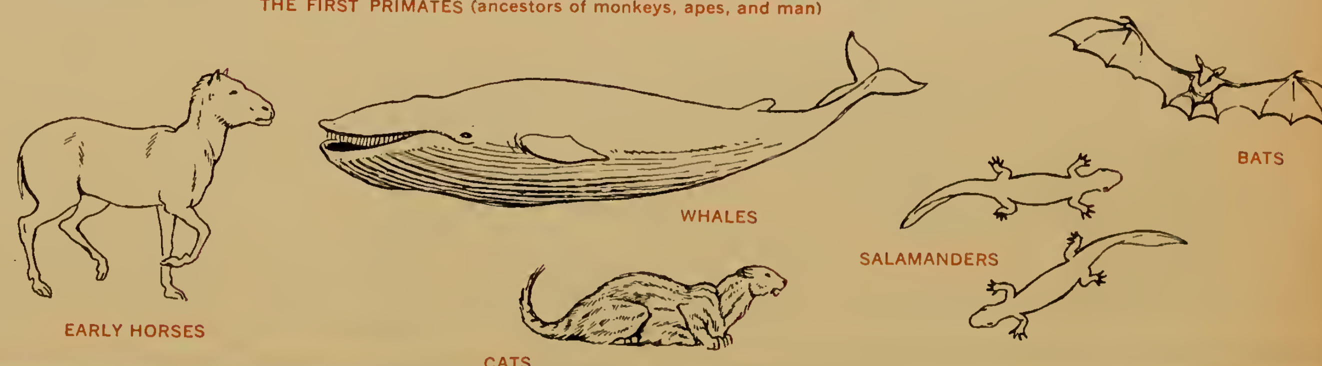
When a plant or animal dies, it begins to lose a substance called carbon-14. It loses half of its remaining carbon-14 each 5,760 years. Scientists measure the amount of carbon-14 left in the remains of the plant or animal to find out how long ago it lived.

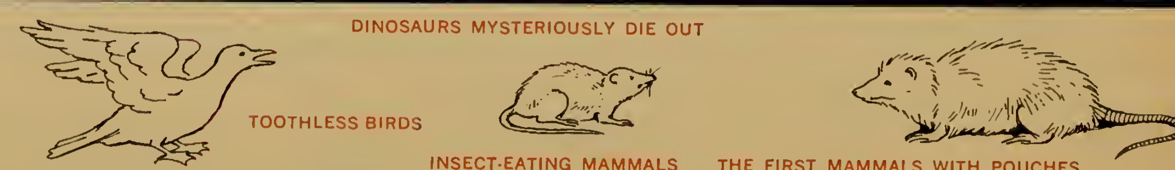
THE AGES OF THE EARTH

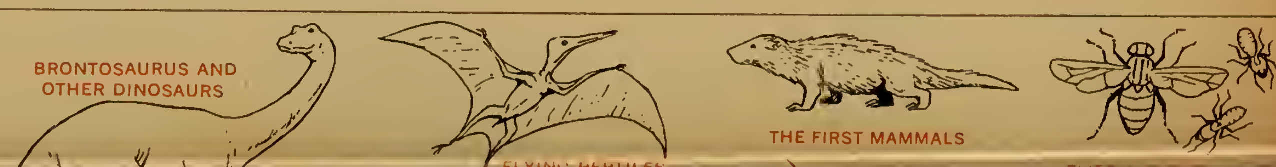
■ A time scale for the history of the Earth has been worked out by scientists who study rocks and fossils. It is divided into *eras* and *periods* (see the dates and names in the left hand columns). Some of the names given to time periods in the scale are names for places. The *Jurassic Period* is named for the Jura Mountains of Europe because rocks of that age form these mountains. The *Cambrian Period* is named for Cambria, the Latin name for Wales in the British Isles. Other periods are named for a special type of rock—*Cretaceous* means "chalk-bearing." *Tertiary* (third) and *Quaternary* (fourth) are names held over from an earlier scale in which the periods ar numbered.

This chart will tell you some of the major event in each period, such as when certain mountain ranges were formed, and when various forms o animal and plant life developed ■

ERA	PERIOD	SOME MAJOR EVENTS DURING THE HISTORY OF THE EARTH
CENOZOIC (RECENT LIFE) THE AGE OF MAMMALS	**QUATERNARY** Present to 1.5 million years ago	Glaciers sweep south over parts of the Northern Hemisphere four times and recede.
	TERTIARY 1.5 million to 63 million years ago	Grasslands take over from forests. The Alp Mountains are built. Mammals take on many different forms.
ZOIC THE AGE OF REPTILES	**CRETACEOUS** 63 million to 135 million years ago	Seas are warm and shallow. Flowering plants begin to take over the landscape. The Rocky Mountains are built.
	JURASSIC	Warm moist climate.



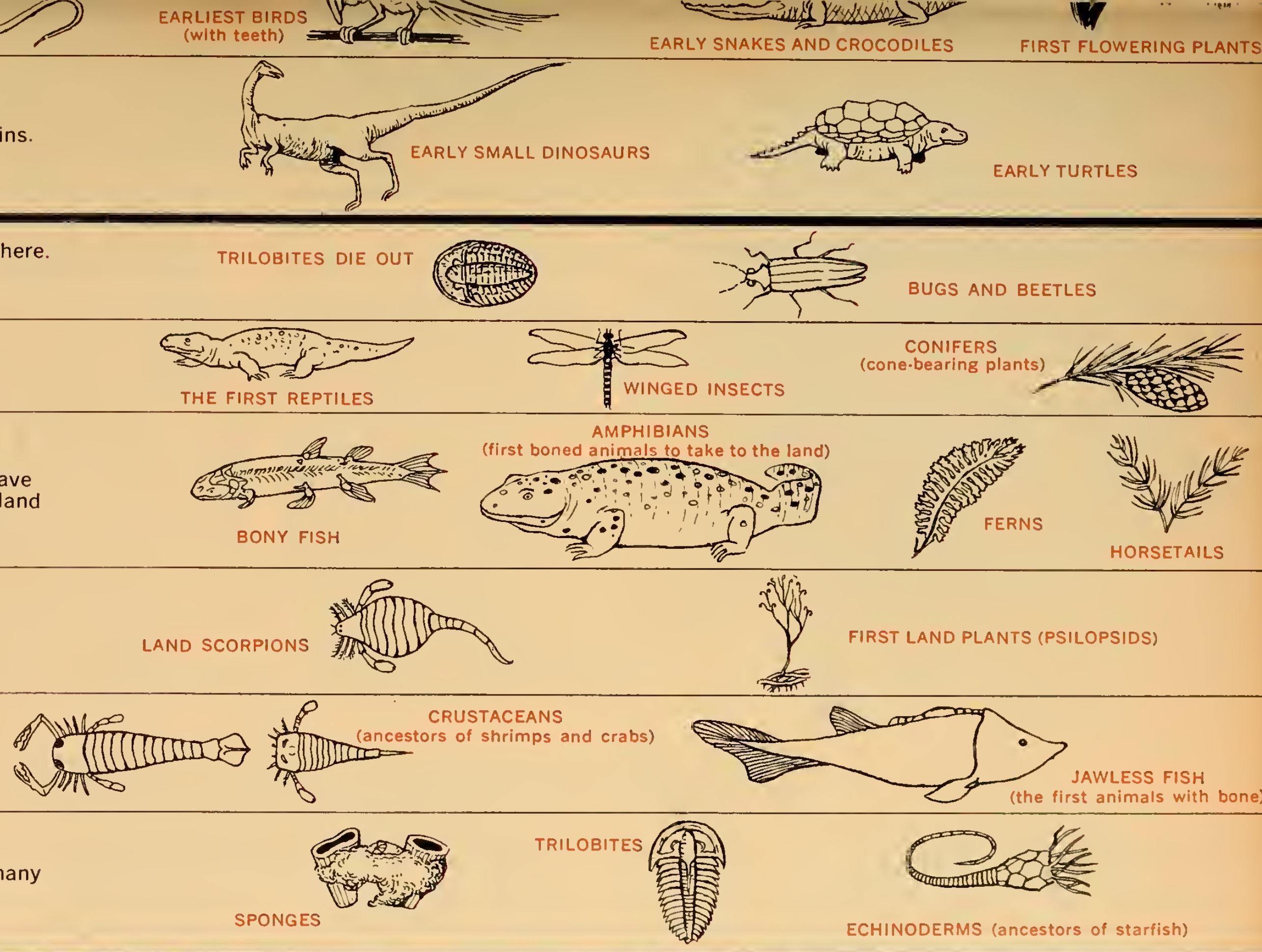




ME (MIDD

PALEOZOIC (ANCIENT LIFE)

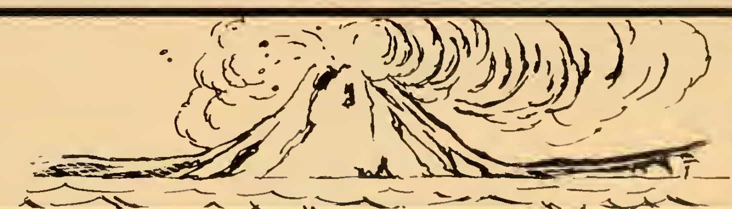
TRIASSIC 181 to 230 million years ago	Deserts give way to forested plains.
PERMIAN 230 to 280 million years ago	Hot deserts in Northern Hemisphere. Ice in Southern Hemisphere. Appalachian Mountains built.
CARBONIFEROUS 280 to 345 million years ago	Evergreen forests and swamps. 15-foot amphibians flourish.
DEVONIAN 345 to 405 million years ago	Many changes in the landscape. Volcanic eruptions. Sea-beds heave up into mountains. Areas of dry land become seas.
SILURIAN 405 to 425 million years ago	
ORDOVICIAN 425 to 500 million years ago	Life still found only in the warm, shallow seas.
CAMBRIAN 500 to 600 million years ago	Cambrian seas abounded with many forms of life:



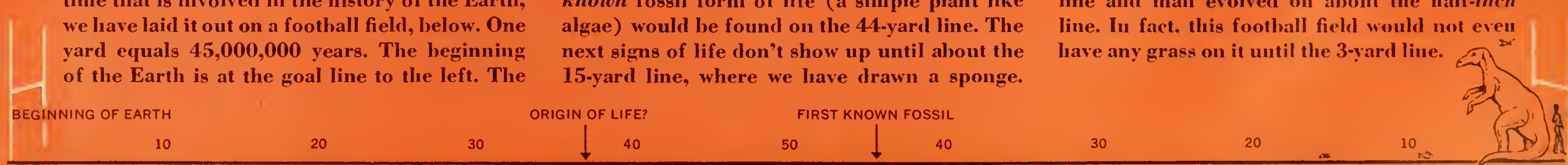
PRE-CAMBRIAN

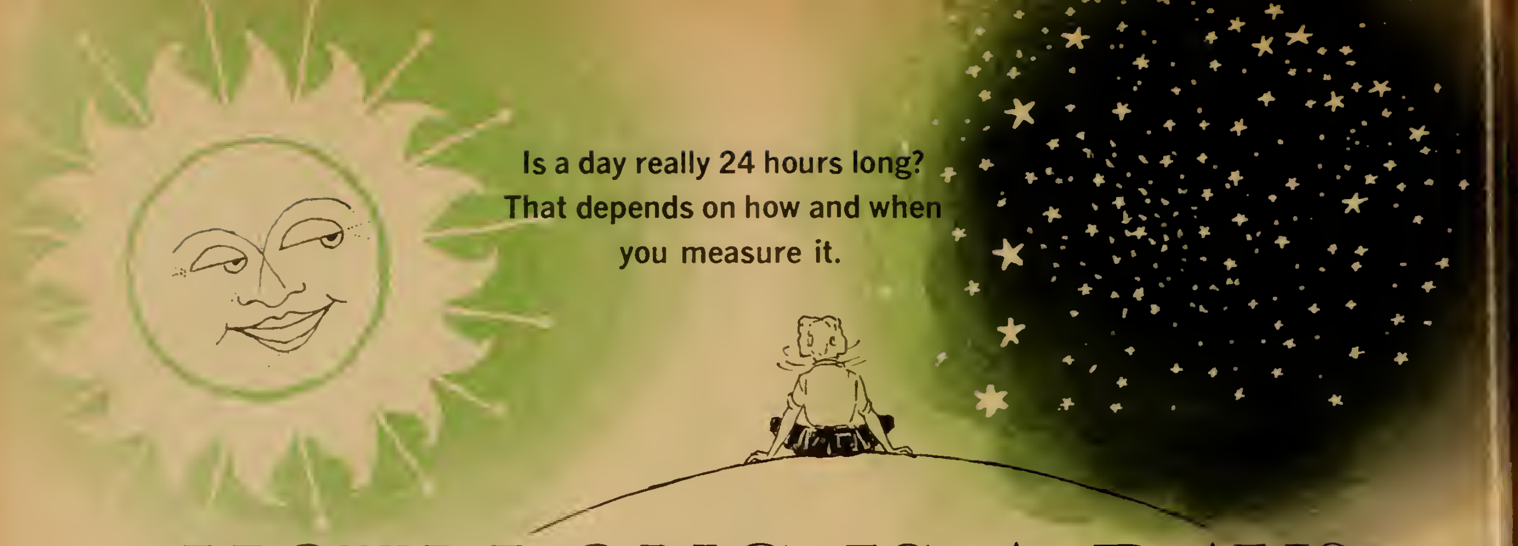
600 TO 4,500 MILLION YEARS AGO

By the end of this era there were many forms of sea-life, including bacteria and simple plants, and perhaps sponges, but very few fossil remains have been found.
The oldest fossils yet discovered are of very simple plants that lived 2,000 million years ago. These fossil plants are something like algae and fungi. Scientists think that even first forms of life existed 3,000 million years ago.



To give you an idea of the relative amount of time that is involved in the history of the Earth, we have laid it out on a football field, below. One yard equals 45,000,000 years. The beginning of the Earth is at the goal line to the left. The righthand goal line is the present. The first *known* fossil form of life (a simple plant like algae) would be found on the 44-yard line. The next signs of life don't show up until about the 15-yard line, where we have drawn a sponge. The first true fish evolved on about the 9-yard line and man evolved on about the half-*inch* line. In fact, this football field would not even have any grass on it until the 3-yard line.





HOW LONG IS A DAY?

by ROY A. GALLANT

■ We say that a "day" is the time it takes the Earth to *rotate,* or turn, once on its axis. During that time we go through one period of daylight and one period of darkness. If you wanted to start your own system of time-keeping, you could invent your own units of time. You could have a day of 10 *ruohs,* each *ruoh* having 100 *etunims,* or whatever. So long as everybody agreed to use your time units, there would be no problem.

Today we use a time system based on time units worked out by Babylonian and Egyptian astronomers more than 4,000 years ago. Each hour has 60 minutes and each minute has 60 seconds. Like these astronomers of ancient times, suppose that you did not know how many hours and minutes a day lasted. Suppose that you wanted to find out exactly how long it takes the Earth to rotate once on its axis. How would you do it?

Measuring the Length of a Sun Day

You get up in the morning and, with a stopwatch in hand, wait for the Sun to travel across the sky and reach a point exactly south of you. The instant it does you start your stopwatch. On the following day, the instant the Sun reaches its due-south point again, you stop the watch. By counting the hours and minutes that passed from your first sighting to the second one, you would have the length of the *Sun day,* or *solar day.* You have measured the rate of rotation of the planet, using the Sun as your guide. And you find the length of the solar day is 24 hours, more or less.

Measuring the Length of a Star Day

The stars also appear to move across the sky, just as the Sun does. How long would a day be if you used a star as your guide instead of the Sun? Say that you selected a star that passes directly overhead tonight and tomorrow night. Tonight you start your stopwatch the instant the star is overhead, and tomorrow night when the star is overhead again, you stop your watch. What you have done is measure the length of a day—one rotation of the Earth—using the stars as your guide. This gives the length of a "star" day.

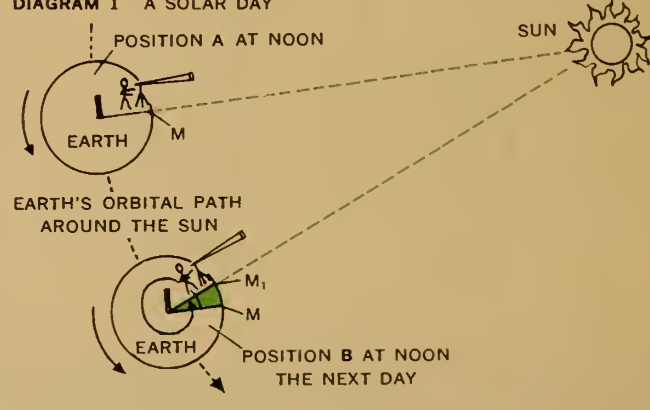
It may surprise you to learn that a star day is 3 minutes and 56 seconds shorter than a solar day. Why this difference? And which time—solar time or star time—is "right"?

Extra Time in a Solar Day

Star time gives the true measure of the time it takes the Earth to rotate. Diagram 1 on this page shows why the Sun does not give us a true measure of the Earth's rotation, and why a solar day is longer than a star day.

Suppose that the Earth is at position A in the diagram. The time is noon, which means that the Sun is due south of

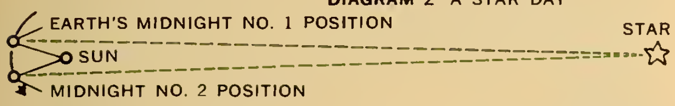
DIAGRAM 1 A SOLAR DAY



you. Suppose also that you are standing at position M, and that you record the exact moment the Sun passes the due-south point. The next day you do the same thing. But while you have been waiting to take your next time measurement the Earth has moved about 170,000 miles along its orbit around the Sun, to position B. This means that at noon the next day you will be looking at the Sun from a different point in space, because the Earth has carried you along its orbit. It also means that you will have to wait until the Earth's rotation carries you around to position M_1 before you see the Sun due south again. Since the Earth is moving around the Sun, our planet has to make a little more than one complete rotation before you see the Sun due south again on the second day. The colored part of the diagram shows the amount of extra rotation.

The stars are so far away that the Earth's motion around the Sun makes no difference in the apparent position of a star when we measure the overhead position of the star from one night to the next *(see diagram below).*

DIAGRAM 2 A STAR DAY



That is why the stars give us the exact rate of the Earth's rotation. It also explains why a star day is shorter than a solar day.

Since star time gives a more accurate measure of the Earth's rate of rotation than solar time does, you might think that we keep star time on our watches and clocks. But we don't. Our watches keep solar time. After all, we regulate our daily lives by the Sun.

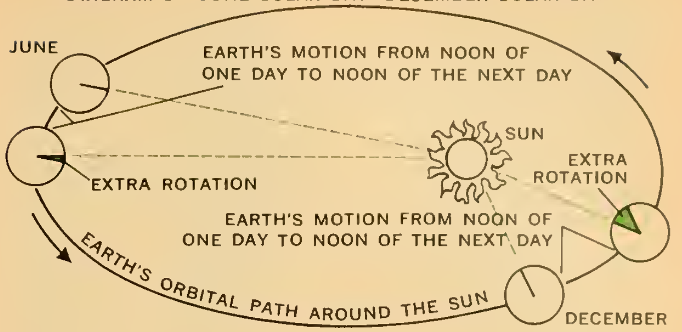
Solar Time Keeps Changing

Let's go back to something we said earlier: A solar day has 24 hours, *more or less*. Why "more or less"? Shouldn't each solar day have the same number of hours, minutes, and seconds? Suppose that you measured the length of the solar day from noon of September 16 to noon of September 17, 1965. You would find that the length of the solar day for that day would be 23 hours, 59 minutes, and 42 seconds. If you made another measurement next December 22-23, you would find the length of that solar day to be 24 hours and 30 seconds. Why is a December solar day longer than a September solar day?

The length of solar days changes because the speed of the Earth around the Sun changes. If the Earth traveled at the same speed all the time, every solar day would be almost exactly the same length. In December, when the Earth is very close to the Sun, our planet's orbital speed is 67,700 miles an hour. In June, when the Earth is much farther away from the Sun, it is traveling slower along its orbit—65,700 miles an hour.

The faster the Earth travels along its orbit, the longer a solar day is. Diagram 3 will help make this clear. The June diagram shows that the Earth has moved only a little way along its orbit in one day. The colored triangle shows the extra distance the Earth must rotate to bring the Sun due south at noon of the second day you make your time measurement. The December diagram shows the same thing, but you will notice that the colored triangle is bigger. This is because the Earth, which travels farther along its orbit in a December day than in a June day, has to rotate a bit more in December than in June in order for the Sun to appear due south again on the second day of the observation.

DIAGRAM 3 JUNE SOLAR DAY—DECEMBER SOLAR DAY



A Make-believe Sun

What all of this means is that the length of nearly every solar day is different. Since our watches and clocks tick off the same number of seconds every day, then how can they keep accurate time without our resetting them every few days?

Astronomers have helped us with this problem. They invented an average sun, called the *mean sun,* and a *mean solar day*. They imagine that the mean sun moves across the sky at the same speed day after day. Or to put it another way, they have imagined an Earth that does not change its orbital speed. This makes each solar day the same length as every other solar day—exactly 24 hours. It is this make-believe sun time that we keep on our watches and clocks. But you can't see the make-believe mean sun and neither can the astronomers who tell us how to set our clocks. So they measure the days by the stars with very accurate instruments and find out what time it is by star-time. Then they make the proper correction to get mean-sun time.

The next time someone asks you what time it is, you can look puzzled for a moment. Then ask him: By the real Sun? By the mean sun? Or by the stars? ■

PROJECT

Why did astronomers of old divide hours into 60 minutes, and minutes into 60 seconds? See how many numbers you can divide into 60 without having anything left over. Can you find any number less than 60 that can be divided by so many numbers?

WHAT TIME IS IT?

by Thomas D. Nicholson

One Master Clock keeps the time by which we set our clocks and watches, but even the Master Clock has to be adjusted now and then.

■ "At the tone, the time will be three o'clock," says the voice on the radio. And then you set your watch.

So do millions of other persons all over the country. Scientists measure time by the stars, but if you judge by the customs of most Americans, the correct time comes from the radio.

Where do the radio stations get the time? How can they be sure that their time is right?

The clocks in a radio station can be wrong, just as your watch or clock can be wrong. So radio stations check their clocks daily—sometimes hourly—against time signals that are broadcast throughout the day and night by certain short-wave radio stations. These short-wave stations are operated by the government, and every five minutes they tell exactly what time it is.

Time broadcasts from these stations are also listened to in the Time Service Room of the United States Naval Observatory in Washington, D.C. Every now and then, the Observatory finds that the time signal broadcast by one of these stations is a little fast or a little slow. The Observatory then tells the station how much its signal is behind or ahead of the Master Clock *(see photograph).*

The Master Clock

The Master Clock is an electronic clock. It depends for its accuracy on a crystal made of quartz. This crystal is mounted in a case from which most of the air has been removed. An electric current makes the crystal vibrate. The number of times a crystal will vibrate back and forth each second depends on its size, shape, and what it is made of. So the Master Clock crystal always vibrates the same number of times a second. Its vibrations regulate an electronic switch that sends out a pulse of electricity every second. These pulses regulate the clocks at the Observatory. Throughout the United States, time is based on this Master Clock.

The time signals broadcast by the various short-wave radio stations are received in the Time Service Room and compared to the pulses from the Master Clock. Their accuracy is measured to within a few millionths of a second. So, when you set your watch by the radio you can be sure that it is pretty accurate.

The quartz-crystal clock measures seconds with amazing precision, yet every now and then even it has to be corrected by the astronomers at the Naval Observatory. The reason for this is that we measure time by the rotation of the Earth *(see page 10),* and the Earth does not rotate at a constant speed. Over a period of years, it speeds up slightly, then for several more years it slows down. As a result, the Master Clock is getting slightly out of step. There is no way of predicting when these changes will take place, so astronomers must keep observing the stars to check on the time it takes for the Earth to rotate once.

Adjusting the Master Clock

Every clear night of the year, an astronomer at the Naval Observatory photographs the stars with a special telescope called a *zenith tube (see photograph).* The telescope points to only one small part of the sky—straight

Dr. Thomas D. Nicholson is Chairman of the American Museum-Hayden Planetarium.

The time-keeping center of the United States is this Time Service Room at the U.S. Naval Observatory in Washington, D.C. The Master Clock—a crystal that vibrates at a constant speed—is in the middle of the panel at the right. It regulates the hands of the clock above it. Time signals broadcast by short-wave radio stations are recorded on the rolls of paper at the left. When a station's signals are out of step with the Master Clock, the Observatory tells the station how much to speed up or slow down its signal.

Astronomers use this zenith tube telescope to photograph a star at the exact instant the star passes overhead (*see text*). The exact time the photograph was taken is recorded. From photographs made on two successive nights, astronomers can figure out how many hours, minutes, and seconds it took the Earth to rotate once. This time is used to keep our clocks in step with the Earth's rotation.

up, to the point directly overhead called the *zenith*. Certain stars pass close to this point every night. These stars are photographed, and the exact time when each star crosses the *meridian* is recorded. (The meridian is the north-south line in the sky running through the zenith.) From photographs made on two successive nights, astronomers can figure out exactly how many hours, minutes, and seconds it took the Earth to rotate once. This tells them whether the Master Clock is out of step with the Earth, and if so, how much it must be corrected.

Over the past several years, the Earth's rotation has slowed ever so slightly. As a result, the Master Clock was getting slightly out of step. To put the clock back in step with the Earth, on last April 1 the tone sounded at midnight was held up one-tenth of a second.

So you see, time does come from the stars, but it travels a very roundabout route to your watch ■

BOOKS ABOUT TIME AND TIMEKEEPING

If you want to know more about time and timekeeping, you might enjoy reading these books: **The Clock We Live On,** by Isaac Asimov, Abelard-Schumann, Limited, revised edition, 1959, $3.50; **Experiments in Sky Watching,** by Franklyn M. Branley, Thomas Y. Crowell Company, 1959, $3.50; **Sundials,** by Roy K. Marshall, The Macmillan Company, 1963, $3.50; **Understanding Time,** by Beulah Tannenbaum and Myra Stillman, McGraw-Hill Book Co., 1958, $3.

HOW ACCURATELY CAN YOU JUDGE TIME?

Can you count seconds? One way to do it is by saying to yourself, "a thousand and one, a thousand and two, a thousand and three, a thousand and four," and so on.

Try counting up to 10 seconds while a friend, or your teacher, checks you on a clock with a second hand. Then try counting larger intervals, say 30 seconds, or even 60.

Can you count short intervals more accurately than long intervals? Why? How can you correct this? Does your error change each time you try counting? How can you correct this? When you count up to 60 seconds, is the error six times as large as when you counted to 10 seconds? Should it be? If not, why not?

Here's another way to count seconds. Watch the second hand of a watch or clock while you count the seconds to yourself, or even out loud. Try to develop a rhythm so that your counting matches the clock's beat. Now, can you count seconds more accurately?

HOW IT WORKS

Clocks

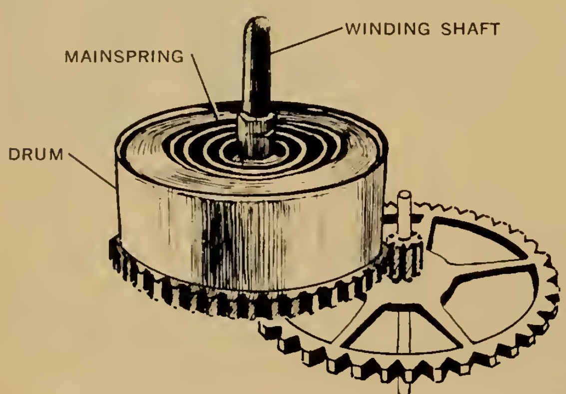
■ A clock measures time by moving its hands around the dial so that they always turn the same distance in the same period of time. It has to have a *driving mechanism* to turn the hands and a *regulator* to keep them moving at the same speed.

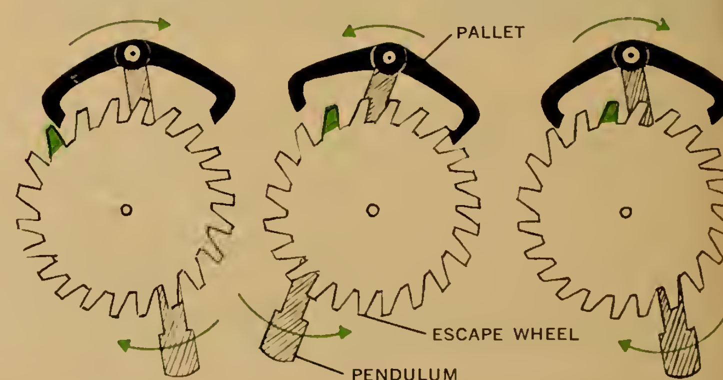
Most of our clocks and watches are driven by a spring something like the coiled strip of metal that turns the wheels of a toy wind-up automobile. The *mainspring* of a clock is coiled inside a metal drum. One end of the spring is attached to the side of the drum, and the other end is attached to the winding shaft at the center of the drum *(see diagram)*.

When you wind a clock, you turn the inside end of the spring around and around, bending it into a tighter coil. As the spring unbends, it pushes the drum around the shaft. The drum has gear teeth around its edge, and as the drum goes around, it turns a series of gears that make the hands of the clock go around.

What Makes a Clock Tick?

If there were nothing to slow down the turning of these gears, the mainspring would unwind in a few moments, like the spring of a wind-up toy. But one of the gears turns a wheel with long, slanted teeth sticking out from the edge. This is called the *escape wheel.* Next to the escape wheel is a bar, called the *pallet,* that rocks back and forth on an axle at the center of the bar. At each end of the pallet there is a hook *(see diagram below).* When one





TIME
THE SHORT AND THE LONG OF IT

■ If you were a cave-dweller, like early man, you wouldn't have to measure time very accurately. You would probably be satisfied with the differences in day and night, one season and another, and periods of the Moon.

But today we need accurate measures of time periods—from very small ones to very large ones. Electronic engineers and photographers, for example, split seconds into tiny fractions. Geologists and astronomers measure time in billions of years.

This table shows some of the time periods we use today and the number of seconds each contains. With these divisions of time, we can measure the past, present, and future of the world more accurately than ever before ■

SECONDS
.00000000
.000001
.001
.01
.1
1.
60.
3,600.
86,400.
31,557,000.
3,155,700,000.
31,557,000,000.
31,557,000,000,000.
31,557,000,000,000,000.

end of the pallet rocks toward the escape wheel, the hook on that end blocks a tooth on the escape wheel and stops it from turning. When the pallet rocks the other way, that tooth is no longer blocked. The escape wheel turns just a little way before the other hook blocks a tooth on the escape wheel. Each tick you hear is the sound of an escape wheel tooth striking a hook. But what makes the pallet rock back and forth?

Some clocks have a *pendulum* attached to the center of the pallet bar. A pendulum is a weight that hangs from the end of a string or rod and swings back and forth. If you have ever experimented with a pendulum, you know that it swings back and forth faster as you shorten the string or rod. The pendulum of a clock is just long enough so that it swings back and forth in one second, or 60 times a minute. This rocks the pallet bar back and forth once each second and keeps the escape wheel—and the other gears in the clock—turning at just the right speed.

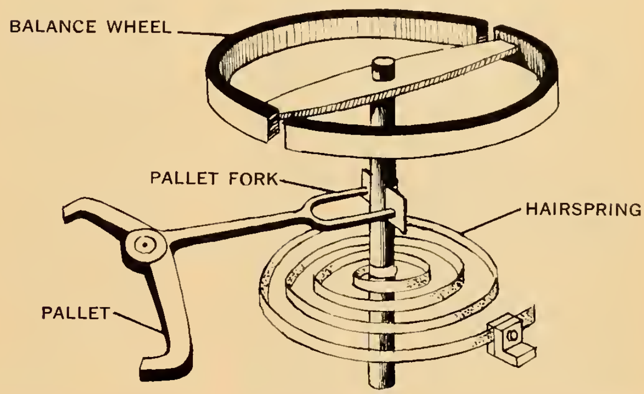
You may wonder what keeps the pendulum swinging back and forth. The end of each pallet is slanted so that as the pallet lifts out of the way of a tooth in the escape wheel, the tooth gives it a slight push.

Circular Pendulums

Watches and many clocks are regulated by a circular pendulum called a *balance wheel (see diagram)*. The balance wheel is heavier around the edges than in the center. It is turned by a forked rod attached to the pallet. When the pallet rocks one way, the balance wheel turns part way around on its axle. As the balance wheel turns, it winds up a tiny coil spring, called the *hairspring*. The spring winds up until it is tight enough to push the balance wheel back in the opposite direction. This rocks the pallet the other way and frees the escape wheel for one more short turn.

The speed of the escape wheel regulates the speed of all the other gears in the clock. But how do these three hands turn at different speeds if they are all attached at the center of the clock? The answer is that each hand is fastened to a different shaft, one inside the other. The two outside shafts, of course, are hollow.

Many clocks today are driven by electric motors. An electric clock has no escape wheel. The speed of the clock's moving parts is regulated by the *frequency* of the electric current fed into the motor. The frequency is the number of times each second that the current reverses its direction. In the United States, alternating current changes its direction 60 times each second. Since there are 60 seconds in a minute and 60 minutes in an hour, it is easy to arrange gears to turn the clock hands at the right speeds ■



NAME OF TIME PERIOD	WHAT HAPPENS IN TIME PERIOD
anosecond (billionth of a second)	Light travels one foot
icrosecond (millionth of a second)	Radio waves travel 1,000 feet
illisecond (thousandth of a second)	Bullet travels through a rifle barrel
undredth of a second	Sound travels 10 feet
enth of a second	Eye blinks in 4/10 second
econd	One human heartbeat
inute	High-speed jet airplane travels 25 miles
our	Morning glory flower opens
ay	Earth rotates once
ear (365¼ days)	Earth revolves once around Sun
entury (100 years)	Life span of Box Turtle
illennium (1,000 years)	Life span of Giant Sequoia tree: 3 to 5 millenniums
illion years	Mankind's existence on Earth: 2 million years
illion years	Age of Sun and Solar System: 5 or 6 billion years

Make Your Own WATER CLOCK

■ Thousands of years ago people did not have the kinds of clocks we have today. One way they kept track of the passage of time was by using water clocks. You can make your own water clock with a glass jar that has smooth straight sides, and an empty milk carton. You will also need a watch or clock with a sweep second hand, and a piece of sticky tape that you can write on.

Place the glass jar in front of you on a table and stick a strip of the sticky tape on it *(see diagram)*. With a common pin, punch a hole in the bottom of one milk carton. Fill the milk carton with water and put it on top of the glass jar. How long does it take for the water to come out? Use a watch or clock to find out. (This is only a trial run.)

In another carton punch a hole with a large safety pin. You could make the hole even bigger by wiggling a sharp pencil point in it. How long does this clock run? Make a still larger hole. Can you make a clock that runs for only five minutes? Or one that runs for 20 minutes? An hour?

Marking the Minutes

When you decide which carton you want to use, you will be ready to *calibrate* your clock, or put minute marks on the tape. Set the jar so that the strip of tape is facing you. Place the watch or clock with the sweep second hand beside the jar. You will also need a very sharp pencil.

Hold a finger over the hole in the milk carton and fill the carton to the top. With a pencil, mark the water level on the carton. (Each time you use your water clock, fill the carton to the same level. When you calibrate your clock you will understand why.)

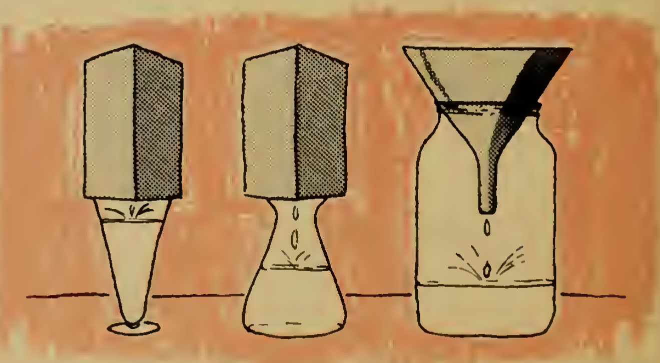
Now hold the carton on top of the jar, but don't take your finger off the hole yet. Wait until the sweep second hand of the watch reaches 12, then take your finger away and rest the carton on top of the jar.

The water will start coming out in a small stream. At the end of one minute, or at the end of five minutes, draw a thin line on the tape, marking the water level in the jar. Write "1" or "5" beside this mark.

To make the mark, put your eye at the level of the water in the jar. You will not see a sharp line of water, but a band. This band is caused by water climbing part way up the side of the jar. Use the *lower* edge of the band of water as the guide for your mark. This edge is easier to see than the top of the band.

Keep track of the sweep second hand. One minute later, or five minutes later, draw another mark and write "2" or "10" beside it. Keep drawing more marks until all or most of the water has run out of the carton. As the water level in the carton gets lower and lower, the water comes out more slowly. Can you guess why the same amount of water does not run out of the carton each minute as the water gets lower in the carton?

When you finish drawing a minute scale on the sticky tape, the markings near the top of the tape will be closer together than the markings near the bottom of the tape. If you wanted to make a water clock that had one-minute marks evenly spaced from top to bottom, how could you do it? What would happen if you used a jar shaped like those shown in the diagram below? Draw the kind of minute scale you think each of them might have. What if you use a funnel instead of a milk carton? Try it and see ■



nature and science
TEACHER'S EDITION

VOL. 2 NO. 11 / MARCH 1, 1965 / SECTION 1 OF TWO SECTIONS

Time and Man by Joseph M. Chamberlain

■ Most of us think of time as being a very simple affair. We have clocks that can tell us to a small fraction of a second how long it takes a man to run a mile. We have calendars that show us how many days, weeks, and months have passed since some important historical event took place centuries ago. The way we keep track of time today is very different from the time-telling devices invented by men of long ago.

To keep track of the days, primitive men observed the periods of the Moon. They could see that it took about 30 day-night cycles for the Moon to change from crescent to full and back again to crescent. They could also count the number of moons it took between the arrival of warm weather and cold, of rainy seasons and dry, of planting time and harvesting time. Each of these events, they found, returned again after about 12 moons, or what we today call a "year."

Of course, time today is really the same as it was in primitive ages. The motions of the Earth give us two units of time which we call the day and the year. The motion of the Moon gives us a third—the month. These are the *natural time units*. All other units of time—seconds, minutes, weeks, decades, centuries—are man-made. That is, they have been invented by man to divide or add up the natural time units in convenient ways.

So far as we know, all people have used the day as a unit of time. The duration of a day is the period of time required for the Earth to rotate once on its axis [*see page 10*]. As it does so, it carries us once around through sunlight and darkness.

The *average* time the Moon takes to go through its phases—new moon, first quarter, full moon, last quarter, and back to new moon again—is 29½ days. So far as we know, in ancient time the *average* length of a month was not used. Instead, men observed the actual number of days that passed from one full moon to the next. It was either 29 or 30 days.

The longest of these three natural time units is a year, the interval during which the Earth goes through the full cycle of seasons—spring, summer, autumn, and winter. This regular change of the seasons probably was the first "clock" used by primitive peoples to observe the length of a year. As they did so, they found that during the four seasons, the Moon went through its phases about 12 times. For this reason the year came to be divided into 12 months, or 12 lunar cycles.

The Year and the Seasons

One of the earliest known attempts to measure the length of the year was made by the ancient Greek astronomer Hipparchus about 125 B.C. Hipparchus set up a vertical post and observed how the shadow cast by the post at noontime each day changed throughout the year. At noon on the first day of winter the shadow was longer than at any other time of the year, and at noon on the first day of summer, it was the shortest. By counting the days from the time the noon shadow was shortest until it was once again shortest—that is, from the first day of summer in one year until the first day of summer in the next—Hipparchus measured the length of the year of the seasons and found that it was slightly more than 365 days.

Solar Year and Sidereal Year

We can measure the period of the Earth's revolution in its orbit—a year—by using either the Sun or the stars. The length of a year based on ob-

(Continued on page 8T)

This article is adapted from Time and the Stars, *by Joseph M. Chamberlain, in the* Astronomy Highlights *series published by The Natural History Press, Garden City, N.Y. Copyright © 1964 by Joseph M. Chamberlain.*

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 7T.)

IN THE NEXT ISSUE

A high school student tells how he helps scientists study the dwindling Grizzly Bears of Yellowstone National Park . . . The WALL CHART shows old and new ways of making maple syrup . . . Using a microscope to measure tiny objects .

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Poets have sung of time. To the mathematician, time, like the velocity of a moving train, or a star, is relative. The telescope serves as a kind of "time machine" that enables us to see—in our reference of "now"—astronomical events that took place hundreds of thousands of years ago.

Time, Webster tells us, is "measured, or measurable, duration." But what is *duration* but another word for time? Can there be time without change? What is time to a hibernating animal? To a child who has just reluctantly settled into the dentist's chair? To an Olympic sprinter?

In this special-topic issue of *Nature and Science* we examine some of the many aspects of time.

PAGE 3 Biological Clocks

This article describes how a variety of animals (and plants) respond to "biological clocks" that seem to be inside us all. Our biological clocks operate in many different ways. Part of the "routine" in our lives consists of regular and predictable changes in such things as body temperature, blood sugar, blood pressure, kidney excretion, and hormone secretion.

Day after day these body clocks inside us keep pace with the day-night cycle to which we are accustomed. While it is an easy matter to reset our mechanical watches quickly after a long journey resulting in a time change of many hours, we cannot reset our biological clocks quickly. Our body has to do it in its own good time.

Topics for Classroom Discussion

• *Have any of your pupils made nonstop jet flights across the country or to Europe?* They may be able to describe how they felt the first day or two after arriving at their destination.

• *Have your pupils pretend that they are flying by jet to London.* They leave New York at 7 A.M. It is a six-hour flight, which means that they arrive at London Airport at 1 P.M. New York time, but it is 6 P.M. London time. (London time is five hours ahead of New York time.)

Ask them to list the conflicts between their body time and local London time. For example, a youngster in London will be having his evening meal when his American friend arrives and is ready for lunch. What time will it be (London time) when the American visitor is ready for bed? When, by his body time, will he be ready to get up in the morning and have breakfast?

It takes from one to two weeks before all of a person's biological clocks reset themselves to a new time that is five or more hours ahead or behind the traveler's home time.

• *How could you "set your body clock" to London time before the trip so that you would be in phase with London time when you got there?* For example, five days or so before you left you could begin to eat your meals on a schedule dictated by London time.

• *How many of your pupils depend on an alarm clock, or on someone who wakes them up in the morning?* Do any wake up by themselves at just about the same time each morning? What about Saturday and Sunday mornings?

Activity

• *Are there "things that happen" around the school, or around home, that take place at regular intervals without reference to a clock?* For example, youngsters who have spent any time on a farm know that the cows "know" when it is time to come to the barn. People who live in city apartments have to walk the dog several times a day. Usually the dog announces when it is time to be walked. Have your pupils make a list of some of the natural clocks around them, and say what they think the "alarm" is. For instance, the walking-time alarm signal in a dog may be a kidney function.

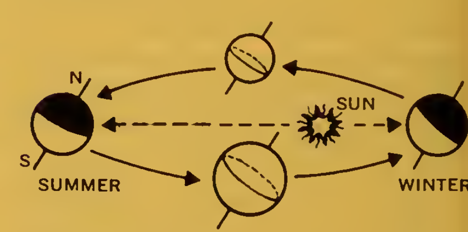
PAGE 10 How Long Is a Day?

This article shows how astronomers use the apparent motions of the Sun and stars to measure the rate of rotation of the Earth. Some of your pupils may have trouble grasping the concept of *mean solar time,* which is the time we keep on our clocks and watches.

The *mean* sun is a mathematical sun which averages out the irregularities in the apparent motion of the real Sun. While the mean sun crosses the observer's meridian once every 24 hours exactly, the real Sun sometimes takes more than 24 hours, sometimes less.

Another thing that may be puzzling is the statement (on page 11) that in December the Earth is closer to the Sun than in June. On January 1 the Earth is closest to the Sun, and July 1 it is most distant.

Ask some of your astronomy enthusiasts if they can explain why it is summer in the Northern Hemisphere when the Earth is farthest from the Sun and winter when the Earth is closest to the Sun. This results from the inclination of the Earth's axis to its plane of orbit (*see diagram*).



Because the Earth's axis is inclined to the plane of orbit, we have seasons. In the Northern Hemisphere it is summer (left) when that hemisphere is tilted toward the Sun and receives the Sun's radiation more directly than it does in winter (right).

Your pupils may be fascinated by the idea that a telescope enables them to look millions of years back into time. The velocity of light is about 186,000 miles per second. If we look at a star known to be 10 light-years (58,800,000,000,000 miles) away, we are seeing that star as it was 10 years ago. If the star exploded as we watched it tonight, we would not see the explosion for 10 years.

(Continued on page 7T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue...
(continued from page 2T)

Another fascinating view of time is the so-called "clock paradox" problem. Some of your pupils may know about this one. We are told that the closer a person approached the velocity of light, the slower time would pass for him with respect to the time reference system he left behind on Earth. Seconds and minutes for a space traveler, whose velocity is nearly that of light, would tick off more slowly than seconds and minutes back on Earth.

Biological processes would also slow down for our space traveler. Since they would, it would still take four of his space minutes to boil an egg the way he likes it. But those four space minutes would be equivalent to more than an hour of Earth time.

The British astronomer Hermann Bondi goes into this problem in some detail in a new Science Study Series paperback, *Relativity and Common Sense* (Doubleday & Company, Inc., New York, 1964, $1.25). According to Bondi, a man who leaves the Earth and travels through space at nearly the speed of light for 40 years by his clock would return to an Earth that is 48,000 years older, not 40 years older.

The following limerick makes the point in an amusing way:

There was a young lady named Blight,
Who could travel faster than light.
She departed one day in an Einsteinian way,
And returned on the previous night.

Topics for Classroom Discussion

- *What do we mean when we say that time "passes slowly" or "passes quickly?"* Does time seem to pass more quickly when we are doing something we enjoy doing than when we are doing nothing at all, or doing something we dislike doing? *(See Activity below.)*
- *What do we mean by such common expressions as these:* "to make up time," "to kill time," "to do time," "the test of time," "time stood still," "in the nick of time," "behind the times,"etc? Can your pupils think of others?

Activity

- As biological timepieces *(see page 3)* all of us are fairly reliable. As mathematical timepieces, however, we are hopeless. We have no reliable internal means of gauging the passage of the arbitrary units we call "minutes" and "hours."

While the class is engaged in routine work, blindfold one pupil volunteer and tell him to raise his hand when he thinks five minutes have passed. Try the same thing (with the same pupil) while the rest of the class is silent. Does time seem to pass more slowly in a situation of quiet, or in a situation of noise? Let several pupils try this for periods ranging from one minute to 15 minutes or more. You could let the entire class take part. You be the timekeeper (make sure that all watches are hidden and the classroom clock is covered), and ask each youngster to raise his hand when he thinks five minutes are up.

PAGE 8 Ages of the Earth

The panorama of changing conditions on the Earth's surface from Pre-Cambrian to modern times is bound to raise more questions than it will answer.

Here we are concerned with still another kind of time—geological time, which involves long-term changes remote from our human experience.

Some of the questions your pupils may come up with: How can scientists tell that something happened, say, 20 million years ago? How do they *know* that features of the Earth's surface (mountains, for example) have changed over the ages? That climates of the past have been different from today's climates? How do they know when certain prehistoric animals lived, and when certain kinds of rocks were formed?

The article, "Measuring the Past," on page 7 will help answer one of these questions: "How can scientists tell that something happened, say, 20 million years ago?"

In addition to the carbon-14 and potassium-argon methods of dating (mentioned in the article), uranium dating is used to determine the age of igneous rocks—*e.g.* schist and granite, which have their origins deep within the Earth and are formed under conditions of great heat and pressure.

The abundance of certain kinds of plant fossils found in an area is one of the clues scientists use to make inferences about past climate conditions of the area. For instance, fossils of tropical vegetation found in Antarctica show that the continent's past climate has been vastly different from its climate today.

Imprints that dinosaurs and other animals left in rock provide important clues about these animals. You can demonstrate how this particular type of fossil is formed by using a flattened piece of modeling clay and a shell, leaf, or twig *(see diagram)*.

To help your pupils understand how some kinds of fossils form, have them press shells and other objects into clay, then remove them, leaving "fossil" imprints.

As animal and plant life have changed through the ages, as they are changing today, so has the surface of the Earth gone through many changes. Even in our short lifetimes we can observe some of these changes. The Mississippi River Delta can be seen to change from one decade to the next. Active volcanoes, such as Mexico's famed Paricutín, which within a year after it erupted in 1943 grew to a third the height of Mt. Vesuvius, sometimes give us a view of short-term changes in the Earth's crust. Other mountains, such as the Alps, Rockies, and Appalachians, were many thousands of years in the making. Of the three, the Appalachian Mountains are the oldest. Since they were thrust up, millions of years of erosion by rain, wind, and ice have worn them smooth.

Suggestions for Classroom Use

- Have some of your pupils find out about the geological history of your state and prepare bulletin board material. If fossils are abundant in your area, what are the predominant known fossils? A visit to a museum might be your best research source.
- Dinosaurs are bound to arouse the interest of many of your pupils. Playing on this interest, show them that, although the dinosaurs lived very long ago, other forms of animal life existed much earlier in time.

Time and Man

(continued from page 1T)

servations of the Sun can be measured by noting the exact day and second when the Sun arrives directly over the Tropic of Cancer on two successive summers. The Tropic of Cancer is the northernmost latitude at which the Sun appears directly overhead. It is located at about 23½ degrees north latitude. The interval is 365 days, 5 hours, 48 minutes, and 46 seconds of mean solar time [*see page 11*]. We call this the *solar year*. It is also called the *tropical year*.

The length of a year based on observing the stars can be measured by noting the exact day and second when the Sun, the Earth, and some bright star are exactly in line at two successive times. During that interval the Earth revolves around the Sun exactly once. Since we cannot see the Sun and the stars at the same time, the measurement of this period is not simple, but astronomers have found ways of doing it. The interval turns out to be 365 days, 6 hours, 9 minutes, and 10 seconds. This interval, this *sidereal year*, is the true period of the Earth's revolution.

The Origin of the Calendar

Thousands of years ago, people in many parts of the world arranged their activities—such as hunting and farming—according to the phases of the Moon. Each month began at sundown of the day when the new crescent moon was seen in the western sky. But 12 of these months, measured by the Moon and only 29 or 30 days long, added up to only 354 days, which was 11 days short of the 365 days in the year of the seasons. So once every two or three years, an extra month had to be added to these lunar-measured years in order to keep up with the seasons. This was true of almost all calendars in Middle Eastern lands.

Calendars in which the months are governed by the Moon, and in which the year may have either 12 or 13 months, are still used by some people today. One example is the Hebrew calendar which is used for determining the dates of Hebrew holy days, Another is the Christian method for fixing the time of Easter and other important Christian dates. In many parts of India, lunar calendars are used today to regulate events of everyday life.

By Roman times, around the first century B.C., astronomers believed that the length of the year was about 365¼ days. In 45 B.C. the Roman Emperor Julius Caesar ordered that each year was to be 365 days long and that every fourth year was to be 366 days long. The one extra day every fourth year—Leap Year—made up the difference between the 365-day calendar of the Romans and the 365¼ days which they believed to be the true length of the year. The lunar months were dropped and 12 new months were invented and named, each with 30 or 31 days except for February with 28. In the new calendar, called the *Julian Calendar* after Julius Caesar, each month began and ended at very nearly the same time each year, without regard to the phases of the Moon. This is the practice we still use.

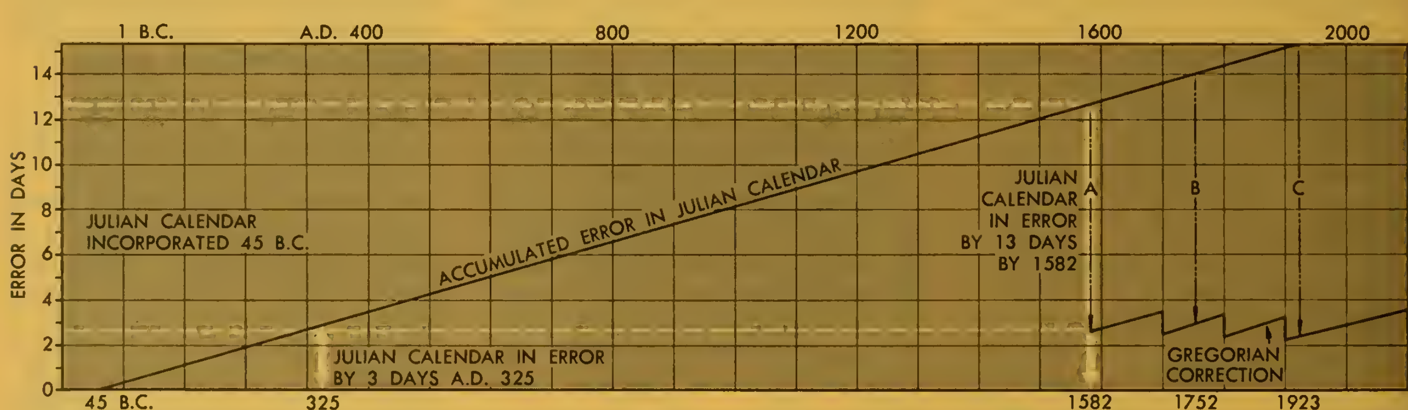
The Julian Calendar was used throughout Europe without any changes for more than sixteen centuries. By the 1500's, however, astronomers realized that the year was not quite 365¼ days long, but just a little shorter than that. The Julian Calendar had been gaining one day on the season every 125 years. In 1582, Pope Gregory XIII corrected this error with a new Leap Year rule which dropped three Leap Years each four centuries. According to this rule, Leap Year was not used in the first year of any century not divisible by 400. Thus in the years 1700, 1800, and 1900, there was no Leap Day (February 29). But the year 2000 will be a Leap Year because 2000 is divisible by 400.

This calendar, the one used in the Western World today, is called the *Gregorian Calendar*. It gains one day every three thousand years, but this can be easily corrected by dropping a day at the proper time.

The Week

No one knows for sure where or when the week became a part of the calendar, and no one knows exactly why seven days were chosen. Why not six or eight or some other number? It may have been because people in ancient times saw seven objects in the sky which they called "planets." These objects were the Sun, the Moon, Mercury, Venus, Mars, Jupiter, and Saturn.

The Moon's phases may also help to explain why there are seven days in a week. The average number of days from one phase of the Moon to the next—from new moon to first quarter, from first quarter to full moon, and so on—is about seven. The seven-day week is just about one-fourth of the lunar month ■



Errors and changes in calendars used since 45 B.C. are shown in this diagram. The calendar of Julius Caesar was corrected by Pope Gregory XIII in 1582 by dropping 10 days (A), and by changing the leap year rule (*see text*). The Gregorian calendar was adopted in America in 1752, at which time 11 days had to be dropped (B). In 1923 (C) the Russians had to drop 13 days.

nature and science

VOL. 2 NO. 12 / MARCH 15, 1965

A high school student tells how he spends his summers...

FACE TO FACE WITH GRIZZLY BEARS

see page 4

HOW TO WEIGH A LIVE BEAR see page 2

ABOUT THE COVER

How do you weigh a bear? The photo on our cover shows one way to do it. The young Grizzly Bear in the photo was drugged and put into a large sling attached to a scale. Then the scale was hooked to a cable, which hangs over the metal pipe you see in the top left corner of the picture. When the cable was wound up, the bear was lifted off the ground (helped by the men pushing up on the metal pipe). Then its weight was read off the scale.

Weighing bears is a summer job of the two boys in the photo above. Charles, 15, (left), and Lance Craighead, 17, help their father and uncle study the Grizzly Bears that live in Yellowstone National Park. In this issue Lance tells how the scientists study the bears and what they have learned about them.

Lance Craighead is a senior at South Middleton Township High School in Boiling Springs, Pennsylvania. He is on the varsity wrestling team and is a member of the National Honor Society and the Science Club. Lance likes many outdoor sports, including hunting, fishing, skiing, and skating. He plans to enter college this fall and study science.

To find out more about the unusual summer vacations of Lance and Charles Craighead, read "Face to Face with Grizzly Bears" on page 4.

nature and science

VOL. 2 NO. 12 / MARCH 15, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

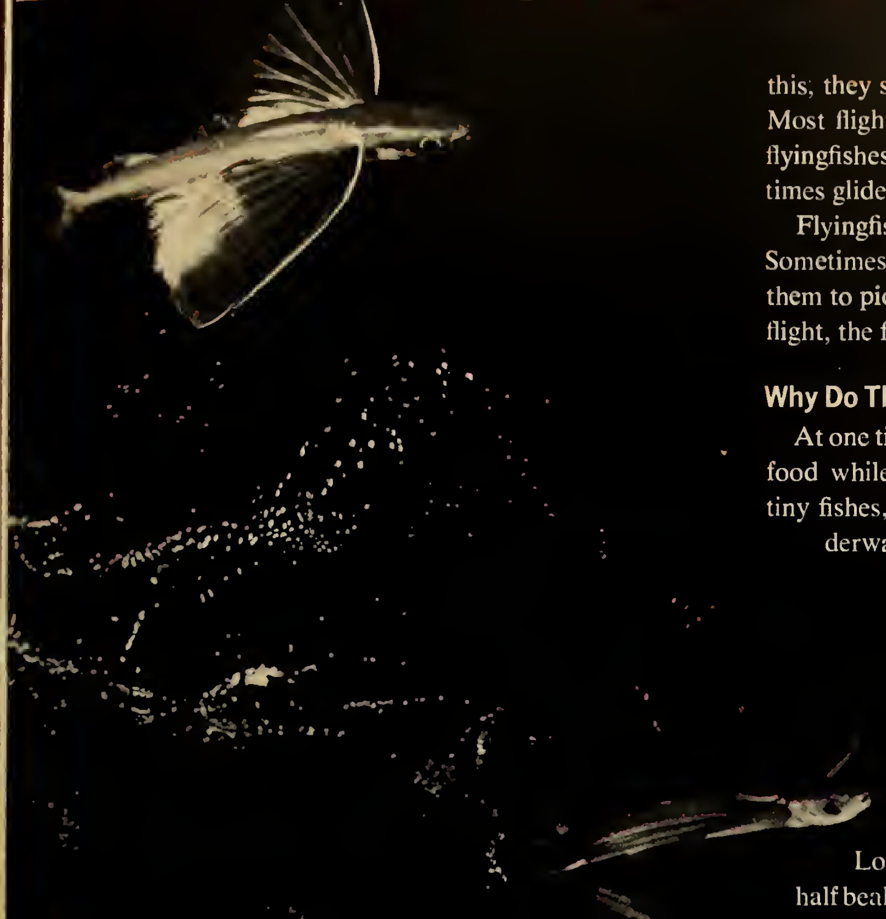
CREDITS: Cover, pp. 2, 4, 6, 7, photos by Frank and John Craighead; p. 3, photo by Dr. Harold E. Edgerton, drawing by Juan Barberis; pp. 5, 10, map and drawings by R. G. Bryant; pp. 8, 9, sap collecting and boiling down photos by Grant Heilman, others by Harry L. Beede; p. 10, photo by George Cope, Educational Services Incorporated; p. 11, photo by Franklyn K. Lauden; pp. 11, 12, 13, 15, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 14, 15, photos by AMNH; p. 16, drawing by Joseph M. Sedacca.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y. and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The National History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

The Fishes That FLY



■ As the ship slid through the sparkling Pacific Ocean, some passengers looked out on the water for a sign of life. Suddenly, dozens of silvery fishes burst from the water and began sailing over the waves. They glided on for hundreds of feet. Then they disappeared into the water.

Flyingfishes are a common sight in tropical oceans. Whenever they appear, people wonder: How do they fly? How far can they fly? Why do they fly? Scientists have answered these questions by careful observation and by taking pictures of the fishes at high speed.

How Fishes Fly

The "wings" of flyingfishes are actually large fins. Some kinds of flyingfishes fly with a pair of fins near the front of their bodies. Others fly with both their front fins and another pair of fins near their tails *(see diagram)*.

Here is how one of the "four-winged" fishes flies: First it speeds along just below the surface. Then it turns upward and spreads its front fins, lifting almost completely out of the water. (Most of the time flyingfishes launch themselves into the wind, which gives them added lift.) The lower part of the fish's tail stays in the water and pushes the fish ahead as it beats back and forth *(see lower fish in photo)*. The fish taxis along the surface like an airplane, picking up speed. Then it spreads its rear fins and rises into the air.

Flyingfishes *glide* through the air. They do not move their fins in the way that birds flap their wings. Because of this, they seldom rise more than five feet above the water. Most flights are about 100 to 300 feet long. The largest flyingfishes, which are only about 18 inches long, sometimes glide a thousand feet or more.

Flyingfishes usually stay in the air for about 10 seconds. Sometimes they drop their tails into the water and wiggle them to pick up speed, then take off again. At the end of a flight, the fishes close their fins and dive into the water.

Why Do They Fly?

At one time, people thought that flyingfishes caught their food while flying. However, studies show that they eat tiny fishes, shrimp, and other small animals that live underwater.

Scientists now believe that the flyingfishes became flyers because they were chased by bigger fishes. Many kinds of fishes jump from the water when they are in danger. The halfbeaks, for example, manage to skitter along the surface, entirely out of the water except for the lower part of their fins.

Long ago, the flyingfishes may have been like the halfbeaks of today. They leaped from the water and struggled along, trying to escape their enemies. Some of them had bigger fins than others. When chased, the fishes with the bigger fins were better able to escape. More of them survived and had young, so that more and more of the young fishes had big fins.

In each generation of fishes, the ones with the largest fins were more likely to survive and have young. Gradually, over many thousands of years, flyingfishes developed the pairs of large fins that enable them to take off and glide away from their enemies.

The fast-swimming bonitas and dolphin-fishes often chase flyingfishes. Once in the air though, a flyingfish can glide along at about 35 miles an hour—much faster than it can swim. Dolphin-fishes can swim at about the same speed. However, when the flyingfishes leave the water, their underwater enemies cannot see and follow them.

Flyingfishes often take off and glide ahead of or beside a ship. The ship may seem to them like a huge, pursuing fish.—LAURENCE PRINGLE

FACE TO FACE WITH GRIZZLY BEARS

A high school student tells how he helps scientists study the huge Grizzly Bears of Yellowstone National Park.

by Lance Craighead

■ Maurice, Harry, and I looked down at the Grizzly Bear at our feet. She had been "shot" with a drug, but was starting to rise. If she regained her feet and charged us, Maurice might have to kill her. I looked around for a tree to climb, but the huge bear soon fell to the ground, unable to move.

The Grizzly was in Yellowstone National Park, Wyoming (*see map on next page*). Maurice Hornocker is one of a group of scientists who are studying Grizzly Bears; Harry Reynolds is one of several college students at Montana State University working on the study; and I am one of a small group of high school students who are helping on the project *(see page 2, "About the Cover")*.

This is the sixth year that my father, Frank Craighead, my uncle, John Craighead, Maurice, and other scientists have been studying Grizzly Bears in Yellowstone Park. The purpose of the study is to learn enough about the Grizzlies to keep them from dying out (becoming *extinct*). These magnificent animals have been disappearing from areas where they were once abundant. There are perhaps 10,000 in Alaska, but as few as 500 to 1,000 Grizzlies in the rest of the United States. There are only about 200 Grizzlies in Yellowstone.

It is difficult to tell what might happen if an animal such as the Grizzly is wiped out. The bears live together with many other kinds of animals and plants, just as you live in a community with other people. If all of the bears die, the rest of the animals and plants in the community are affected. For example, Grizzlies eat plant-eating animals such as gophers. The gophers might multiply rapidly if there were no bears or other meat-eating animals to kill them. They might increase and destroy plants over a large area in order to get food. The large numbers of gophers and the small supply of plant food would then affect other animals. Some of the food eaten by the gophers would be needed by elk or deer. There is no telling where the changes might stop.

Another reason for saving the Grizzly from extinction is that there is no other animal quite like it in the world. Grizzly Bears have lived in North America for many thousands of years. Now, in a little more than 100 years, humans have nearly wiped them out. They have done this not just by shooting the bears, but by settling on the wild land which the Grizzlies need for life. By studying the Grizzlies that remain, we hope to be able to help them survive in the wild areas that remain.

Humans are even the main cause of death of the protected bears in Yellowstone. Grizzlies wander a lot and those that leave the Park are usually shot by hunters or ranchers. Some ranchers believe that the only good Grizzly is a dead one. They kill them because they think that the bears kill their cattle or sheep. Sometimes this is true. More often, however, the Grizzlies find the carcass of an animal that died or was killed in some other way. When the ranchers find them eating the dead animal, they assume that the bears have killed it.

How the Bears Die

Many young Grizzlies die of natural causes, such as accidents, and from diseases. In some years about one-half of all Grizzly cubs fail to live a whole year. This is to be expected, since many newly born and young animals die in all animal populations. Most cubs that die do so during their first winter. To learn more about this, my father and uncle have been putting small radios on Grizzlies and then following the radio signals, tracking the bears to their winter dens. (*For more information about how scientists track animals by radio, see "Deer 54, Where Are You?",* N&S, *November 2, 1964.*)

Grizzly Bears are also bothered by parasites—animals that live upon other animals. Tapeworms and roundworms infest many of the bears. In one bear we found so many roundworms that they must have taken most of his digested food before his body could use it. Parasites weaken the bears so that they catch diseases more easily. A friend of mine, Jim Berthrong, has been collecting and identifying the parasites found in Grizzlies. His father is a scientist who helps in the bear study.

The conditions under which the Grizzlies live—severely cold winters and the never-ending search for food—also help destroy some. Finally, diseases also kill some of the bears. By studying the diseases, parasites, and other causes of death, we hope to learn how to save the Grizzlies from extinction. However, finding out how the bears die is only part of the study. We also are trying to learn about how they live.

Trapping and Marking Grizzlies

A study to save the Grizzly must include his surroundings: the food, water, plants, climate, other animals around him, and the country he lives in. A study of this kind is called *ecology.*

In order to tell different bears apart and see where they travel, we must mark them. To do this we put metal tags and plastic markers in their ears. The plastic markers are of different colors and can be seen from a distance.

To mark the Grizzlies we first have to capture them. If we want to get a particular bear, we use a dart gun. Each dart contains a drug that paralyzes the animal's muscles. When the dart hits the bear, it injects the drug. Soon the drug takes effect and the bear cannot move.

One night when a Grizzly cub was shot with the dart gun, he rolled down a hill and fell into a little creek. My father had to run down and drag him out to keep him from drowning. Another time we hit a cub with a dart and he fell down immediately. However, his mother wouldn't leave him, even though we shouted and tried to scare her away. She stayed with the cub until he recovered.

If we don't want a particular bear, we set a trap. The trap we use is a large cylinder made of culvert pipe, with a sliding door *(see page 6).* The trap, which weighs about 1,000 pounds, is mounted on wheels so we can move it by car. We bait the trap with meat, bacon rind, honey, fruit juices, and other delicacies. When a bear enters the trap and pulls on the bait, the sliding door drops down.

This method catches whichever bear comes first, and we have even caught two or three bears at a time. Different bears react to the trap in different ways. Some roar, hit the trap with their claws, and bite it. Others just lie quietly in the corner like cute "teddy bears."

Once a bear is in the trap, we inject a drug into it with a hypodermic needle on the end of a stick. Then we take him out of the trap and set to work. We begin by weighing and then measuring him. We measure his neck, feet, and length, among other things. At the same time, someone marks his ears and tattooes a number on his hide. In previous years, when we used a drug that worked only for a short time, Grizzlies would sometimes "wake up" at about

(Continued on the next page)

Only about 200 Grizzly Bears remain in Yellowstone National Park.

This bear trap is made of a section of culvert pipe, with sturdy bars on one end and a sliding door on the other. A bear is lured into the trap by meat, honey, or other bait. When the bear pulls on the bait inside the trap, the sliding door falls. The trap is on wheels.

A rifle that shoots darts is used to capture some bears. Each dart contains a drug that paralyzes the bear's muscles for a short time.

Face to Face with Grizzly Bears (continued)

this stage and run away before we were finished with them. Even if we tried to give them another shot of drug, some got away before it took effect. Occasionally large male bears, called *boars,* charged us.

After measuring and marking the bear, we take samples of its blood (and milk if the bear is an adult female), and check its teeth for wear (to find its age). All this information is written in notebooks.

By studying the samples we can find out how healthy the bear is. If we catch the same Grizzly later, we can see how much he has grown since the last time he was caught. Marking enables us to identify the bears we see and tell where they've traveled. We tattoo the bears because they sometimes lose their tags in fights. The tattoo cannot be removed, and we can recognize the bear if it is trapped again or found dead.

Once we wanted to release a bear from the trap without drugging him. We pulled the trap along behind a car and one man opened the door of the trap while it was still moving. We drove slowly enough so the bear could get out, but fast enough so he couldn't catch up with us if he tried. This method usually worked fine, but this time the bear wouldn't leave the trap. We drove slower and slower, and the man on the trap banged on the top and shouted. Still the bear wouldn't come out.

We drove even slower until suddenly the bear burst out of the door. He tried to get at the man on top.

"Get moving!" the man yelled, and we started going faster. The bear climbed onto the trailer. He was just about to bite our friend when he put a foot on the moving wheel of the trailer and was flipped off. We sped away.

Face to Face with a Grizzly

Grizzly Bears usually attack only when they are provoked. Once while hiking along a ridge, a companion and I heard some growls. We walked in the direction of the noise to see where it came from. Suddenly we came face to face with a female *(sow)* Grizzly and two cubs. Startled,

A special collar that sends radio signals is being fitted on this bear. A radio receiver (right) will be used to trace the bear's travels when it recovers from being drugged. The scientists can then locate the bear from a distance of several miles without disturbing it.

ch drugged bear is tattooed th an identity number. ntity tags are also put on ears. The tags may be lost, t the tattoo remains. These rkings help identify the ar if it is trapped again or nd dead.

Colored plastic markers are attached to the ears of some bears. Each bear has a different colored marker. Then scientists use telescopes or binoculars to watch the bears from a distance and identify them.

we dropped our packs and shinnied up a couple of trees. (Adult Grizzlies cannot climb trees.) The bears ran off in the opposite direction.

Another time, my father, uncle, and I were tracking a young sow by radio. We discovered her sleeping in the woods. After finding her, we stumbled onto a large boar sleeping nearby. We quickly backed away and climbed some trees. As I climbed, a branch broke with a loud snap. Both bears awakened suddenly and ran off, and so did another—a male we call "The White-faced Boar"—that had been sleeping only 50 feet from my tree. These bears did not want to cause trouble.

The only times that Grizzlies have charged us during the study have been when they were cornered, surprised at close range, or recovering from being drugged.

One such bear, "Old Ivan," recovered suddenly and attacked, scattering men into several nearby cars. He then attacked the cars as they sped away and returned to hit the trap and to scatter and break all the equipment which had been left behind in the rush. When the men cautiously returned a short time later, he rose up and chased them away again.

In six years, we have marked 198 bears and handled over 300. We've learned many things about the Grizzly Bears. We know what they eat—mostly roots, plants, berries, and small animals. Sometimes they kill large game like deer or elk when they find a sick or injured one. We know the places where they live and the country they travel in. Using radios, we have followed them and made maps of their home territories. Some bears have even been tracked to the dens where they spend the winter. (This always happens in the late fall after I have returned to school.) We have also learned about their diseases and their habits.

This information may help the Grizzly Bear to survive as humans destroy more and more of the bear's wild country. In these times when "peaceful coexistence" is sought by nations of the world, we hope to find a way of "peaceful coexistence" between humans and Grizzly Bears ■

From Sap . . .

This Vermont farmer is collecting sap from pails hung on maple trees. The sap is dumped into a vat on a trailer, which is pulled by horse or tractor. The bigger the tree, the more pails can be hung on it. A tree measuring about 30 inches across will keep filling four pails without harm to itself.

To collect sap
called a *spile*
Sap oozes fr
nearly full.

■ It's March
liquid called
ready for th
the food tha
eastern Nor
kinds of tre
Long ago,
Maples. The
maple syrup
For many
However, n
found. Scien
sweet sap. T

To

The new way t
short length o
of the sap so
that leads dow

r first drills a hole into the tree. He then puts a short pipe, hole. Each spile has a hook on which a metal pail is hung. ee, out through the spile, and into the pail. This one is

The fresh sap is taken to the *sugar house*. Inside, the sap is poured into huge pans, which are heated from below. Some are heated by burning wood. More modern ones are heated by oil. As the sap boils, most of the water in it turns to water vapor and escapes into the air.

frosty nights are followed by sunny, thawing days. In the woods, a ins to flow up from the roots and through the trees, and farmers get syrup season. Sap carries food to all parts of a tree. In the spring, ries is mostly sugar. The sap of Sugar Maple trees (which grow in ica) contains up to seven per cent sugar, much more than other

discovered how to make a sweet liquid by boiling sap from Sugar then taught the early colonists how to make this tasty syrup. Today, in about 15 states and in Canada, but nowhere else in the world. eople made maple syrup in much the same way as the Indians. etter ways of collecting the sap and making syrup from it have been trying to breed a new kind of fast-growing maple tree with very tures show both the old and new ways of making maple syrup ■

As the water is boiled away, the sap that remains becomes thicker and sweeter. At the same time, the sap flows through sections of the pan. By the time it reaches the far end, it is ready to be put into bottles or cans. It takes about 40 gallons of sap to make one of syrup.

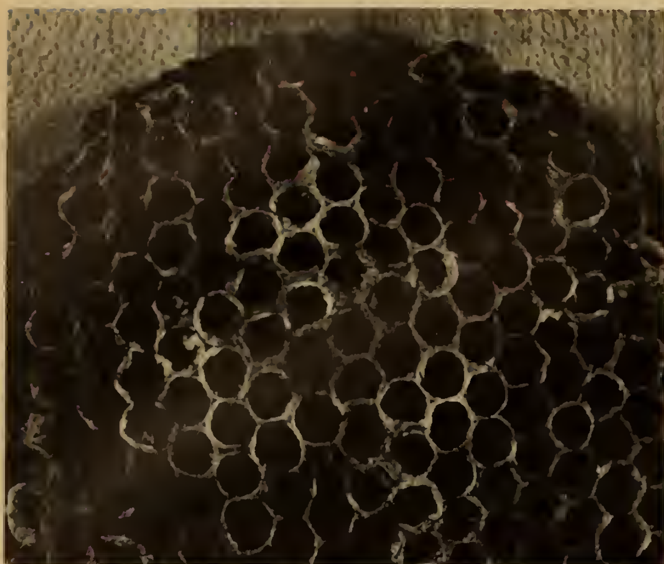
Syrup...

ap is by plastic hose. A new kind of spile (left) is used. The cking out of the top of the spile helps keep air bubbles out ws freely. The hose from each spile leads to a larger hose it).

A network of plastic hose gathers the sap from hundreds of maple trees. Eventually the sap flows into a large storage tank near the sugar house. A pipe connects the storage tank to the sugar house, and sap is piped to the sugar house, ready to be boiled down to tasty syrup.

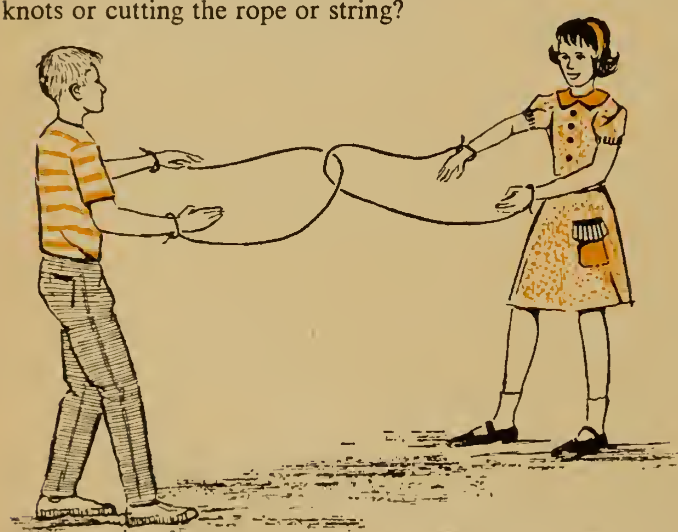
brain boosters

prepared by **DAVID WEBSTER**

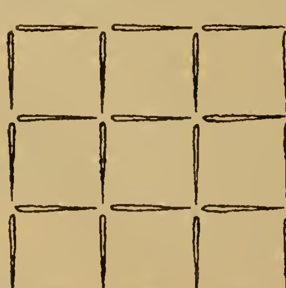


MYSTERY PHOTO
What is it?

Can you do it?
Tie yourself to a friend as shown in the drawing. Can you separate yourself from your friend without untying the knots or cutting the rope or string?



Fun with numbers and shapes
Take away 8 toothpicks, so there are only two squares left.
submitted by Sue Autrand, Pacifica, Calif.



For science experts only
From which jar will the water completely evaporate first?

What do you think would happen...
...if a balloon were blown up, tied, and put in the refrigerator? Try it at home tonight.

Just for fun
What is it that no one wants, yet no one wants to lose?

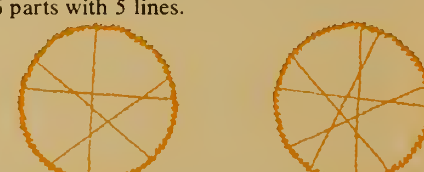
Answers to Brain-Boosters in the last issue

Mystery photo. The tree is about 30 years old. Wider rings might indicate years of abundant rainfall, which enabled greater growth of the tree.

Can you do it? If the ice cube is large, it almost always drifts slowly from the middle of the water and touches the glass. You can make it stay longer in the middle by adding some soap to the water. Why does the soap help to keep the ice from moving to the glass?

What do you think would happen? Some water would rise up inside the jar containing the steel wool. As the steel wool rusts it uses up some oxygen in the air. Water takes the place of the oxygen which disappears. Would anything happen if there were no steel wool in the jar?

Fun with numbers and shapes. One circle has been divided into 11 parts with 4 lines. The other circle has been divided into 16 parts with 5 lines.



For science experts only. The girl was born in the Southern Hemisphere in December, January, or February. In the Southern Hemisphere it is summer during these months. She now lives in the Northern Hemisphere, where December, January, and February are in the winter.

How long will it take? It will take 11 seconds for the clock to strike 12 o'clock.

What time was it? The jar was half filled with microbes at one minute before 3 o'clock.

SCIENCE WORKSHOP

Suppose that you wanted to cover a floor with tiles that are all the same shape. Could you do it with tiles shaped . . .

PUZZLING POLYGONS

by Howard E. Smith, Jr.

■ The puzzle shown above is fairly easy to solve. One way would be to trace the triangle on a piece of paper, cut out a number of triangles the same shape and size, and see if you could fit them together without leaving any spaces between them. You could do the same thing with each shape.

These shapes are called *regular polygons.* A polygon is any flat, closed shape that is formed of straight lines. Shapes like these  are all polygons. What makes a regular polygon different from other polygons is that a regular polygon has sides that are all the same length and angles that are all equal.

The Greek mathematician, Pythagoras, who lived around 500 B.C., was fascinated by regular polygons. He asked himself the question we asked above. He decided that only three kinds of regular polygons could do the tiling job.

The Search for Regular Solids

Pythagoras was also interested in *regular solids.* A regular solid is a solid that has sides, or faces, made of regular polygons that are all the same size. Cubes, such as dice, are regular solids. Pythagoras asked himself this: "How many differently shaped regular solids are there?" You can draw regular polygons with any number of sides, so why not regular solids with any number of faces? By drawing many different patterns, Pythagoras discovered that some of the patterns could be folded up to form regular solids *(see photo and page 12).* To his surprise, he found only three patterns that produced regular solids. This bothered him so much that he traveled to Egypt to see if mathematicians there knew the answer. All they could do was show him the three regular solids they knew.

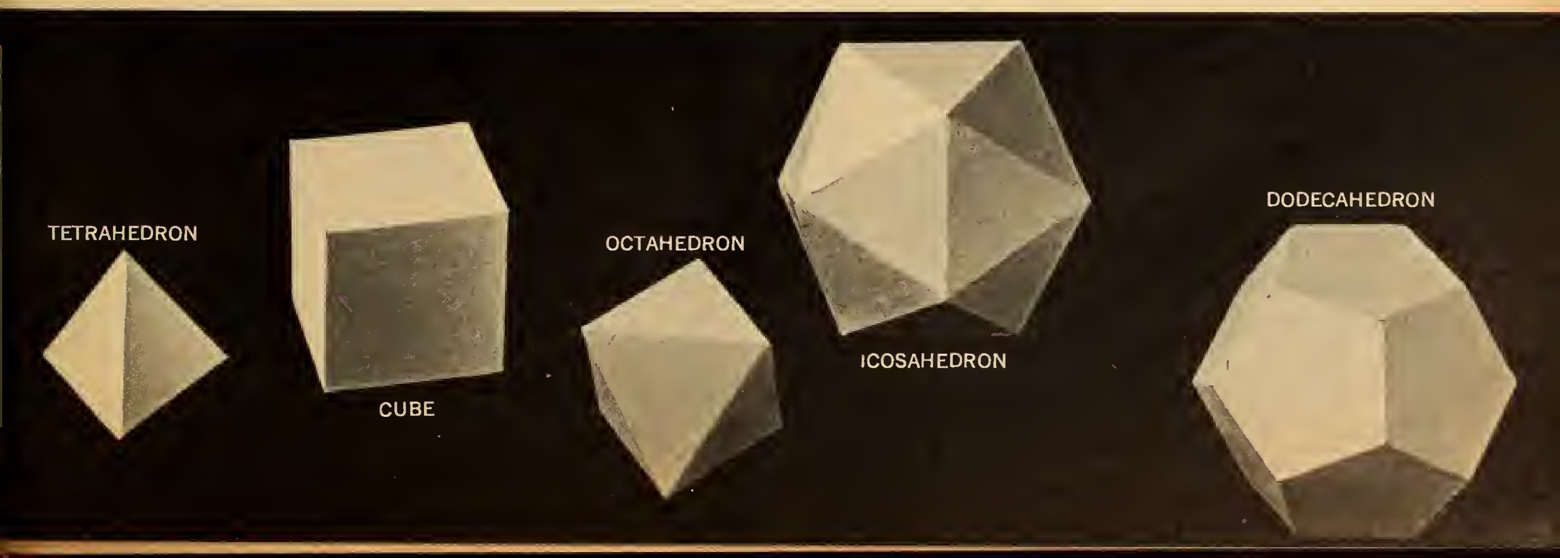
The first was the cube *(see photo).* The Egyptians also knew of a regular solid formed of eight triangles with equal sides and equal angles. When these eight triangles are fitted together they form a figure called an *octahedron (see photo). Octa* means "eight" in Greek, and *hedron* means "side" or "face."

The third regular solid known to the Egyptians was the *tetrahedron. Tetra* means "four" in Greek. It is made of four triangles with equal sides and equal angles fitted together *(see photo).* Unlike other regular solids, if it is placed flat a point will always be sticking up.

When Pythagoras realized that the Egyptians could not help him, there was nothing to do but work the problem out for himself. After many experiments he found two other regular solids. Mathematicians have proved that only five different regular solids can be made.

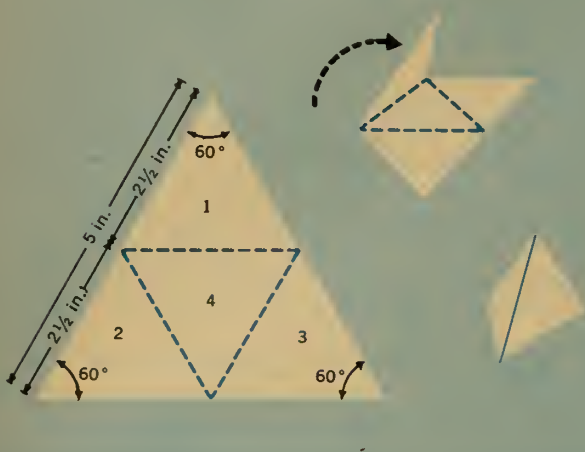
The first of the other two solids that Pythagoras discovered is called an *icosahedron. Icosa* means "twenty" in Greek. This regular solid is made of 20 triangles. The other regular solid is a *dodecahedron. Dodeca* means "twelve." This figure has 12 faces made of regular pentagons. This is the only regular solid with five-sided faces. It seems the most beautiful and unusual of them all ■

On pages 12 and 13 you will find the directions for making each of the five regular solids.

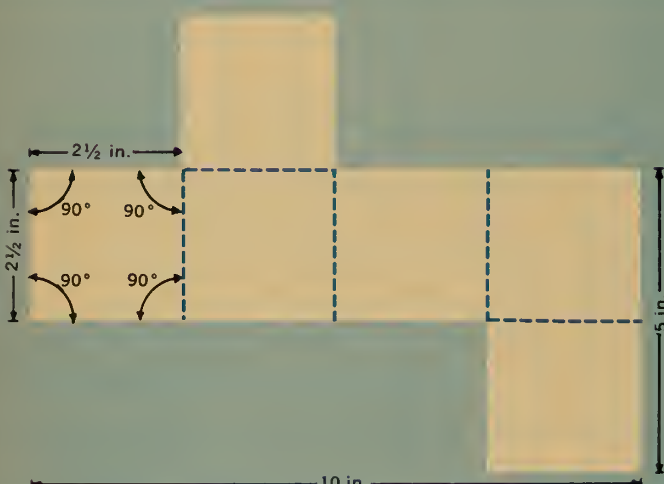


How To Make the Five Regular Solids

By following the directions and patterns on these pages, you can make the five regular solids shown in the photograph on page 11. You will need some heavy construction paper (or cardboard file folders), scissors, a protractor (to measure angles), pencil, ruler, and sticky tape. Make the easiest ones first—the tetrahedron and the cube.

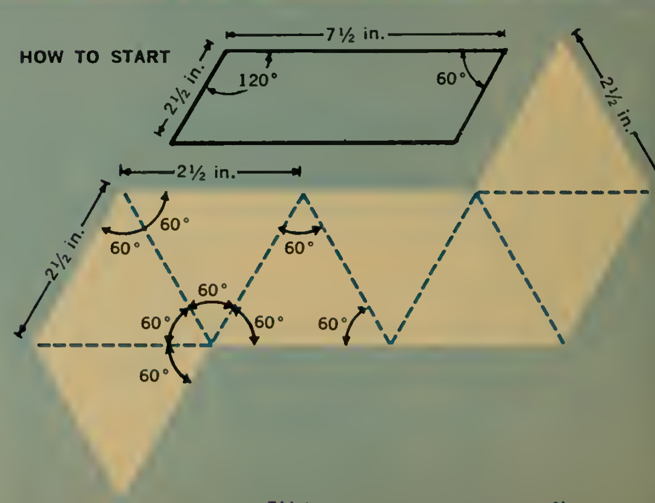


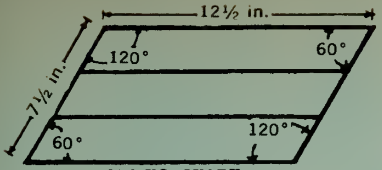
Making the Tetrahedron Draw one triangle with each side exactly five inches long, and each angle exactly 60 degrees. The smaller dotted-line triangle within the big triangle is made by connecting lines to the mid-points of the three sides. Carefully cut the big triangle from your construction board and fold each corner of the triangle in toward the center along each dotted line *(see diagram)*. Fold the cardboard over a ruler so the fold will be straight. Make sure that each of the outside triangles (1, 2, and 3) lines up exactly with the dotted-line triangle (4) when it is folded over it. After you have creased each dotted line, form a solid as shown in the photograph and tape two of the sides together with sticky tape. Hold one finger inside the tetrahedron so you can press the tape firmly. Now tape the other two sides together. The last side will be hard to do because there is no way to keep your finger inside the solid. Heavier cardboard will make the taping job easier.



Making the Cube Now that you have made the tetrahedron, you will find that the cube is easy to make. Enlarge the cube onto a sheet of construction board, as you did the tetrahedron. Make each side of the cube exactly 2½ inches long, and each angle exactly 90 degrees. Cut it out, and then fold along the dotted lines, making sure that each square folds over and fits exactly on top of its neighboring square. When you have made all five folds, tape the sides together. Keep one side open as long as you can so you can keep a finger inside the cube.

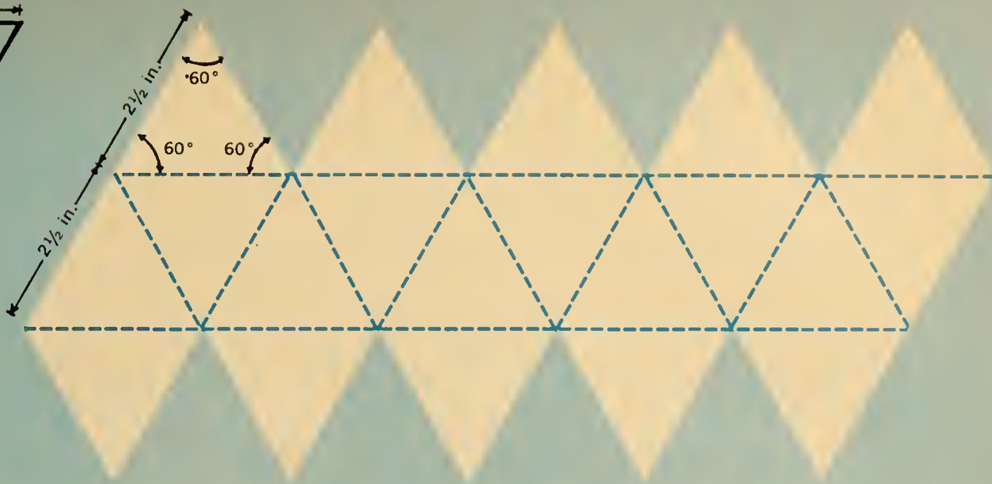
Making the Octahedron As with the other figures, enlarge this one onto a piece of construction board. Make each side of each triangle exactly 2½ inches long, and each angle exactly 60 degrees. Cut out, fold, fit, and tape as before. Warning: Don't try to draw each small triangle separately. Instead, begin by drawing one straight line 7½ inches long *(see "How to Start" diagram)*. This line will be the top long line in the diagram. Next, at the left end of the line draw an angle of exactly 120 degrees and extend its side downward exactly 2½ inches. Draw a 2½-inch slant line down from the other end, at an angle of 60 degrees from the top line. Now connect the two slant lines to form the long bottom line. *That line should also be exactly 7½ inches long.* Next draw the top and bottom triangles and fill in the dotted lines. When you tape this one together remember to leave one flap open so you can keep a finger inside the figure as long as possible.

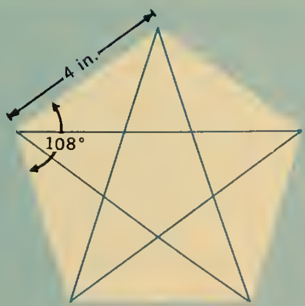




HOW TO START

Making the Icosahedron To enlarge this figure, just repeat the way you laid out the octahedron, except this time you will want to draw four long lines *(see "How To Start" diagram)*. When you have finished the figure, cut it out and assemble, as before.





HOW TO START

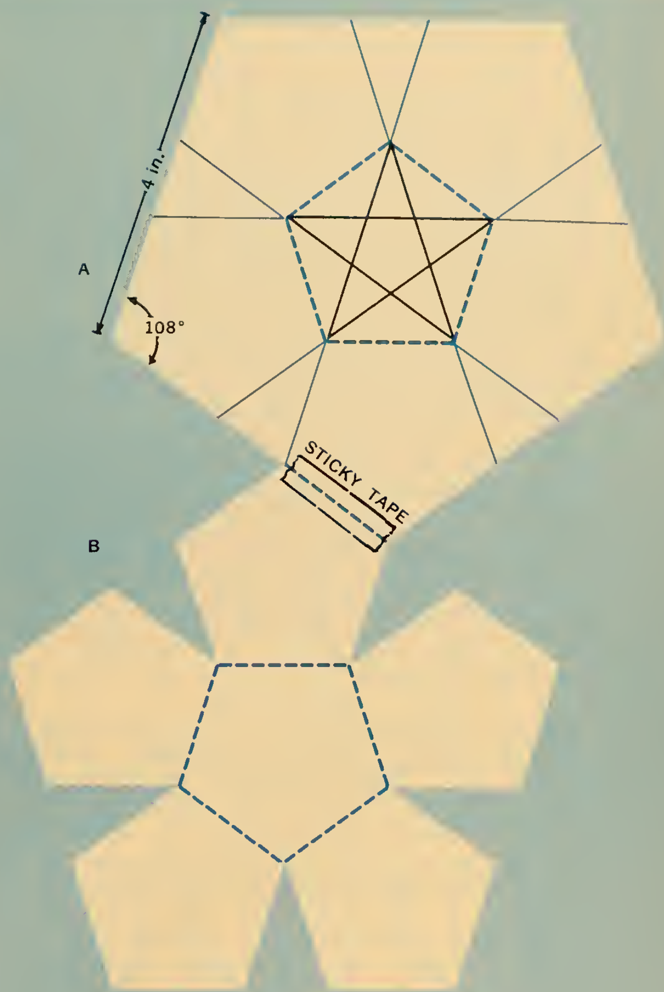
Making the Dodecahedron This is the hardest of the five to make. To begin, make one large regular pentagon. Make each side four inches long, and each angle 108 degrees. Measure very carefully. When you have done this, draw light lines connecting all the angles *(see "How To Start" diagram)*. These light lines will produce the small dotted-line pentagon in the middle of the big one.

Next you will have to draw in the V-shaped wedges, which will then complete the five small outer pentagons. To make the wedges, draw two lines through each angle of the small pentagon, as shown in diagram A. If you do all of this carefully, each of the six small pentagons, including the one in the middle, will have sides all the same length and angles all the same size. If they do not, redraw the figure.

Cut out the figure so that you have a piece of cardboard that looks like "windmill" B. You will need two of these, so trace an outline of the one you have just made, cut it out, and draw in the dotted lines to form the inner pentagon. When you have done that, put one figure on top of the other to make sure that they are as near exactly the same shape and size as you can make them.

Next, place the two figures side-by-side, exactly as the diagram shows, and bind them together with a piece of sticky tape. Turn them over and put a piece of sticky tape on the other side. Now fold along each dotted line, fitting each outer pentagon flat against the dotted-line pentagon in the middle. When you have made all the folds you will then see how the completed solid takes shape.

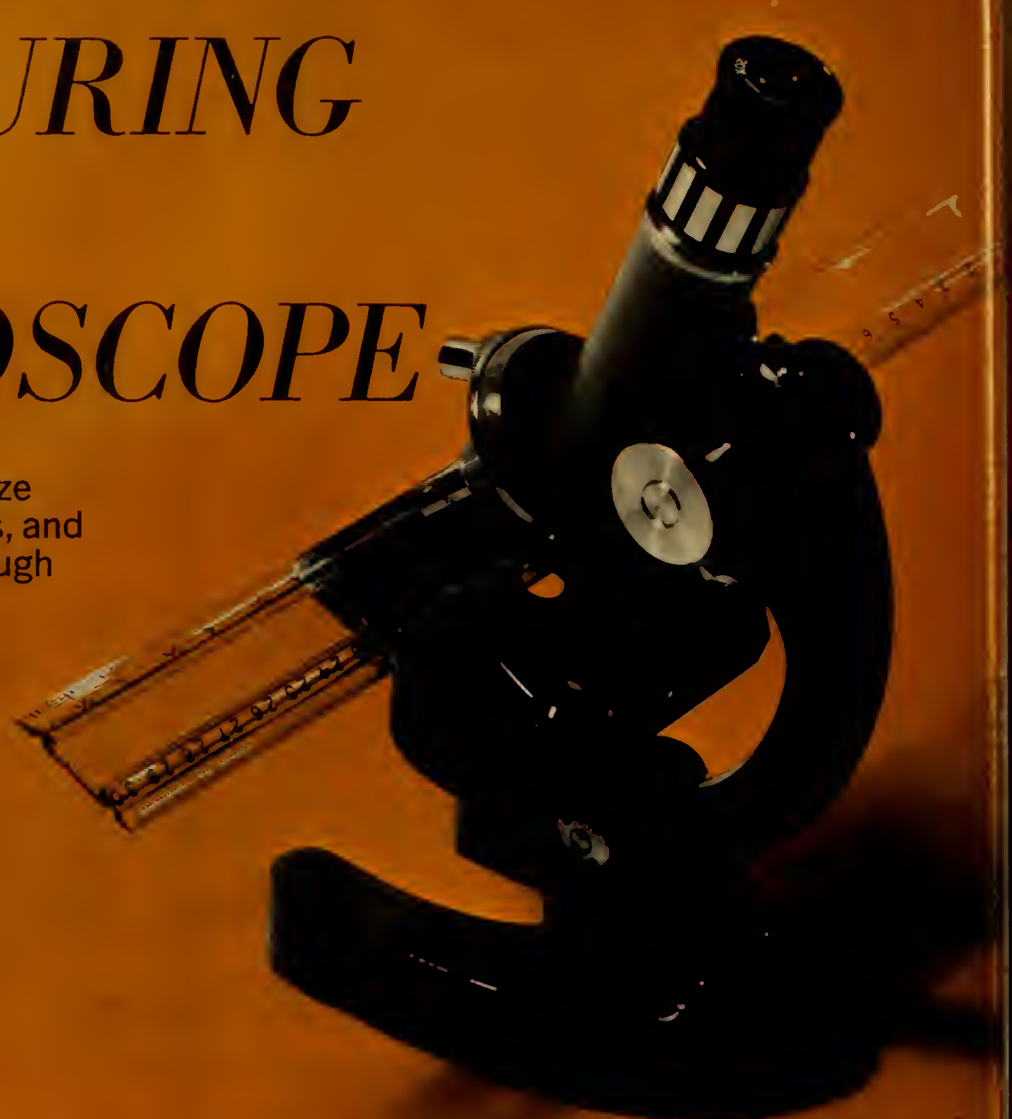
Tape each side of each pentagon to each side of its neighboring pentagon. If you have done your work carefully, you will have a beautiful 12-sided solid just like the one shown in the photograph.



PROJECT

Follow the directions above to make the five regular solids. Color each solid so that no two neighboring sides are the same color. Use as few colors as possible. Before you start to color the solids, work out the color scheme on the construction diagrams. You can paint the dodecahedron using only four colors, but it is hard to figure out.

MEASURING with a MICROSCOPE



Here is how to find the size of the tiny plants, animals, and other things you see through a microscope.

by Raymond E. Barrett

■ Imagine that you were only the size of your thumb! What a strange world this would be. The sight of your pet cat would terrify you as much as coming face to face with a dinosaur.

It might be fun to enter the world of the very small—as long as you can return at your own choosing. However, you needn't become a Tom Thumb or Thumblena to explore the world of the very small. The lens of a microscope can be your keyhole for viewing the micro-world (*see "Exploring With a Microscope,"* N&S, *December 7, 1964).*

Strange things happen to you when you enter this micro-world. You lose all sense of size. The head of an insect can appear larger than an elephant's. When you view an insect in your normal world, you compare its size with objects around you. An insect is usually smaller than a pencil. On the other hand, most insects are larger than a grain of sand. In the normal world you have many standards for comparing size.

This is not true in the micro-world. When you look through a microscope you often see only one object. You have no way of comparing the object with those around it.

You need a standard to take along on your adventures into the micro-world. One standard is a foot. Your ruler is one foot long. This unit is much too large for many objects. Suppose you wanted to measure the length of your pencil. You would need a smaller unit such as the inch. An inch is divided into even smaller units. These standards are all much too large to use when you enter the micro-world.

A giant of the micro-world is about the size of the head of a pin. You can imagine the problem of selecting a standard unit so small that it would take a thousand such units to cover the width of the period at the end of this sentence.

If you have a clear plastic ruler, you probably have all the tools you need for measuring size in the micro-world. Many such rulers contain two scales. One scale is the familiar inch-foot scale. The other is the *metric* scale.

The numbers on the metric scale show a unit called the *centimeter*. It takes about two and one-half of these to equal one inch (*see diagram*). The centimeter is divided

into ten smaller units called *millimeters*. The millimeter (mm.) is the standard unit for most microscopic measurements. How large an area can you see through a microscope? Here's how to use your ruler and see.

Measuring with Millimeters

The area that you view through the eyepiece of the microscope is called the *field*. The size of the field changes as you change magnification. For instance, under low magnification you may see the entire leg of a fly. Under higher magnification, perhaps only a part of the end of the foot is visible.

The problem then, is to measure the size of the field for the different magnifications. For low magnification, select the lowest power eyepiece and objective lens. The lenses are usually marked with their power of magnification. An eyepiece of five power (5X) and an objective lens of ten power (10X) gives a total magnification of 50 power.

The first step in measuring the size of the field is to place the clear plastic ruler on the stage, or platform, of the microscope in such a position that the millimeter scale is directly in line with the lenses (*see photograph at top of page 14*). Turn the focusing knob so that the lower (objective) lens almost touches the ruler. Then, as you view the ruler through the eyepiece, slowly turn the focusing knob so that the objective lens moves up from the stage. (Always focus by *raising* the objective lens to keep from striking and damaging it.)

When the ruler is focused clearly, you should see the markings on the ruler somewhat like the markings shown in photograph 1.

Since the distance between each mark represents one millimeter, the field in this example is about 1½ millimeters across. If you rotate the barrel so you are using a 20X objective with your 5X eyepiece, your total magnification would be 100 power. The field is about ¾ of a millimeter across when viewed under 100X magnification, as shown in photograph 2.

Now, suppose you want to measure the thickness of a human hair. Place a hair on a slide and then cover the hair with a drop of water. Hold the hair in place by lowering a cover glass over it.

When viewed through a microscope (*see photograph 3*),

you can see that a hair is much less than a millimeter in width. The one shown seems to be about 1/25 of a millimeter.

Suppose, in your mind, that you divided a millimeter into a thousand equal parts. Since these parts are very small, let's call them *microns*. A micron then is one-thousandth of a millimeter. The hair is 1/25 of a millimeter in thickness, or 40 microns, since 1/25 of a thousand is 40. Is your hair that thick?

Now that you know how to measure with a microscope, try to find the size of different objects. You might try to measure a fly's eye or a salt crystal. Can you think of other things to measure with a microscope? ■

PROJECT

Get some hairs from your friends, or from members of your family. Look at the hairs under a microscope. Are dark hairs thicker than light colored ones? Is straight hair thicker than curly hair? Compare your hair with that of your parents. Does hair thickness change with age? You might examine hairs from dogs and cats. How do they differ from human hair?

How Good Is Your Sense of Touch?

■ Hundreds of times each day you use your sense of touch to find out certain things—how hot or cold something is, how smooth or how rough, how sharp or how pointed. Your skin helps tell you these things. But just how good is your sense of touch alone? Here are some ways you can find out.

First, gently press the *sharp* point of a pencil onto your fingertip. Make sure the point is good and sharp. After you have done this a few times, turn the pencil around and press your finger with the eraser end. Describe the different feelings you get. Sensitive nerve cells near the surface of your skin "feel" the sharp point. Nerve cells deeper in the skin "feel" the blunt eraser. If you were blindfolded, could you tell the difference between a sharp pencil point touching your fingertip lightly and a blunt eraser touching it lightly? Have a friend test you.

With a pencil point, move a single hair on your head or arm. Try other hairs on your arm. How would you describe the feeling? Are the nerve cells at the base of your hairs of any use to you? How are they useful to a cat or a dog?

Can Two Points Feel Like One?

Do you think that your skin's nerve cells are the same on all parts of your body? To find out, bend a paper clip so that it is a straight wire. Then bend it once in the middle to form a V. Open up the points to about 2½ inches. Have a friend close his eyes. Then touch both points *lightly* to the skin on the underside of your friend's arm, just above the wrist. Ask him how many points he feels. Now squeeze the points a little closer together and try it again. Continue squeezing the points closer each time until he tells you that he feels only one point. When this happens, measure the distance between points with a ruler. Mark this figure down in the table above. Can you guess why he feels one point instead of two?

Repeat these steps on the back of your friend's hand, on one of his fingers, his cheek, lip, and back of his neck. Mark down the "one-point" figures each time. Where do you get the largest measurement? The smallest? What does this tell you about the closeness of touch nerve cells in different skin areas?

"One-Point" Touch Measurements					
ARM	BACK OF HAND	FINGER	CHEEK	LIP	NECK

How sensitive is your sense of touch? Many blind persons can tell what an object is and what it is made of by running their fingers over the object. Here's a way to find out if you can recognize materials and objects by touch.

Collect five or more objects that are made of common materials, such as glass, metal, wood, cotton, blotter paper, leather, and so on. Have a friend collect the same number of objects, but don't tell each other what objects you have.

When you are ready to make the test, blindfold your friend. Set an object from your collection in front of him and have him touch it with the tip of his finger. Can he tell what material the object is made of? If not, tell him to rub his finger back and forth over a small spot on the object. If he still can't tell what it is made of, have him feel the shape of the object. Can he tell now what the object is? Can he guess what it is made of?

On a sheet of paper, write down the name of each material and how he was able to tell what it was. Write T for *touching,* R for *rubbing,* or F for *feeling* the shape of the object. Do this with each of the objects in your collection, then have your friend test you the same way.

Which materials could you tell by just touching them? Which ones could you tell by rubbing? If you could tell what an object was by feeling its shape, could you guess what it was made of? If you put the two collections of objects together and tested each other several times with them, do you think you could learn to tell the materials apart by just touching them? Try it and see ■

nature and science

TEACHER'S EDITION

VOL. 2 NO. 12 / MARCH 15, 1965 / SECTION 1 OF TWO SECTIONS

"See What You Can Find Out"

by Brenda Lansdown

How much can your pupils discover for themselves about the life and habits of an unfamiliar animal? More, perhaps, than you might expect, according to this report by Prof. Brenda Lansdown of the Department of Education, Brooklyn College, City University of New York. Professor Lansdown often uses materials developed by the Elementary Science Study (ESS) Program of Educational Services Incorporated with her classes of children as well as teachers.

■ Although there are many ways to teach children and many ways to teach teachers, I have used a simple formula for launching teachers into the discovery method. I use the method with the teachers and ask them to adhere to it as they orbit their new science program. The formula has five points:

1) Structured material is arranged for each four or five children in a class.

2) The only instructions given are, "See what you can find out."

3) After a period of free experimentation, the whole class gathers for a colloquium.

4) During the colloquium the children share their discoveries and exchange hypotheses. The teacher redirects the thinking at a few appropriate points. He tells no facts.

5) The colloquium agrees on a joint statement of discoveries which is recorded by the teacher as *The Scientists' Log.*

Teacher interference during free experimentation must be kept at a minimum. Hovering hopefully, making suggestions, or even answering questions, tend to dampen the initiative of the experimenter. The teacher may, of course, give reassurance: "Sure, go ahead and try it," or, "No, the dry cells won't electrocute you." After an impasse, the teacher may offer a new piece of material, using no more directives than, "Maybe you could use this?"

During the fall of 1963, I presented my Science Workshop at Brooklyn College with mealworms and the other materials suggested in the ESS unit, "Behavior of Mealworms." One of the participants, Arthur Weiner, took the mealworms to his school and tried out the new method for the first time. He invited a group of 10 seventh graders into his lab during a free period. The I.Q.s of these children ranged from 60-90. In their regular classrooms they were reported to be restless, with short attention spans, disruptive, and of course they had the poor language ability characteristic of urban youth from low socio-economic districts.

On each of two tables were sealed plastic boxes containing mealworms. The children were told to see what they could find out. Mr. Weiner wrote down what he heard.

Al: It's worms.

Charles (immediately): What is the stuff they're eating?

Maria: Looks like oatmeal.

Jose: The ones at the bottom look like they're sleeping.

Al: No, they don't. If you look hard you can see most of them moving.

Maria: They have legs.

Charles: Yes, look at the legs... they're all over, in the front and back.

Maria: No, can't you see that they only have legs in the front? Here, look. *(Holds up container so that everyone can see.)*

Miriam: One has a covering like a cocoon, and another one seems as if it has been all bitten up.

(Continued on page 4T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

The Fishes That Fly
Flying fishes actually glide; scientists believe they have gradually become "flyers" to escape their underwater enemies.

● **Face to Face with Grizzly Bears**
A high-school student tells of his adventures while helping to study the ecology of Grizzly Bears.

From Sap to Syrup
This WALL CHART shows the traditional and modern ways of collecting Sugar Maple sap and converting it to syrup.

● **Puzzling Polygons**
By solving a jigsaw puzzle and making three-dimensional models, your pupils can discover some fascinating characteristics of certain geometric shapes.

● **Measuring with a Microscope**
This SCIENCE WORKSHOP shows your pupils how to use a plastic millimeter rule to measure tiny objects they see through a microscope.

How Good Is Your Sense of Touch?
Your pupils can test each other's sense of touch in a number of ways suggested in this SCIENCE WORKSHOP.

IN THE NEXT ISSUE

The mystery of Stonehenge—who built it, when, and why—is being unraveled by scientists using modern techniques and instruments . . . A SCIENCE WORKSHOP tells your pupils how to find and study the tuneful tree frogs called Spring Peepers . . . A WALL CHART shows how green plants convert raw materials from the soil and the air into stems, leaves, flowers, fruit, and other products.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 4 Grizzly Bears

By now, your pupils should be familiar with our belated concern for preserving the world's wildlife. They have read about efforts to save the Galapagos iguanas (N&S, *Sept. 21, 1964*) and the "Arrau" turtles of Venezuela (N&S, *Jan. 18, 1965*), and perhaps know of examples closer to home, such as the Whooping Crane. This article will help them understand that even animals that sometimes destroy men's property have an important place in communities of plants and animals. Humans tend to forget (or never learn) that they too are part of plant and animal communities. This ignorance leads to extinction of species, water and air pollution, soil erosion, and many other costly environmental problems.

Topics for Class Discussion

• *Why are the numbers of Grizzly Bears dwindling?* The article lists a variety of reasons, but the most important one is "progress." Grizzlies require large tracts of wild land for survival. Today this kind of habitat has been drastically reduced.

• *What animals have disappeared from your area due to man-made changes? Why have they disappeared?* Your pupils can probably name some animals that formerly lived in your area, and a committee can look up others in a library. You may find that the animals were large, and easily seen and killed by humans. Or perhaps they had very valuable fur or meat. Or they may have been highly specialized, and could not survive when the environment was changed. How do these extirpated wild animals compare with those that live in your area now? Man-made changes have caused increases in some animal numbers, such as rabbits, crows, and deer.

• *Why do scientists mark the Grizzlies?* It is important to recognize individual animals when studying the entire population. For example, knowing that a 400-pound male Grizzly was trapped on the north shore of Yellowstone Lake on May 23 becomes much more meaningful when the animal is identified by an ear tag as the bear that weighed 460 pounds last fall, when it was trapped 10 miles to the west. Thus something is learned about the weight changes and travels of a particular male bear. After many such observations, scientists can draw some conclusions about the entire bear population.

• *The article states that "many newly born and young animals die in all animal populations." Is this knowledge put to practical use by humans?* Yes, in hunting seasons. The populations of wildlife species follow an annual pattern with low numbers in the spring, high populations in the late summer and fall, and a drop to low numbers again by spring. This rise and fall of animal numbers goes on whether the animals are hunted or not. By hunting game in the fall, some of the surplus animals are harvested, furnishing food and recreation.

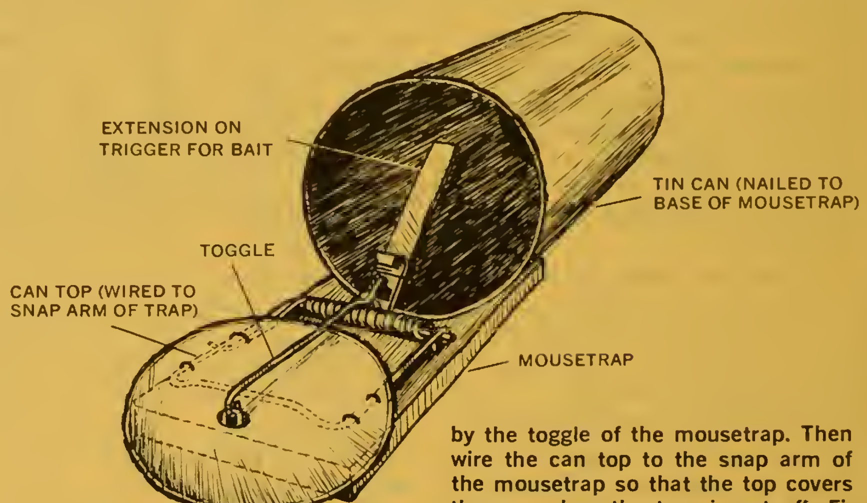
Activity

Your pupils can make small animal traps, somewhat similar to the bear traps described in the article *(see diagram).* They can be used for catching mice and other small mammals. *(Be sure that the class has made preparations for the animals' care before trying to catch them.)*

PAGE 11 Puzzling Polygons

Shapes are mathematical ideas which enter into our conceptual thinking very early in life. Youngsters learn to recognize shapes long before they learn to count. Shapes are very important to engineers, builders, designers, artists, and scientists. This article is designed to draw your

(Continued on page 3T)



To make this trap for catching small animals, cut the top from a tin can (fruit juice size or smaller), and nail or wire the can to the wooden base of a mousetrap. Make a hole in the can top so that it can be held down by the toggle of the mousetrap. Then wire the can top to the snap arm of the mousetrap so that the top covers the can when the trap is set off. Finally, wire a stick or other extension onto the trap's trigger. Put the bait (peanut butter is best for most small mammals) on the end of this extension. When the animal enters the can to get the bait, the trigger is pushed down and the top snaps up to close the animal inside.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teachers' Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue...
(Continued from page 2T)

pupils' attention to some interesting properties of certain *regular* shapes—both plane and solid.

Suggestions for Classroom Use

Many of the shapes named in this article are probably unfamiliar to your pupils. Emphasize that a polygon is any closed, two-dimensional (plane) shape formed of straight lines; in a *regular* polygon, the sides are all the same length and the angles are all equal. To help your pupils understand the difference, draw on the board a square, an equilateral triangle, a hexagon, and some irregular polygons like these:

Ask your pupils which of the shapes are *regular* polygons, and why.

Have your pupils try to solve the floor tiling puzzle at the beginning of the article. They will probably guess that square tiles could be used. The only other regular polygon shapes that can be fitted together without leaving any space between them are equilateral triangles and hexagons. For an example of the latter, see the "Mystery Photo" on page 10, which shows the hexagonal cells of a wasps' nest.

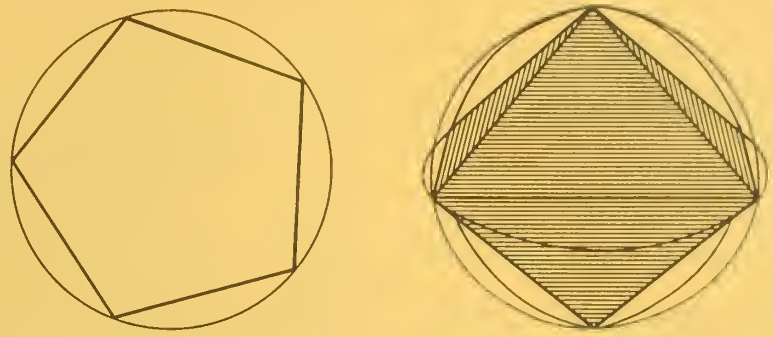
It might be well to explain that mathematicians use the word "solid" to describe three-dimensional objects. In this sense, a solid is a kind of package, or box, that may or may not have something inside of it.

Making and coloring the five regular solids is fun as well as instructive.

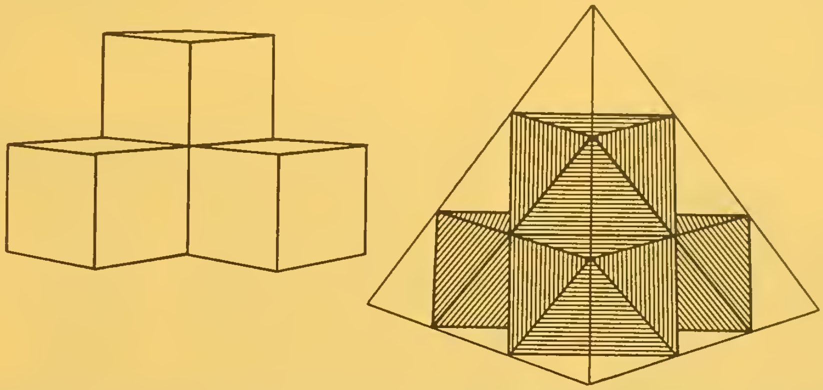
Additional Activities

• The article states that a polygon can have any number of sides. What would a regular polygon with, say, 100 sides look like?

Have your pupils trace each of the regular polygons shown at the top of page 11 on a sheet of thin paper. Then ask them to find out if a circle can be drawn with a compass around each regular polygon so that all the corners of the polygon touch the circle. (It can be.) You can also explain that a regular solid fits inside a sphere in such a way that each vertex of the solid touches the surface of the sphere *(see diagram)*.



As these illustrations show, a regular polygon fits within a circle so that each vertex of the polygon touches the circle. In a similar way, a regular solid fits within a sphere so that each vertex touches the surface of the sphere.



Cubes are the only regular solid that, by themselves, can be stacked to fill three-dimensional space. Of the five regular solids, only two differently shaped solids—tetrahedrons and octahedrons—can be stacked in combination to fill three-dimensional space.

• If a number of your pupils have made models of the five regular solids, ask them to find out whether solids of any one shape, or of two different shapes, can be stacked together tightly, leaving no space in between. Cubes can be stacked this way, and tetrahedrons and octahedrons can be stacked in combination to fill three-dimensional space *(see diagram)*. No other solids can be stacked in this way.

• Some crystals found in nature are regular solids. Have your pupils look at salt grains under a magnifying lens and they will see perfect cubes. Some alum crystals are in the shape of octahedrons. Some crystals of "fool's gold" are dodecahedrons.

PAGE 14 Microscope

For general comments on using microscopes in the elementary classroom, see the *N&S* Teacher's Edition, Dec. 7, 1964, pages 1T and 4T. Some suggestions pertinent to making microscopic measurements are offered here:

• Make sure your pupils use a clear plastic ruler to allow light to pass through it from the microscope mirror below.

• Plan this activity for a time when you will be free to give individual assistance.

• Give the class some preliminary practice in measuring with metric units. Ideally, they should start out with a meter stick, measuring the dimensions of the room, their desks, a piece of paper. Gradually work down to centimeters and millimeters.

They may also need some practice in estimating fractional parts of the space between ruler markings. Reproduce sample situations on the board, working large at first and gradually reducing the size of the space.

• Whenever your pupils observe something through the microscope—cubes of salt, a fly's leg, microscopic pond animals, and so on—have them use the method described in this article to measure the object.

"See What You Can Find Out"
(continued from page 1T)

Al (pointing): That one is dead. Look, one of them is white.

Maria: Yes, some of them are also dried up.

Rose: Looks like it. I wonder what kind they are?

Maria: They look like worms but they have legs. I've never seen worms with legs.

Charles: Could be baby caterpillars. But I really don't know.

Rose: Yes, they have lines, brown lines through them.

Maria: I have never seen worms with legs, and I've never seen worms eating oatmeal. I think they are caterpillars.

After a while, Mr. Weiner removed the plastic tape and gave the children direct access to the mealworms. At this point, real curiosity had overcome any residual Freudian reaction to wiggly snakelike forms, or any desire of adolescent boys to drop worms down the necks of adolescent girls! Observation and comments occupied 20 minutes. Then followed the colloquium, with the children sitting in a circle facing each other. One may note the amazing fluency of speech, the amount of knowledge exhibited, the coherency of ideas and the fact that the teacher did not need to speak at all, except to launch the discussion.

Mr. W.. What did you see? *(The children had used hand lenses.)*

Miriam: I saw some type of family of caterpillar. At the front end of each one are three pairs of legs. They are light brown with dark lines across, separating each part. From the head they have two things coming out which look like antennas. They look like they're eating something dry like oatmeal. At the end of the tail they are black, that is darker, and they sometimes try to crawl up the sides but they can't get all the way up.

Jimmy: They look like caterpillars. Most have different colors, some are light brown, some are dark brown and others are white. Most of them are digging under. It seems as if their skin comes off as they get older. Each has six legs. They are all climbing over each other. Maybe they are fighting.

Jose: They are caterpillars when they are in the cocoon. Some look like they are in a cocoon. They form a cocoon and then change into an insect or something like an insect. You can see that some are white and others are getting white. The skin must have peeled off.

Al: Their top and bottom are the same color. They try to crawl under the grain. They dig their way under. They have six legs and try to crawl up the sides. I know they aren't worms. They must be some kind of caterpillar or in the caterpillar family.

Ada: They look like they're going to turn into something. Maybe a moth or a butterfly. They might even lose their legs and change into some kind of flying insect.

The children came to the lab every day to watch the metamorphosis of the meal worms, and when four beetles finally appeared, excitement was about equally great for teacher and children. (All this preceded the arrival of the British homonyms!) ■

HELP WANTED

Do you have a science teaching technique or suggestion that you would like to pass on to others? *N&S* welcomes suggestions and articles for the Teacher's Edition that will lead to more effective science teaching in the elementary grades, as well as articles for the student's edition. Articles are paid for on acceptance. All manuscripts should be accompanied by a self-addressed envelope and return postage.

Common Sense and Uncommon Experiences

■ Common sense refers to the tremendous amount of experience we gain in early life that tells us such an enormous amount about the world we live in and the objects that surround us. Though possibly some elements of it are instinctive, the bulk of common sense is distilled experience.

The experiences we gain in those early years of life are naturally gained in our ordinary surroundings, using the tools and materials that are at hand. We do not gain any common sense appreciation of the behavior of gas at a million degrees because we do not meet that kind of thing in ordinary life. Nor do we gain any appreciation of the view of the world one would have if one were speeding through the countryside at 100,000 miles a second, simply because this does not happen to us. On the other hand, common sense is a splendid guide in that particular field on which it is based—that is, the experience of everyday life.

It is the task of the physicist to go beyond this, to devise and use instruments that enrich experience, that allow one to gain knowledge of objects and circumstances one would not normally come across. One would then expect that when the physicist, in his exploration of a larger range of experience than what has gone into the making of common sense, examines his results, he may find either that the impressions of common sense apply or that they do not apply.

If they do apply then it merely means that, in his extension of range of circumstances, he has not gone beyond the validity of what was acquired in a narrower context. If he does run out of this set of circumstances, then naturally, one would not expect common sense to apply. In fact, common sense would then be an unwelcome intruder making it more difficult for us to adapt ourselves to these new circumstances than it might otherwise be.

Adaptation to a new set of circumstances is always possible. Human beings are intelligent, which is equivalent to the statement that they are flexible. Once one has met enough of a new set of circumstances, one can order them and acquire a new understanding of them, in just the same way that one can learn a new language.

It so happened historically that the physicists' instruments became sufficiently powerful to outrun the range of validity of common sense at the end of the nineteenth century and in the early years of the twentieth century. Then, for the first time, results were derived clearly contrary to experience in our ordinary and very different circumstances, and a great deal of heart-searching and trouble arose.

Nowadays we know that this is totally misplaced; the farther we range with our instruments, the stranger the worlds we investigate, the more different they will clearly be from what we are accustomed to. The modern physicist, to follow Lewis Carroll, is used to believing at least two incredible things every day before breakfast.

To put it again a little differently, the surprising thing, surely, is that molecules in a gas behave so much like billiard balls, not that electrons behave so little like billiard balls ■

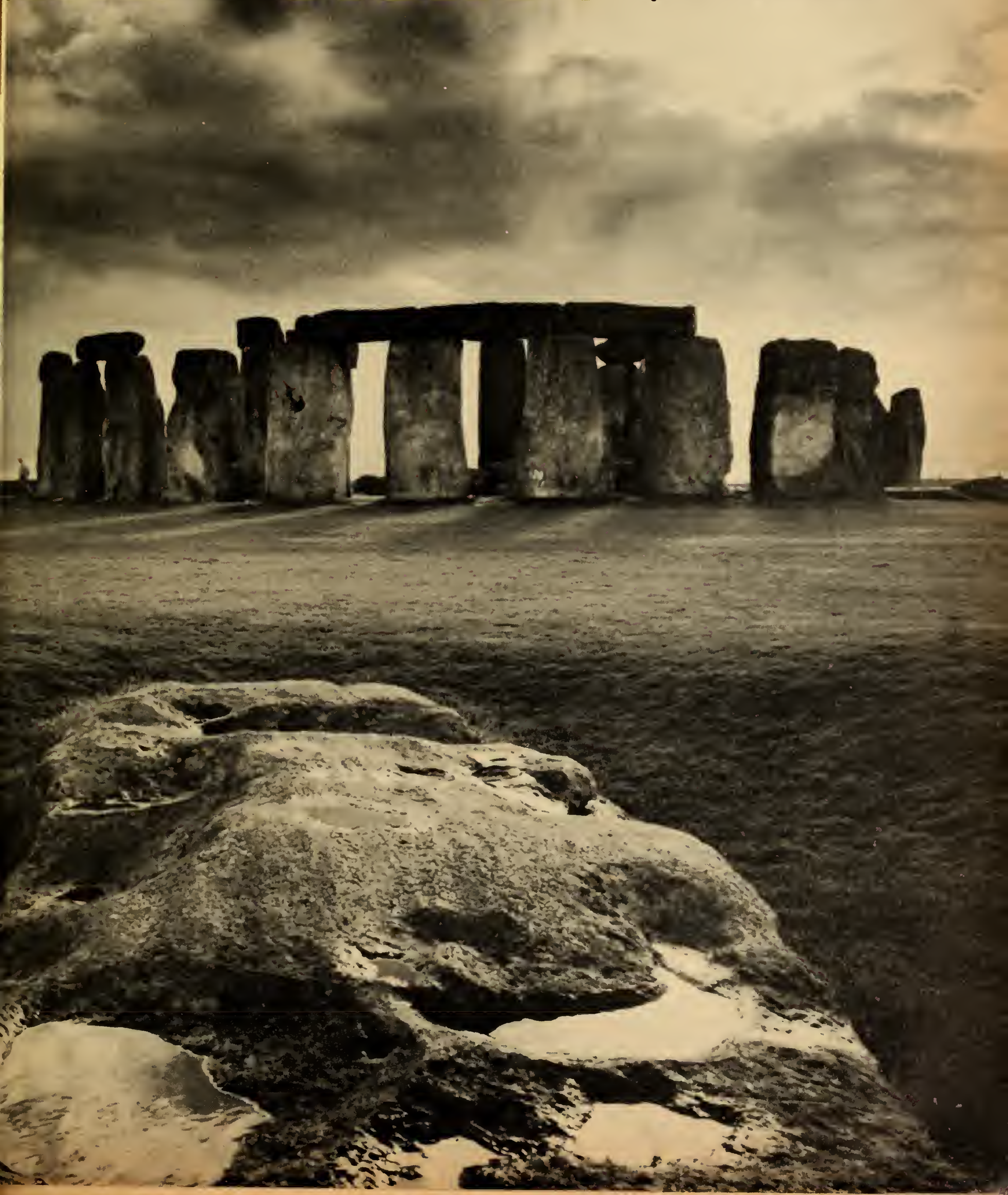
nature and science

VOL. 2 NO. 13 / APRIL 5, 1965

Why were these huge stones set up nearly 3,500 years ago? A young astronomer may have the answer.

see page 3

THE MYSTERY OF STONEHENGE



ABOUT THE COVER

Our cover photograph shows Stonehenge, the famous stone ruins that rise from a plain in southern England. Stonehenge is a strange, circular arrangement of stones and holes in the ground. For hundreds of years, men have wondered how and why Stonehenge was built. The article beginning on page 3 tells how scientists have unraveled part of the puzzling past of Stonehenge.

The photo above shows some of the massive sandstone blocks that form the most outstanding part of Stonehenge. Compare their size with that of the man on the tower. (He is a television cameraman who helped film a CBS Television Network show about Stonehenge. The film was broadcast on February 1, 1965.) These huge stones weigh up to 100,000 pounds each. Eighty-one of them were used in building Stonehenge. It seems impossible that people living over 3,000 years ago were able to shape and move these giant stones without modern tools like power drills and strong cranes.

However, scientists have figured out how these people built Stonehenge, and know something about why they built it. Author Diane Sherman tells how scientists have partly solved "The Mystery of Stonehenge," beginning on page 3.

nature and science

VOL. 2 NO. 13 / APRIL 5, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

CREDITS: Cover photo by Fritz Henle, from Photo Researchers, Inc.; p. 2, photo from CBS Television Network; p. 3, photo by Aerofilms, London, England; pp. 3, 16, drawings by R. G. Bryant; pp. 4, 11, 12, 13, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, photos by R. J. C. Atkinson; p. 6, photo from Ministry of Public Building and Works, England. Crown Copyright; p. 7, photo from Boston University Photo Service; pp. 8, 9, drawing by Peter Richard; p. 10, 11, adult Peeper photo by Hugh Spencer, eggs by George Porter, both from National Audubon Society, map by Thomas Hayden, photo of young Peepers from AMNH; p. 12, photo by George Cope, Educational Services Incorporated; p. 13, photo by Schulze & Schulze; pp. 14, 15, photos from General Electric Research Laboratory.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y. and at additional office. Copyright © 1965 The American Museum of Natural History. All Rights Reserved. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The National History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

From an airplane, Stonehenge looks like this. The white spots around the edge are holes that have been filled with chalk.

The Mystery of Stonehenge

by Diane Sherman

Archeologists have learned much about the men who built this unusual arrangement of stones and holes nearly 4,000 years ago. Now a young astronomer, using a computer, may have discovered why they built it.

■ For centuries men have wondered about Stonehenge, the unusual arrangement of mammoth stones that sits on a slight rise in Salisbury Plain, in southern England *(see map on page 4)*. Far back in history, men have been asking questions about it. Who built it? How did they do it? And, most puzzling of all, *why?*

Stonehenge is laid out as a series of circles inside each other *(see diagram)*. The outermost circle is a big ditch. Inside it is a low bank of earth that may once have been a wall six feet or so high. Next comes a ring of evenly spaced holes in the ground. Toward the center are huge sandstone blocks. Originally they formed a circle 100 feet across. Smaller blocks called *lintel stones* rested on top of the upright stones, joining them into one continuous ring. Inside of this ring is a circle of smaller bluestones, then sandstone blocks arranged in the shape of a horseshoe. Inside of that horseshoe is another one, formed of bluestones.

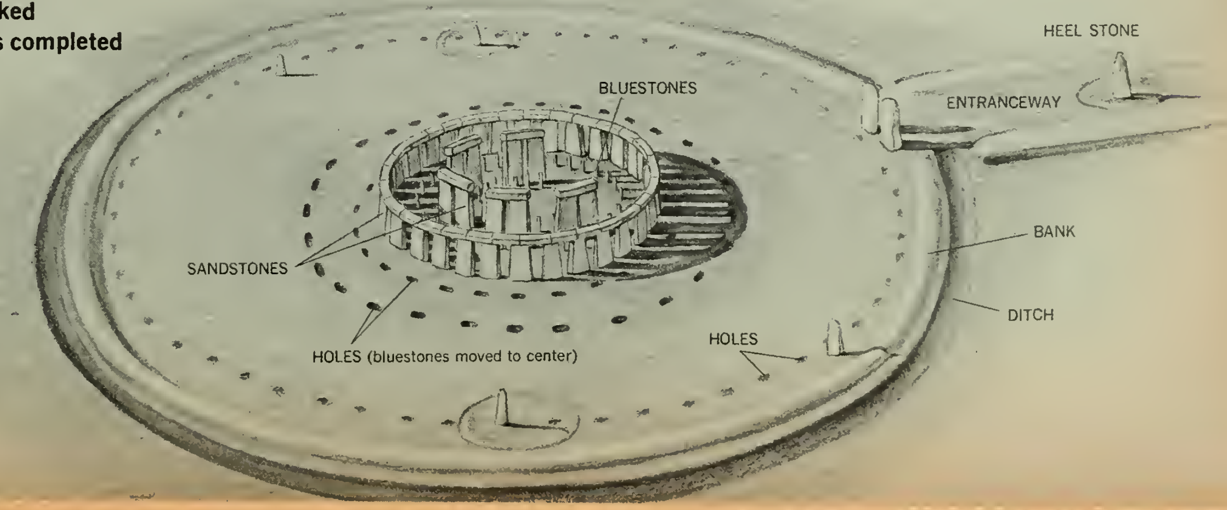
What does it all mean? Some people thought that Stonehenge was an old Roman temple. Others insisted that it was a court built later by the Danes. Still others said that Merlin, the wizard of King Arthur's Court, had whisked the rocks from Ireland in a single night. In the 1700s and the 1800s, the most popular idea was that Stonehenge was a temple used for religious ceremonies by the Druids. The Druids were the religious leaders of the people who lived in England not long before the time of Jesus.

How Old Is Stonehenge?

Then, in 1901, a British astronomer named Sir Norman Lockyer had another idea. If you stand inside Stonehenge at dawn on June 21st, the longest day of the year, and look through the opening of the two horseshoes, you will see the midsummer Sun rise over a large pointed stone called

(Continued on the next page)

Archeologists believe that Stonehenge looked like this when it was completed around 1400 B.C.



This map shows the probable route by which the bluestones were brought from the Prescelly Mountains over land, ocean, and rivers to the site of Stonehenge.

The Mystery of Stonehenge (continued)

the Heel Stone, that stands in the middle of a long entranceway. Most of the people who had studied Stonehenge thought that this was just a coincidence. But Sir Norman was not so sure. What if Stonehenge had been built this way on purpose?

It was hard to be sure whether the midsummer Sun rose *exactly* over the Heel Stone. The first flash of sunrise was a little to the left of the Heel Stone, but the Sun's disc itself was over the stone. Sir Norman knew that the Sun's position keeps changing slightly every year. He tried to figure out when the first flash of the rising midsummer Sun would have appeared in the middle of the entranceway. He decided that if Stonehenge was built to face the midsummer Sun, it must have been built around 1840 B.C. or within 200 years of that date.

But Sir Norman's idea was considered just another guess until the 1950s. Then three British *archeologists*—scientists who study how man lived in the past—began a 10-year study of Stonehenge. Professor Richard Atkinson of University College in Wales, Professor Stuart Piggott of the University of Edinburgh in Scotland, and Dr. J.F.S. Stone of the Salisbury Museum found some charred fragments in one of the outer holes. Other scientists measured the amount of radioactivity left in the fragments *(see "Measuring Past Ages,"* N&S, *March 1, 1965)*. They figured out that the fragments dated back to about 1850 B.C. This would make Stonehenge almost 4,000 years old—far older than the Romans or the Druids!

The three archeologists did a great deal of digging, at Stonehenge and at hundreds of other old dirt circles around the English countryside. They found bits of broken pottery, and jewelry and weapons that prehistoric people had buried with their dead. Fitting each scrap of information together carefully, they came up with a remarkable story.

The People Who Built Stonehenge

Around 2300 B.C. a group of people came from the European continent to what is now England. The people who roamed England before them lived by hunting, but the newcomers were farmers and herders. Using deer antlers for picks, they built huge circular corrals with sides of heaped earth. Archeologists believe that each fall, as grass grew sparse, the herders drove their cattle into the corrals and killed off extra steers.

About 2000 B.C. another group of people came from Europe, bringing different customs. They began to use the corrals as temples and meeting places. Around 1850 B.C. these people started work on what was to become Stonehenge. They dug a circular ditch, heaping the earth high inside the ditch. Then they set the Heel Stone, and dug a circle of evenly spaced holes in the ground.

About 150 years later, a third group of settlers arrived. Archeologists call them the Beaker people because much of their pottery looked like the tall, wide-mouthed containers called beakers that chemists use. These people came to England just after copper and gold had been found in Ireland. The highly civilized people who lived around the Mediterranean Sea wanted all the metal they could get. The Beaker people became traders. The places where their remains have been found show that they traveled around the coast of Wales to the metal-working center in Ireland. They must have explored the Welsh coast, too, because their handsome battle axes were made from the beautiful polished bluestone that is found only on the Welsh peak of Prescelly *(see map)*.

Soon the Beaker people became wealthy and powerful. They turned their attention to Stonehenge. They added an avenue leading to the entranceway. Then they decided to bring some bluestone blocks from Wales to place inside the circle.

Moving the Stones

They chose 80 stones that weigh up to six tons apiece. As far as we know, these people had no wheels or pack animals. They had to haul the stones themselves, using wooden logs as rollers. Archeologists think they must have taken the stones most of the way by water, since it would be far easier to float them on rafts than to drag them over hilly country. They probably hauled the stones to the ocean, lashed each one to a raft or some kind of boat, and sailed along the coast to the mouth of the Bristol-Avon River *(see map)*.

Rafts are better than boats on the ocean, because a raft can't be sunk, even in rough weather. But a raft big enough to carry a bluestone and a crew would be too big to travel up English rivers. The stones must have gone upriver on dugout canoes, probably on two or three canoes lashed together. Between rivers, men must have pulled the stones on rollers.

How can we know all this? In 1923, Dr. Herbert Thomas of the British Geological Survey proved that the Stonehenge rocks match the Welsh bluestone perfectly. Later, Professor Atkinson worked out what he thought was the most likely route to get the rocks from Wales. He may have been right, because a 600-pound piece of bluestone has been found in a grave near one of the rivers on Professor Atkinson's route. It matches the Stonehenge bluestones exactly, and it may have been abandoned on the way.

Professor Atkinson still wasn't sure whether such heavy stones could be handled by men using only rollers and rawhide rope. In 1954 he got a group of English schoolboys to try it. They used a cement block the same shape and weight as a bluestone. Moving it over land and water wasn't fun, but they found that it could be done *(see photos)*.

About 1500 B.C., at the height of their wealth and power, the Beaker people began to rebuild Stonehenge. They took down the bluestones and dug new holes for a circle of massive sandstones weighing up to 100,000 pounds each. Eighty-one of these stones had to be brought 21 miles from the quarry.

The question is—how? These rocks weighed 120 times as much as the bluestones. They probably were loaded on sledges and pulled along over wooden rollers.

Putting the Stones Together

Another question to be answered was how these mammoth rocks were shaped and polished. Archeologists have found huge, 50-pound stone hammers. The workmen must have heated a rock with torches where they wished to make a cut. Then if they poured cold water on the hot rock, it would weaken the stone so that it would break smoothly when pounded by the hammers. The final shaping and polishing was done by teams of men who pounded the stone repeatedly, and pulled grinders over its surface.

Now the stones were ready to be put into place. Modern workmen used a strong crane to lift a fallen lintel-stone back on top of two upright stones. But the builders of Stonehenge had only lumber and rawhide rope. With these alone they set huge stones upright and lifted 7-ton lintel stones to the tops of the columns. The bluestones were then set up inside the ring of sandstones.

Stonehenge probably was finished by 1400 B.C., some 400 years after it was begun. Archeologists consider it a masterpiece of architecture. Other monuments of stone had been built in western Europe about the same time, but

(Continued on the next page)

British students are shown moving a block of concrete about the same shape and weight as a bluestone by poling it up a shallow river on boats (above) and by hauling it over land on rollers (below). This showed that the builders of Stonehenge could have brought the bluestones from Wales in the ways suggested by Professor Atkinson.

none of them were made of stones that had been shaped and polished like those of Stonehenge.

In 1953, Professor Atkinson was taking a picture of one of the stones. He noticed the hazy outline of a dagger carved in the sandstone. He called to Dr. Stone, who was working with him. One look and Dr. Stone bit his pipe so hard he broke a tooth!

Dr. Stone knew that the dagger was a kind found nowhere else but in Mycenae, an ancient Greek city. Such daggers were made there only between 1600 and 1500 B.C. Had the rich English chieftains hired an architect from Greece? That is a possibility, though no one knows when the dagger was carved.

Why Was Stonehenge Built?

At last archeologists had solved some of the mysteries of Stonehenge. But the biggest mystery—its purpose—remained as dark as ever. In 1961, a young astronomer named Gerald Hawkins *(see page 7)* visited Stonehenge. He hoped the skies would be clear enough for him to see the midsummer Sun rising over the Heel Stone.

As he stood at the center of Stonehenge and looked through the stone arch leading to the entranceway, he saw the Sun on the far horizon rise over the Heel Stone. Stonehenge worked! Dr. Hawkins thought it could hardly be a coincidence. The stones were too carefully placed.

Dr. Hawkins knew that ancient people needed a calendar to measure the seasons. They had to know when to plant their crops. The Heel Stone pointed out midsummer. Did some other stone point to midwinter sunset?

No one had ever tried to figure out what the stones might point to. But now Dr. Hawkins went to work on the problem. He decided to use computers to help him. He put charts of Stonehenge into a machine called "Oscar." This machine recorded the positions of the different stones, archways, and so on, as punch-holes in cards. Then another machine was used to figure out what part of the sky each different pair of stones pointed to.

Dr. Hawkins made a startling discovery! Different arrangements of the stones lined up with 24 separate places where the Sun and the Moon rose and set in different seasons in the years around 1500 B.C.

If Dr. Hawkins is right, it means that Stonehenge was an astronomical observatory and a calendar. By standing in different places, the builders of Stonehenge could predict when the Sun and Moon would rise or set in midwinter or midsummer.

Dr. Hawkins discovered still another way that Stonehenge could be made to work. For a long time the outermost ring of 56 holes had puzzled archeologists. Dr. Hawkins studied the times of the year when there are eclipses of the Sun and Moon. He found that they take place in 56 year *cycles,* or patterns. For instance, if there were an eclipse at Stonehenge in April of 1578 B.C., there would be another in April of 1522 B.C., 56 years later. There would be many other eclipses in between, of course. But it would be 56 years before an eclipse would take place at exactly the same time of the year again.

Dr. Hawkins believes that the 56 holes were used to predict what would happen in the sky. This could be done, he says, if the holes were numbered and six stones were placed inside the circle next to certain holes. The stones would be moved one hole farther around each year. When one of the stones reached a certain hole, the ancient astronomers knew that an eclipse would occur in the spring or the fall of that year. Whenever a stone reached hole 56, they knew there would be an eclipse of the Sun or Moon within 15 days of midwinter.

If Stonehenge was built to be used in this way, its builders must have known what had happened in the skies over a period of more than 300 years. As far as we know, Stonehenge people had no writing. So during that time, stargazers must have carried the information in their heads and passed it along by word of mouth. They figured out what it meant, and finally discovered a way to predict what would happen for years afterward.

Has the centuries-old mystery been solved at last? Some scientists are not yet convinced, but Dr. Hawkins' ideas seem to be slowly gaining acceptance. One thing is sure, though. Stonehenge will continue to fascinate people even if the "mystery" is solved. For the more we learn about Stonehenge, the more remarkable it seems ■

From the center of Stonehenge, you can see the Sun rise over the Heel Stone on the longest day of the year.

AN ASTRONOMER-DETECTIVE

■ How do you go about solving a mystery that is over 4,000 years old? Dr. Gerald Hawkins first became interested in Stonehenge in 1954. He was then 28 years old, and was working at a missile-testing base nearby. Visiting the stones time after time, he began to feel there was some secret about their arrangement that no one had deciphered.

Dr. Hawkins is an astronomer, so it was natural for him to wonder if Stonehenge had some astronomical meaning. In 1961, when he was writing about Stonehenge in his book *Splendor in the Sky,* he decided to look into the problem.

By then Dr. Hawkins was living in the United States. He went back to England in the summer of 1961 to visit Stonehenge. He took movies of the Sun as it rose over the Heel Stone. Then and there he decided that Stonehenge was an astronomical problem that computers could help him to solve.

Dr. Hawkins has been interested in astronomy ever since he was a boy in England. One night when he was about 10 years old, he stayed up late to watch an eclipse of the Moon. He was so impressed that he began to read all he could find about astronomy. When he was 14, he joined the British Astronomical Association, a group of people of all ages whose hobby is astronomy. After a full day in school, Dr. Hawkins would often stay up most of the night plotting meteor tracks with other amateur astronomers. Meteors weren't the only objects in the sky Dr. Hawkins had to watch for, though. England was in the middle of war, and his observations were often interrupted by air raids.

Today Dr. Hawkins is Professor of Astronomy at Boston University, in Boston, Massachusetts. He is also Director of the Boston University Observatory, and is associated with the Smithsonian Astrophysical Observatory and Harvard College Observatory. He lives in Wellesley Hills, Massachusetts, on a hill with a good view of the sky.

Dr. Hawkins' five-year-old daughter Lisette already watches to see whether there is a whole moon or a half moon outside her window. Lisette's baby sister Carina was named for the star Alpha Carina, which is also called Canopus. You may have heard of Canopus, for the rocket now heading for Mars is using Canopus to guide its course in the right direction.

Dr. Hawkins is writing a book about Stonehenge. He is also studying moon craters, and has written a book about his work tracking meteors with radio signals and a high school textbook on Earth and space science.

He's not through with archeological detective-work, either. In England alone, there may be as many as 200 stone rings and other prehistoric sites still to be dug up. Do some of them point to things that happen in the sky? They may, Dr. Hawkins says, but in most cases it is too soon to tell. A great deal of work still has to be done, digging up the sites and drawing accurate plans of them. Only then can some future scientist try to solve their secrets ■

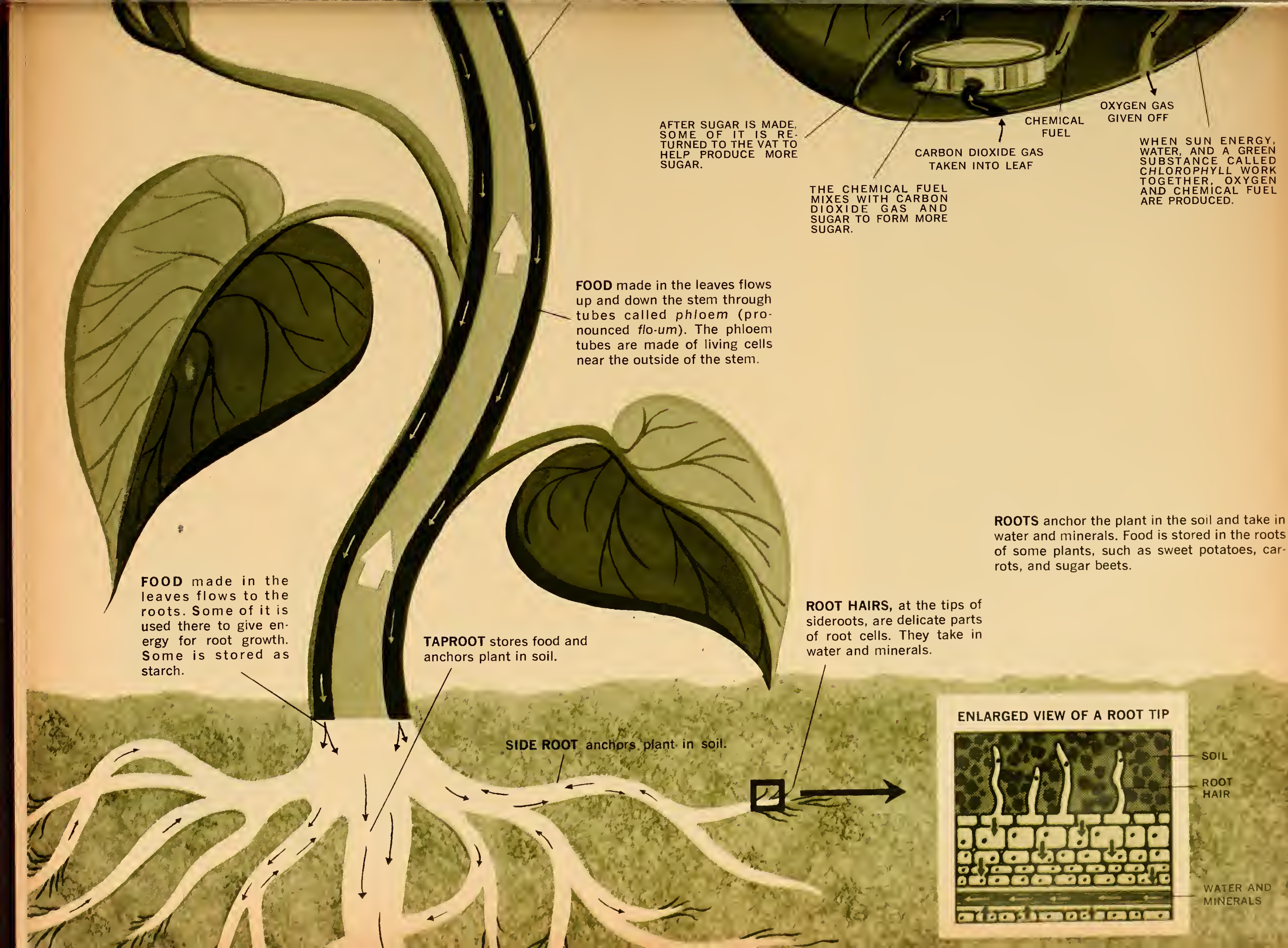
VISIT TO A PLANT FACTORY

A factory is a busy place, turning raw materials like iron or oil into complex products, such as automobiles or toys. A green plant is a sort of factory too. Take a tour of the plant on these pages and see how raw materials from the air and soil are changed into food, then used to give energy for growth of the plant's parts.

FLOWERS use food to get energy needed to produce seeds which, in turn, grow into new plant factories.

LEAVES of a green plant change energy of light from the Sun into chemical food, in the form of sugar, that can move through the plant. The sugar may later be changed to other kinds of food, such as starch. The sugar is also used to make the woody parts of the plant, called *cellulose*. This cutaway view of a leaf shows an imaginary picture of how leaves change raw materials into food for the entire plant.

WATER AND MINERALS flow up the woody center of the stem in a network of pipes, called *xylem* (pronounced zeye-*lem*). The pipes are made of dead cells and run from the roots to the leaves.


AFTER SUGAR IS MADE, SOME OF IT IS RETURNED TO THE VAT TO HELP PRODUCE MORE SUGAR.
CHEMICAL FUEL
OXYGEN GAS GIVEN OFF
CARBON DIOXIDE GAS TAKEN INTO LEAF
WHEN SUN ENERGY, WATER, AND A GREEN SUBSTANCE CALLED CHLOROPHYLL WORK TOGETHER, OXYGEN AND CHEMICAL FUEL ARE PRODUCED.
THE CHEMICAL FUEL MIXES WITH CARBON DIOXIDE GAS AND SUGAR TO FORM MORE SUGAR.
FOOD made in the leaves flows up and down the stem through tubes called *phloem* (pronounced *flo-um*). The phloem tubes are made of living cells near the outside of the stem.
ROOTS anchor the plant in the soil and take in water and minerals. Food is stored in the roots of some plants, such as sweet potatoes, carrots, and sugar beets.
FOOD made in the leaves flows to the roots. Some of it is used there to give energy for root growth. Some is stored as starch.
TAPROOT stores food and anchors plant in soil.
ROOT HAIRS, at the tips of sideroots, are delicate parts of root cells. They take in water and minerals.
SIDE ROOT anchors plant in soil.
ENLARGED VIEW OF A ROOT TIP
SOIL
ROOT HAIR
WATER AND MINERALS

FROGS THAT "SING" IN THE SPRING

Bring a flashlight and sneak up on these amazing amphibians.

by Edward R Ricciuti

■ Have you ever thought you heard sleighbells tinkling on a warm spring night? It wasn't bells jingling, of course. You heard the "singing" of a chorus of male Spring Peepers.

Spring Peepers are treefrogs. They are small, usually not more than an inch long. During the spring breeding season, male Spring Peepers "sing" to attract their mates. So do other kinds of frogs, but the Peepers are usually first to call in spring. From a distance, they sounds like bells.

You can find Spring Peepers in more than 30 eastern states (*see map*). In western United States, you can find other treefrogs, such as the Canyon Treefrog and the Pacific Treefrog. You can learn a lot about these fascinating frogs by spying on them. But first you have to find them.

Spying on Peepers

If you hear Spring Peepers calling nearby, look for them in wet areas such as water-filled ditches or small ponds near woods. Any of these places could conceal dozens of Spring Peepers.

Spring Peepers sometimes call on cloudy, humid afternoons. However, the best time to spy on these tiny frogs is at night. For equipment, you will need a flashlight, a wrist watch with a second hand, a pencil, and a notebook. You will want to record what you see and hear.

Once you find a group of Peepers, move very slowly and quietly. Try to creep close to them. Stop every minute or so and remain still. Listen carefully to the "singing." The sound you heard from a distance becomes a chorus of piping notes at close range. Each note starts sharply. It ends with a slight slur. It may sound like this: "Pe-rep."

Now try an experiment. Shuffle your feet. Does the "singing" stop? Some scientists believe that frogs detect your presence by sensing vibrations from your movements through ground or water. The concert should resume in a short while if you remain still. Do all the Peepers begin calling together? Write down what you hear.

Now look for the frogs. Sweep your flashlight beam over the area from which the loudest calling comes. Move the light along the water's edge. Watch clumps of branches or vegetation in the water.

The swollen *vocal sac (see photo)* of the male Spring Peeper often gives away the frog's hiding place. The sac is a loose pouch of white skin on the frog's throat. The frog's call begins when air is brought up from its lungs, through the throat, and into the vocal sac. As air passes through the throat, it vibrates *vocal cords*. The quivering cords produce the sound. At the end of a call, the Peeper's vocal sac is plump with air.

When you see a Peeper in your light, keep him in the beam and observe closely. Does the frog seem disturbed by the light? Does he keep calling?

The calling may attract a female. If you see two Peepers close together in the water you probably have discovered a male and female mating. The female is larger.

These treefrogs and many other frogs and toads gather in wet areas to "sing" and mate in the spring.

Frogs, toads, and other amphibians must lay their eggs in wet areas. In the spring, female Peepers lay hundreds of eggs underwater (right). Tadpoles hatch from the eggs and gradually change into the tiny Peepers (far right) that grow into inch-long adults.

Focus your attention on the call of one Peeper. Use your watch to determine how many times the frog calls in a minute. How long is the interval between calls?

Catching and Keeping Peepers

Spring Peepers live well in captivity. If you want to capture some to study at home, you will need a small net or kitchen strainer, and a wide-mouth jar or plastic container. Be sure that the jar or container has a top with holes in it that air can pass through. Put a wet cloth in the bottom of the jar. Peepers, and other frogs, absorb needed moisture through their skins.

Use the net or strainer to catch your frogs. Sometimes a fast—but gentle—hand will do just as well. You may collect more than one Peeper at a time by sweeping a large, fine-mesh net through the water.

Have a home prepared for your catch. A 5-gallon aquarium makes a fine one—it will hold four or five Spring Peepers. (You can also use a large mayonnaise jar, which is big enough for about two or three Peepers.) Spread a 2-inch layer of coarse gravel on the aquarium bottom. Leave a clear area at one end of the tank, however. This will be the "pond."

Spread a half-inch layer of filter charcoal over the gravel (you can buy it from a pet shop). Then put some soil, moss, rocks, and twigs over this. Pour about 2 inches of water into the "pond" area. You now have a miniature pond and woodland for your Peepers *(see diagram).*

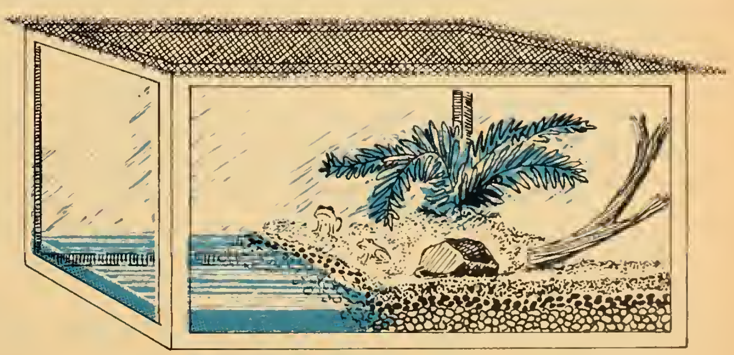
Make sure that you place a screen over the top of the aquarium tank. Treefrogs are good climbers. You will understand why if you see a Spring Peeper climbing the side of your aquarium. Look at the Peeper's feet. Notice the toes end in discs. How may this help the frog climb?

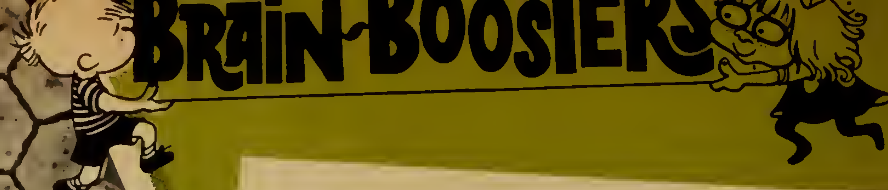
Most of the time, the Peepers will stay on the floor of the aquarium. They need cool, damp quarters. Keep the aquarium out of strong light. Feed the Peepers a few times a week on small mealworms or earthworms, small spiders, and soft insects like flies. Frogs must have moving food or they will not eat readily. You might try feeding them hamburger by sticking a bit of it on the end of a thread and swinging it near the Peepers.

Captive Spring Peepers will call if not disturbed too often. Note the time of day and the room temperature when they call. Leave a thermometer in the aquarium where you can see it without disturbing the Peepers. When are frogs most lively? Do they call only in the dark?

Free your Spring Peepers in the fall before the weather becomes too frosty. It is hard to get proper food for them in the winter unless you live in a place where it is warm all year around. Let your Peepers go in the woods. They will spend the winter under the leaves.

Next spring your Peepers and their fellows will awaken and head for water. The breeding season will begin and you will hear sleighbells again on warm nights ■

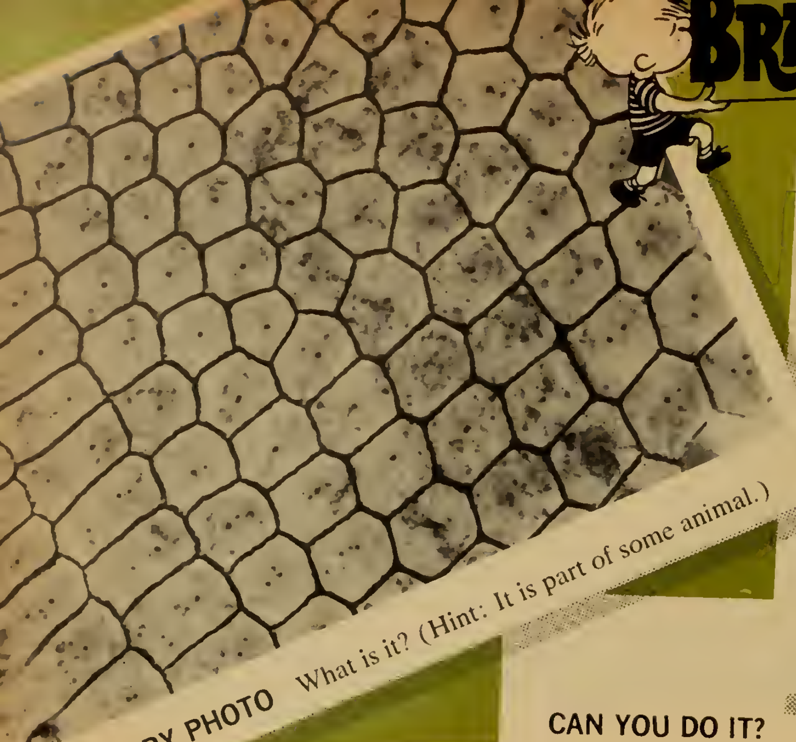




BRAIN-BOOSTERS

We wish to thank the numerous readers of Brain-Boosters who have contributed ideas. We pay for the best of these, and use one in each issue. We also enjoy having readers tell us about how they solve some of the puzzles. Please keep writing.

—David Webster

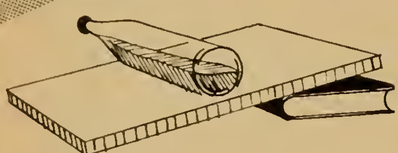


MYSTERY PHOTO What is it? (Hint: It is part of some animal.)

CAN YOU DO IT?

Can you float an egg in the middle of a glass of salt water?

submitted by Howard Kellogg IV, Brawley, California



WHAT DO YOU THINK WOULD HAPPEN . . .

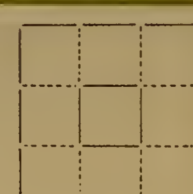
. . . if a bottle half full of Karo syrup were placed on its side on a tilted board? Try it and see.

FUN WITH NUMBERS AND SHAPES

Suppose there were a lot of balls the same size. All of them are white except one, which is green. How many white balls could you make touch the green one at the same time?

FOR SCIENCE EXPERTS ONLY

How would you balance the stick by moving one penny from the right side of the stick to the left side?



SOLUTIONS TO BRAIN-BOOSTERS IN THE LAST ISSUE

WHAT DO YOU THINK WOULD HAPPEN? When an inflated balloon is put into a refrigerator, the air inside it gets colder, and the balloon becomes smaller. What would happen to the size of the balloon on a warm radiator?

CAN YOU DO IT? You can get away from the friend tied to you by slipping the rope loop over one of your hands as shown in the diagram.

FOR SCIENCE EXPERTS ONLY: The water would be completely gone from both jars at about the same time. Why is this?

FUN WITH NUMBERS AND SHAPES: If the 8 toothpicks shown by the dotted lines are removed, only 2 squares are left.

MYSTERY PHOTO: The photograph shows part of a wasps' nest. How do the wasps make the paper which they use to build nests like this?

JUST FOR FUN: A bald head.

WHY DOES ICE FLOAT?

■ Drop a piece of ice into a glass of water. After the ice has stopped bobbing up and down, see how much of it is sticking out of the water. Ice is just frozen water, so why doesn't it sink all the way down into liquid water?

Maybe the piece of ice has some tiny air bubbles in it. If it has, you can probably see the bubbles. Chip off a piece of the ice that you can look clear through without seeing any bubbles. Does it sink all the way into the water?

Do you think that ice could be lighter than water? Here's a way to find out. You will need a simple balance (the one shown in the diagram is easy to make), and three or four small paper cups, all the same size. (You can make these by cutting off the top half of some paper drinking cups.)

Pour water into three cups until each one is about three-quarters full. Then use a pencil or a ballpoint pen to draw a line on the side of each cup exactly even with the top of the water. Set the cups straight up in the freezing compartment of your refrigerator and leave them overnight.

When the ice is frozen solid, look at the mark you made on the side of each cup and see if the water changed in size when it froze. Water is one of the very few liquids that get bigger when they freeze. As the tiny particles of water become solid, they spread apart. Do you think that this makes a piece of ice heavier or lighter than water that takes the same amount of room as the piece of ice?

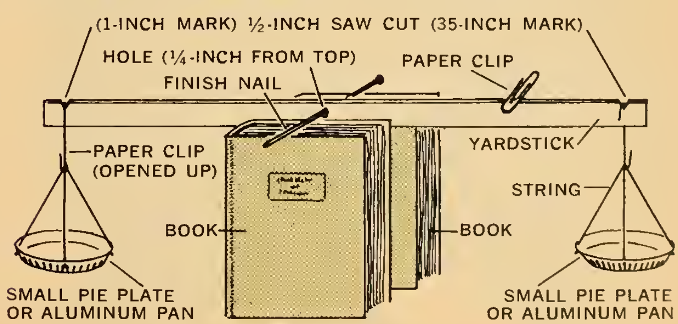
To find out, pick a cup with ice that is fairly level on top and set it on a table. Set an empty cup beside the one with ice in it. With your eye even with the top of the ice, pour water into the empty cup until it reaches exactly the same level as the top of the ice. Now set the ice cup on one pan of your balance and the cup with water in it on the other pan. Does one side of the balance go down? Which is heavier, ice or the same amount of water?

Ice, Cooking Oil, and Water

Will ice float in other liquids? You've seen it float in lemonade and soda pop, but they are made mostly of water. How about cooking oil? Pour a little cooking oil into a small glass and see if ice will float in it. Use your balance to find out which is heavier, a piece of ice or the same amount of cooking oil. Now compare the heaviness of some cooking oil and the same amount of water. Do you think one of these liquids will float on the other? Try it and see. Can you tell by dropping a piece of plastic or a piece of wood into a liquid whether the plastic or the wood is heavier or lighter than the same amount of the liquid? Why? ■

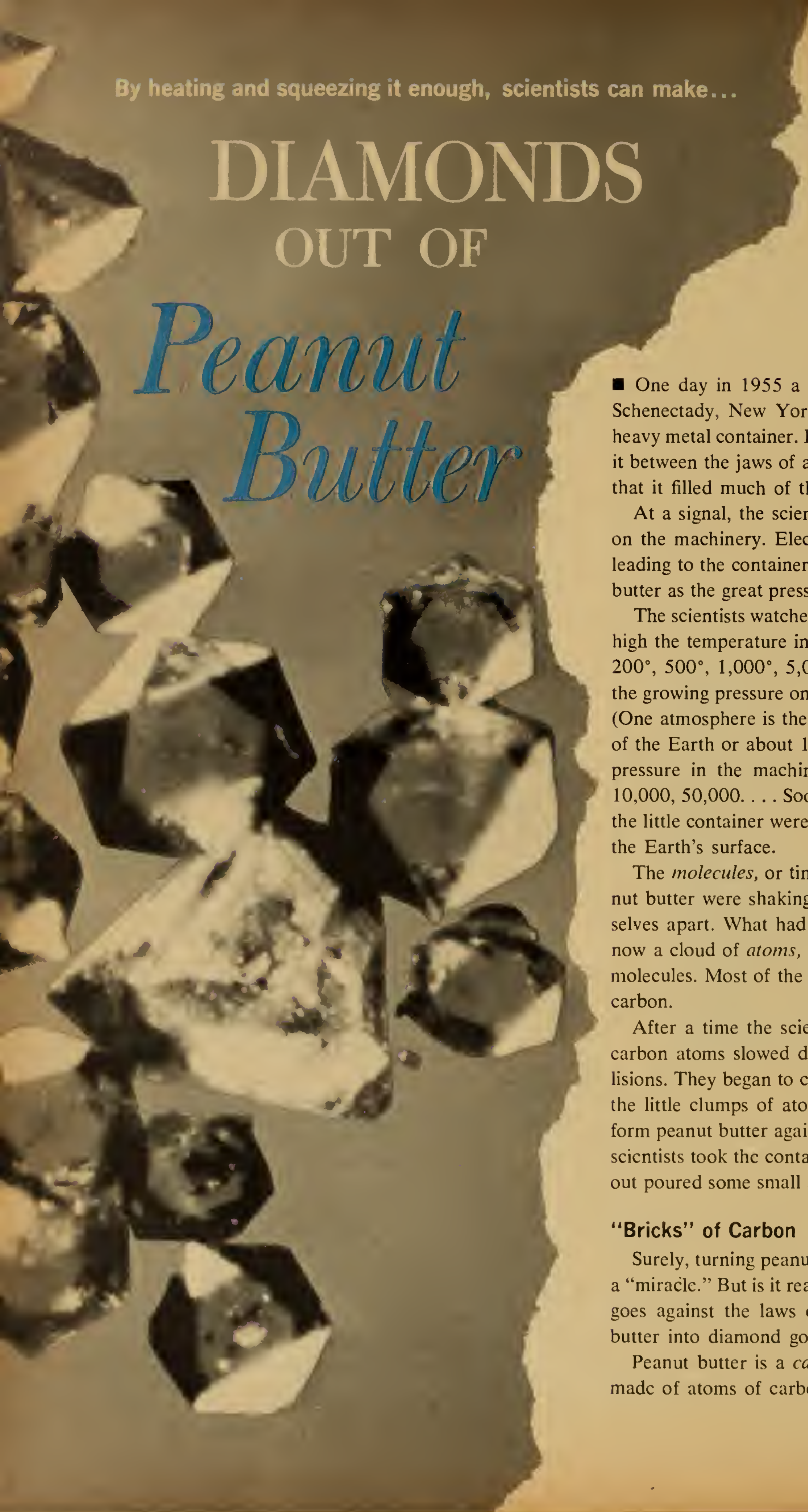
This article is adapted from Melting Ice Cubes, *a teaching unit prepared by the Elementary Science Study project of Educational Services Incorporated. Published with permission.*

Before using this balance, move the paper clip along the yardstick until the two plates are level with each other. You can make other investigations with this balance, too.



By heating and squeezing it enough, scientists can make...

DIAMONDS OUT OF *Peanut Butter*



by Lawrence Sandek

■ One day in 1955 a young scientist in a laboratory in Schenectady, New York, put some peanut butter into a heavy metal container. He closed the container and placed it between the jaws of a great press. The press was so big that it filled much of the laboratory (*see photo*).

At a signal, the scientist and his companions switched on the machinery. Electric current flowed through wires leading to the container and started to heat up the peanut butter as the great press began to squeeze it.

The scientists watched the instruments that showed how high the temperature in the container was going—100°F., 200°, 500°, 1,000°, 5,000°. Other instruments measured the growing pressure on the peanut butter in *atmospheres*. (One atmosphere is the pressure of the air on the surface of the Earth or about 14.7 pounds per square inch.) The pressure in the machine rose to 10 atmospheres, 100, 10,000, 50,000. . . . Soon the pressure and temperature in the little container were as great as those 240 miles below the Earth's surface.

The *molecules,* or tiny particles, that made up the peanut butter were shaking so violently that they tore themselves apart. What had been a dab of peanut butter was now a cloud of *atoms,* the even tinier particles that form molecules. Most of the atoms in the cloud were atoms of carbon.

After a time the scientists let the container cool. The carbon atoms slowed down in their crazy, bouncing collisions. They began to clump together here and there, and the little clumps of atoms grew larger. But they did not form peanut butter again. When the job was done and the scientists took the container from the press and opened it, out poured some small and glittering diamonds!

"Bricks" of Carbon

Surely, turning peanut butter into diamonds sounds like a "miracle." But is it really? A "miracle" is something that goes against the laws of nature. Does changing peanut butter into diamond go against any natural laws?

Peanut butter is a *carbohydrate*. This means that it is made of atoms of carbon, hydrogen, and other elements which are arranged in a certain way. A diamond is made almost entirely of carbon atoms. The great pressure and heat in the press tore the carbon atoms from the arrangement they had in the peanut butter and made them arrange themselves in another way—the diamond way. It's as if you had taken the bricks out of a great heap and put them together neatly to make a house.

The important thing to the scientists was not the peanut butter, but the carbon atoms. They could, if they wished, have used spiders or candy bars, because all living things, and the sugar in the candy bars, have many, many carbon atoms. (Next time you bite into a candy bar, remember that it is made of the same kind of atoms that make diamonds.)

How Others Had Tried To Make Diamonds

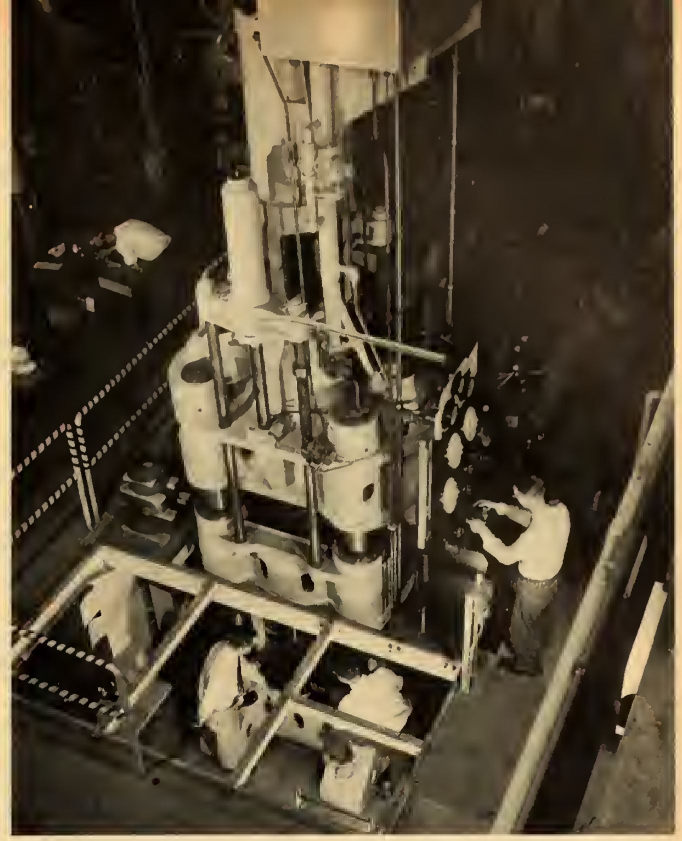
Oil is also rich in carbon. About 80 years ago a Scotsman named J. B. Hannay placed a mixture of oil and some chemicals inside an iron tube and heated the tube to a glowing red in a *forge*. (A forge is a furnace that makes a fire very hot by forcing air through it.) Heating the iron would make it expand, or spread, in all directions. Hannay thought that when the inside walls of the tube expanded, they would squeeze the carbon atoms in the oil with enough pressure to make diamonds.

He made 80 tubes; 77 exploded. In the remaining three, Hannay claimed, diamonds had been made. But others who repeated Hannay's experiment couldn't make it work, and so people now doubt that Hannay ever succeeded. The results of a scientific experiment are not accepted unless it can be repeated successfully by others.

The next famous attempt to make diamonds was made about 15 years later. Henri Moissan, a French chemist, had just invented the electric-arc furnace, which can heat things to much higher temperatures than Hannay's simple forge. In his furnace, Moissan melted iron and *graphite*. (The black stuff in your pencil is graphite, a common form of carbon.) After heating the molten iron and graphite to white heat, Moissan dropped a blob of it into cool water.

The outside of the blob cooled and turned solid before the inside did. Moissan thought that when the iron inside the blob cooled, it would expand and squeeze against the solid outside. The pressure, he expected, would be great enough to turn the carbon of the graphite into diamond.

Unfortunately, Moissan didn't know that cast iron does not expand as it gets solid. It contracts, or gets smaller, so the pressure probably never got strong enough to make diamond. However, Moissan believed he had made diamond. Others repeated Moissan's experiments and thought they had too. But years later, after Moissan had died, his widow told a friend that when Moissan was an old man one of his assistants had put tiny bits of diamond in the graphite they were working with. The assistant, it seems, wanted to please his master and also avoid the hard work of doing his job properly. Moissan's diamonds, it seems, were never *analyzed*, or studied to see what was in them; they were too small.



This huge press in Schenectady, New York, squeezes a small amount of material with pressures up to 1½ million pounds per square inch and heats them to temperatures as high as 5,000° F. It has been used to squeeze the carbon atoms in graphite or in peanut butter together to make diamonds.

Today, scientists can analyze even tiny diamonds. Using an instrument called a *spectroscope*, they can tell what kinds of atoms any mineral is made of. About 30 years ago, a spectroscope was used to examine some famous diamonds that were supposed to have been made by a man named Hans Karabacek. The diamonds were on display at the Harvard Museum when a young scientist got permission to analyze one of them. He found that the Karabacek diamonds were natural diamonds from South Africa.

The diamonds that are now being made—from graphite, not peanut butter—are quite real. They are not quite perfect enough to be used as jewelry, but they are very valuable just the same. They are used to cut and polish and grind even the hardest steel. Diamond is the hardest thing we have. Since it is the only material that will do some of the jobs it does, it is in some ways more precious than gold ■

HOW IT WORKS

Record Player

■ How does a record player get sound out of the grooves in a record? Actually, there is only one long groove on each side of the record. The groove spirals in from the edge toward the center of the disc. If you look at the record through a strong magnifying lens, you can see that the walls of the groove are wavy *(see diagram 1)*. The size, shape, and arrangement of these waves in the groove walls make the different sounds that you hear.

When you put a record on the turntable of a record player and turn the switch to "on," an electric motor makes the turntable and the record go around at just the right speed. When you set the needle on the record, the needle rides along in the groove as the record turns. The wavy walls of the groove make the needle move rapidly from side to side. The needle moves back and forth faster to make a high-pitched sound than it does to make a low-pitched sound.

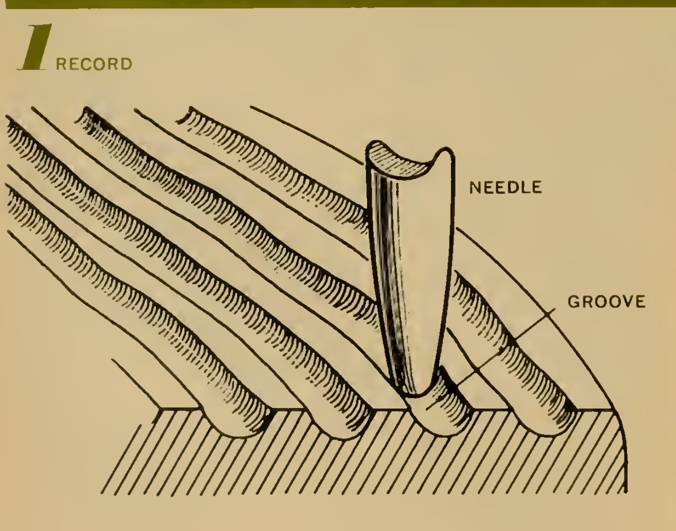
As the needle moves back and forth, the top end of it pushes against a small piece of crystal. Each time this crystal is squeezed, it sends out a tiny current of electricity. The current gets stronger or weaker as the needle pushes against the crystal or moves away from it.

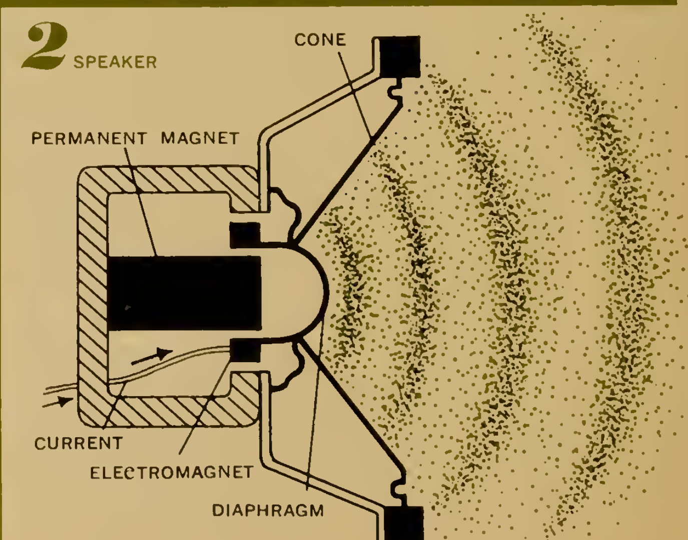
This electric current flows through wires to the *amplifier*. There the current is *amplified*, or made stronger, by passing through electronic tubes or through transistors. When it comes out, the current is still changing its strength many times a second, as it was when it came from the crystal. Next, the current goes through wires to the *speaker*, where it is turned into sound waves.

How the Speaker Works

In the speaker there is an *electromagnet*. This is a wire coiled around an iron core that becomes a magnet when electricity flows through the coil. Near the electromagnet is a permanent magnet *(see diagram 2)*. If you hold two magnets close to each other in a certain way, you can feel the magnetism pushing the two magnets away from each other. This is what happens in the speaker. Each time the current going through the coil gets stronger, the electromagnet gets a "push" away from the other magnet. This makes it vibrate, or move back and forth, as many times each second as the current changes its strength.

The electromagnet is attached to a metal *diaphragm* that is in the center of a *cone* made of stiff paper. The diaphragm and the cone vibrate along with the electromagnet. As they vibrate, they squeeze the air in the speaker and form sound waves. The sound waves make your eardrums vibrate the same number of times each second as the needle is vibrating in the record groove, and you hear sound ■





nature and science
TEACHER'S EDITION

VOL. 2 NO. 13 / APRIL 5, 1965 / SECTION 1 OF TWO SECTIONS

Some Ideas for Outdoor Teaching

by Paul M. Howard

■ Some teachers hesitate to attempt outdoor teaching. They think that a "complete" understanding of the natural environment is necessary before attempting outdoor science classes. However, one need not be an expert to help others become aware of the world in which they live.

You may already take field trips to the post office, fire station, police station, zoo, or museum. These trips away from the classroom can provide a powerful source for motivating the class, as well as letting pupils see how your man-made community "works." Why not a field trip to see the workings of the natural community too?

Schedule a field trip of your neighborhood—a walking field trip. Or, if your school has a playground that has not been covered with asphalt, have you ever thought of developing a nature trail on it? Incredible? Unique? No, not really. Some teachers have used this type of resource for years and others are now learning its multiple values.

An outdoor field trip can be much more than a lesson in natural sciences. The physical, biological, behavioral, and social sciences are all involved in the study of *ecology*—the interrelationship of organisms with each other. An outdoor study program involves the communicative arts: visual arts, tactile arts, audial arts, and mathematics. It can relate to every part of the curriculum.

NOTE: SUMMER ISSUE ENCLOSED

If you receive Nature and Science in class quantities, please note your free advance copy of Summer Issue No. 1, which is included along with your copies of this issue. The accompanying folder tells how you can order the two summer issues for delivery to your pupils at their home addresses, and describes the exciting free booklets you can acquire for your classroom library.

Three Kinds of "Nature" Trails

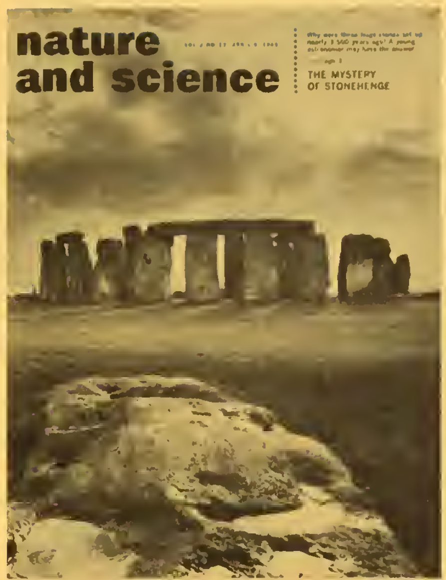
A "nature" trail can take on new dimensions through ingenuity. Three types will be mentioned here: 1) the neighborhood as a "nature" study area; 2) the school campus as a "nature" area; and 3) the developed "nature" trail at a park or nature center.

1. Recently the El Monte, California, School District inaugurated a program to acquaint its primary grade teachers with the neighborhood in which they are teaching. This program consists of taking the teachers on a "nature" tour by bus through the community. Total "nature" tour distance was about 15 miles and the tour took two hours. Maps of the route were provided each person.

The tour passed the post office, city hall, a police station, several fire stations, a river, a reservoir, a lake, several farms, groves of citrus, orchards, oil pumps, markets, a freeway, electric transmission lines, power company, bus barns, city parks, train tracks, and so on. Throughout the tour a running commentary was given on the resources of the community in the past and present, and the prospects of the future.

The trip was much more than a "nature" tour, focusing attention on many of man's problems with his environment. It presented a capsule view of the difficulties of urbanization, growing populations, water and food sources, erosion, and the problems of living in harmony with neighbors. Further, the tour introduced the natural sciences through identification of indigenous and exotic plant species, effects of climate, animal identification

(Continued on page 4T)



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● The Mystery of Stonehenge
Your pupils will be fascinated by the ways in which scientists have unraveled the secrets of this ancient monument—who built it, when, how, and perhaps why.

● Visit to a Plant Factory
This WALL CHART shows how a green plant uses energy from the Sun and raw materials from the atmosphere and soil to make food that provides energy for its own growth.

● Frogs That "Sing" in the Spring
Some of the "bells" your pupils hear may be Spring Peepers. Here's how to find and study them.

Why Does Ice Float ?
With this SCIENCE WORKSHOP, your pupils can find out for themselves.

● Diamonds Out of Peanut Butter
Yes, real diamonds can be made by squeezing peanut butter. (This is *not* a SCIENCE WORKSHOP.)

How It Works—Record Player
This article explains how a record player gets sound out of a wavy groove.

IN THE NEXT ISSUE

A Special-Topic Issue on our natural resources: Why scientists say we should kill more deer . . . How to explore the soil in your area . . . The ugly threat of water pollution . . . Sources of energy for the future . . . A WALL CHART contrasting wise and wasteful use of land.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Stonehenge

Recent discoveries strongly indicate that the ancient relic known as Stonehenge may have been a "living" calendar. In this sense, it is akin to the many stone monuments the Arabs erected, at a later date, to fix the positions of stars at certain times of the year, and to similar structures of the Mayans of Yucatan. In any case, it is an early tribute to man's intellect and dauntless industry.

Topics for Class Discussion

• *Why are calendars important to people?* Your pupils will surely come up with many reasons pertaining to modern life. Help them to think in terms of primitive man. As explained in the article, with the advent of farming, people needed a solar calendar. Earlier men, who lived by hunting, were content with a simple lunar calendar. Lunar calendars, however, are based on a cycle of 29½ days. They do not work out to a solar year. By doing the arithmetic, the class will see that a lunar calendar leaves the year short by 11 days.

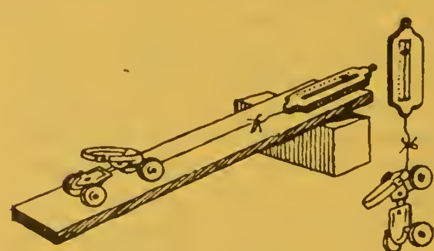
• *Was the building of Stonehenge a superhuman task?* No. As scientists test their ideas about the building of Stonehenge by simulating conditions and re-enacting the process, we see that the job required neither miraculous powers nor great genius. It did require intelligence, time, and the strength of many men working together.

• *What machines did the builders of Stonehenge use?* Your pupils may be quick to answer," None." Point out that simple machines probably were used—the lever, the inclined plane, and the wheel (rollers). Perhaps someone can see ways in which a primitive pulley may have been used.

Activities

• Using log rollers to move heavy stones is an instance of the use of the wheel to overcome friction. Demonstrate this by attaching a spring balance to a bundle of heavy books. First drag the books by the spring balance across the floor and note the reading on the balance. Then place the books on several round pencils and pull. Note that less effort is needed.

This activity may be adapted to show the advantage of using an inclined plane in getting a heavy object from one level to another. This time, attach a spring balance to a roller skate or toy car *(see diagram)*. Note the readings, first when the object is lifted vertically, and second—when it is pulled up a slanting board.



Your pupils can measure the advantage of an inclined plane by comparing the readings on a spring balance, first lifting an object straight up, then pulling it up the inclined plane.

• Some children may find out why Easter is celebrated on a different date each year. They should find that the Christian calendar is regulated partly by the Sun and partly by the Moon. Some holidays, like Christmas, are fixed days. The dates of other holidays are governed by phases of the Moon. They are called "moveable feasts." Easter, for example, is celebrated on the first Sunday after the first full moon following the Spring Equinox (March 20 this year).

PAGE 8 Plant Factory

To illustrate some of the processes that go on in a plant, you might have your pupils try these projects. First, get some "bird seed" (pet bird food) from a pet shop. Sprinkle some of it on a moist blotter. Keep the blotter moist by putting one end in a pan of water. When the seeds sprout in a couple of days, tiny root hairs will be visible on the young roots of the seeds *(see photo)*. Root hairs are responsible for the intake of most of the water and minerals in plants, even in large trees.

PHOTO BY HUGH SPENCER, FROM NATIONAL AUDUBON SOCIETY

As this radish seed sprouts, you can see the fuzzy root hairs growing from the young root. Root hairs absorb water and dissolved minerals from the soil.

To show the upward flow of water in a plant, buy a Coleus plant from a florist or dime store. Be sure that it is well-watered. Then cut off the stem about an inch or two above the soil surface. A surprising amount of water will flow from the severed xylem tissue.

You can emphasize the importance of the photosynthetic process in plants by having pupils trace back their food—beef, bread, milk, fish, and so on—to green plants that convert Sun energy into food energy.

PAGE 10 Frogs That "Sing"

Many people feel that the jingling chorus of Spring Peepers is a more reliable sign of spring than the first robin. Perhaps this is because frogs are cold-blooded and come out of their winter dormancy only when the tem-

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teachers' Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

perature of the earth or pond bottom rises enough to permit movement.

Suggestions for Classroom Use

Your pupils may wonder why Peepers are called treefrogs if they are to be found in or near water. Peepers mate in water, then spend the rest of summer and early fall in the woods.

Point out the difference between reproduction in frogs, toads, and salamanders (amphibians) and reptiles such as snakes and turtles. Amphibians must lay their eggs in moist places because the eggs have no shells to keep them from drying out. The eggs of most reptiles have shells and may be laid on dry land. Your pupils might discuss how these differences affect the geographical and ecological range of reptiles and amphibians.

Once you have a Peeper or another kind of treefrog in captivity, here are some things to observe:

- *Watch his eyes.* See how they retract to close. By closing his eyes when he swallows, the Peeper helps push his food into his stomach.
- *Look at his tongue.* Is it fastened at the front or back of his mouth? What advantage does its forward location have in catching food?
- *Feel the discs on his toes.* Are they sticky or smooth?
- *Measure the length of the Peeper's jump.* The ability to jump many times his own length is one of the ways a frog protects himself.

Reference

If your pupils find Peepers and other treefrogs fascinating, you might get the record *Voices of the Night,* which features the recorded calls of 26 different frogs and toads. (Available from Cornell University Press, Ithaca, N.Y., $6.45.)

PAGE 14 Diamonds

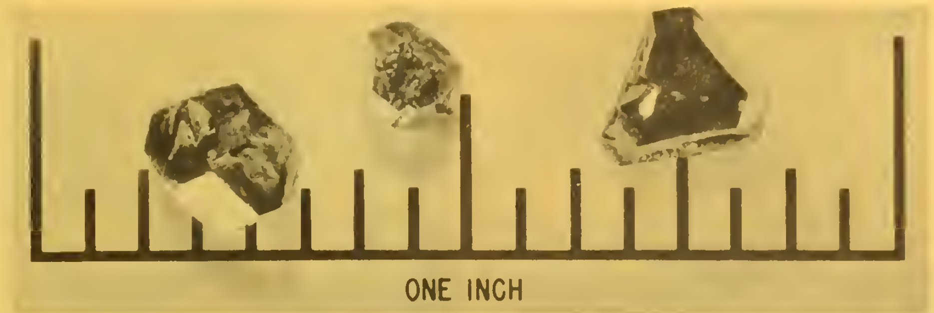


PHOTO BY GENERAL ELECTRIC RESEARCH LABORATORY

These synthetic diamonds were made from graphite by General Electric scientists. Diamonds like these are not precious gems, but have many uses in industry.

This article—the story of an old dream come true—will help your pupils understand one of the ways in which matter can be changed from one form to another.

Suggestions for Classroom Use

Ask the class to recall myths and fairy tales dealing with the transformation of common materials into precious metals and jewels. (The Golden Touch, Cinderella, Rumpelstiltskin.) Is anyone familiar with stories of medieval alchemists who attempted to turn base metals into gold? Bring out that man's preoccupation with the idea of manufactured wealth goes back many, many years. Only recently, however, has it become a scientific possibility.

The article illustrates the concept that under ordinary conditions matter can be changed but not annihilated or created. Care should be taken to distinguish the process described here from that which occurs in an atom-smasher when lead is transformed into gold. The latter is a nuclear reaction that alters the structure of the atomic nucleus and releases great amounts of energy. Synthetic diamonds, on the other hand, are made by altering the *relationship* of carbon atoms with one another.

Topics For Class Discussion

- *What effects do heat and pressure have on matter?* Have your pupils review the changes in state (solid, liquid, and gas) which ice goes through when heated. Bring out that an increase in heat causes particles of matter to move about faster and faster, until they begin to escape in the form of gas. Anything that interferes with the escape of molecules serves to raise the boiling point. Thus, by increasing pressure we can increase the boiling temperature.

Your pupils may observe this action in a pressure cooker, which cooks food at temperatures higher than 212°F. and, therefore, at a faster rate.

- *Why did attempts to make synthetic diamonds before 1955 apparently fail?* Previous experimenters while on the right track, were not able to achieve strong enough pressures. The breakthrough came just before World War II when Dr. Percy Bridgman, an American physicist, found ways of creating pressures up to 30,000 "atmospheres." After the war, scientists at the General Electric laboratories took up work on synthetic diamonds, achieving pressures of up to 130,000 atmospheres.
- *What is the difference between a synthetic diamond and an imitation one?* A synthetic gem is one which has the same chemical composition and atomic structure as a natural gem. An imitation, such as "paste" or rhinestones, is a substance (usually glass) which bears a superficial resemblance. "Paste," which refers to the mixture before it is fused, is a special kind of glass that contains lead to give brilliance. Rhinestones are glass gems that get their brilliance from a foil coating on the underside. Both types are easily scratched and chipped. Which might succeed best in fooling someone?
- *How are diamonds used industrially?* Since diamond is the hardest of all minerals, it is used to drill into or grind down other hard materials. Sometimes whole diamonds are mounted into tools, such as on the tips of drills. Sometimes diamond dust, made from crushed diamond, is baked into the surface of a grinding tool.

Activities

- To give your pupils some idea of the practical value of diamonds, have them examine some used phonograph needles under a magnifying glass. Obtain three kinds of needles—steel, sapphire, and diamond—for comparison. Have someone investigate the price of the different kinds and how many "plays" they are good for. Which is the most economical material in the long run?
- The class might investigate some changes brought about in the Earth by the action of heat and pressure, such as the formation of various kinds of rock and coal.

Outdoor Teaching . . .
(Continued from page 1T)

and adaptation, and so on. Testimony to the success of this program is given through its perpetuation and presentation now to students.

This tour can be adapted to whole cities, or just to a neighborhood. Travelling by bus provides a greater range of experiences than walking, and eases discipline problems. However, a walking tour of the neighborhood can also be rewarding. About 20 pupils is the maximum that can be easily handled at one time this way.

2. School facilities often make a fine nature area. The presence of plants and animals in the proposed nature area is important. If they are absent, however, planning and planting a nature area and making and maintaining bird feeders can be an all-school project. Large areas are good, but miniature habitats can be surprisingly rewarding. Observation of a patch of dust or a fence row can be as rewarding as the study of an acre of woodland. On each the forces of climate act, animals leave tracks, life exists.

Two new school sites in El Monte are developing outdoor nature areas and nature trails planned by the author. Both sites have been leveled during school construction. The sites had to be landscaped, so the plantings were grouped according to the continent from which they were originally introduced. One area is the Orient, another is South America, and so on. The school administrators have received assistance from the neighborhood, local garden clubs, and parents in the development of this project.

3. The "nature" trail at a public park or nature center is a valuable resource for any community. The National Audubon Society now operates six nature centers where over 100,000 school children are given nature and conservation education each year. There are already some 200 nature centers in the United States and Canada. Trained guides are available to lead classes on scheduled tours at these centers. Whether the teacher leads the tour himself or depends on a "professional" guide, it is always best to be as thoroughly informed about the trip beforehand as possible. Class preparation is vital. A trip to a nature center should have three phases—preparation, the nature trail tour, and the follow-up.

PHOTO BY AUDUBON CENTER OF SOUTHERN CALIFORNIA

"Some of the things we see every day of our lives... might be fascinating to a child."

Leading a Nature Walk

Those of us at the Audubon Center of Southern California have condensed the definition of "nature" trail teaching into one word—awareness. Seize on every opportunity: the flight pattern of a bird, the rustle of the wind through the leaves, the color and density of foliage, the cry of an animal, footprints left in dust along the trail. The instructor has to be an opportunist. This technique has prompted blind pupils to say, "Thank you for helping me to see all these wonderful things."

It is not necessary to be a trained ecologist, or to know genus and species names of organisms, to be an excellent outdoor teacher, but it does take loads of enthusiasm. Some of the things we see every day of our lives have so calloused our awareness that we think them uninteresting. Yet, these things might be fascinating to a child. The important follow-up to a field trip can include essays on conservation of natural resources, posters, research committees to answer questions that arise on the trip, spelling and vocabulary enrichment, and many others.

Check Your Qualifications

Don't underestimate your knowledge of nature. You might check your powers of observation by jotting down all the different birds, insects, mammals, trees, clouds, and so on that you see in one day or week. What observations can you make about them?

You have probably found that you have compiled more than enough interesting material to "spontaneously" lead a field trip of your own neighborhood. Besides, you have become more aware of your own environment. Now transfer that awareness to your pupils, and remember that no one can answer all of the questions that will be asked about the outdoors ■

Paul M. Howard is Director of the Audubon Center of Southern California, El Monte.

OUTDOORS IN A CITY

If your school is in a city (or even if it isn't) you will find many useful outdoor teaching tips in *Operation New York*, a 117-page booklet prepared by the Board of Education of New York City. It tells how to discover and use the natural environment of a city in teaching. To order, send a $1 check or money order to Auditor, Board of Education, Office of Publication, Room 136, Livingston Street, Brooklyn 1, N.Y.

nature and science

VOL. 2 NO. 14 / APRIL 19, 1965

SPECIAL-TOPIC ISSUE

YOU AND THE LAND

Are there too many deer?
How to explore the soil
The fight for clean water
Energy of the future

nature and science

VOL. 2 NO. 14 / APRIL 19, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

ABOUT THIS ISSUE

This special-topic issue is all about "You and the Land." By "land," we mean all of the natural resources on, over, and in the Earth. Three important parts of the land—soil, water, and wildlife—are shown in the photos on the cover.

The future of humans on the Earth depends on how they care for the land. Up till now, people have not done very well. Look at the two valleys shown on the WALL CHART (pages 8 and 9). On one side, the land has been used carefully; on the other, it has been used carelessly. How does the land where you live compare with these two views?

The articles in this issue tell how people have used, and are using, some of the resources of the land—deer, soil, water, energy—and what problems must be solved if humans are to survive on the Earth.

The boys in the photo above are planting small limbs of willow trees along a stream bank. The willows will take root and will keep the soil from washing away. This and other projects you can do are described on page 13.

This special issue was prepared with the advice of Matthew J. Brennan, Director of Field Studies for the Pinchot Institute for Conservation Studies, Milford, Pa. Editor of the issue was Laurence P. Pringle.

CONTENTS

CREDITS: Cover, top photo by Grant Heilman, center from Michigan Department of Conservation, bottom by Grant M. Haist, from National Audubon Society; p. 2, photo from Boy Scouts of America; p. 3, photo by Craig Scott, *Erie* (Pa.) *Times;* p. 4, left photo from Michigan Dept. of Conservation, others by Dave Mech; p. 5, forest scene from Wisconsin Conservation Dept., doe and fawns by Leonard L. Rue, III; p. 6, photo by Grant Heilman; pp. 7, 10, 12, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 8, 9, drawing by Robert Gartland; p. 10, photo by George Cope, Educational Services Incorporated; p. 11, photo from U.S. Dept. of Health, Education and Welfare; pp. 12, 15, foam and satellite photos from Wide World Photos; p. 12, eagle photo from AMNH; p. 13, photo from Soil Conservation Service; pp. 14, 15, power plant drawing by R. G. Bryant.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

TOO MANY DEER

by Dave Mech

These beautiful animals destroy crops and starve to death when they are too plentiful. Scientists have studied how deer live to find an answer to this problem.

■ A starving deer isn't a pretty sight. I remember one that fled from a group of us one winter afternoon. It ran a few yards, then collapsed in a heap. One of my companions lifted the feeble animal to his shoulders and carried it out of the woods. In a university laboratory, we made some tests and found out that the deer was starving. It died in the laboratory.

In some states deer starvation is common. In 1952, for example, 4,500 deer starved in five counties of Pennsylvania. The state of Washington lost 40,000 deer in 1956, and 69,000 deer died of hunger in Michigan in 1959. The reason for this is simply that there are too many deer.

It is hard for most people to believe that there are too many deer. People like to watch these graceful, beautiful animals, and deer are by far the most popular big game animal in the United States. All but a few of the states allow deer shooting, and for the 4,000,000 people who hunt deer, there can never be too many.

Death in the Winter

But there *are* too many deer for the deer's food supply. Deer feed on leaves, grasses, and small plants in summer, and on the twigs and buds of trees and shrubs in winter. Each animal eats about six pounds of this food each day.

In summer, deer have no problem finding food. It is late winter when food becomes scarce. At this time, deer gather on hillsides, in swamps, or in other areas where they are protected from the weather. They stay in these areas until spring. If there is not enough food, some deer starve.

Some people haul food such as hay, apples, bread, corn, and donuts into the woods to save the deer. But this is difficult and costly, *and it makes the problem worse.* It saves some deer from starving. However, this means that more deer will have young in the spring and there will be even more starving deer the next winter.

Scientists who study deer and other game animals are called *game biologists.* They keep a close watch on the deer and their food supplies. They visit the wintering areas of deer to find out how much food is left each year. If they find dead deer, they examine them to find out how they died. (Animals that starve have no fat inside their leg bones, so the biologists check these.)

Biologists also learn about a deer herd's food supply from the deer themselves. Hunters bring dead deer to

(Continued on the next page)



Scientists can tell the age of a deer by seeing how much its teeth are worn. When scientists find a dead deer, they look inside its leg bones to find out if it starved. Healthy deer have white fat inside their leg bones (above, left), while deer near starvation have dark, jelly-like centers in their leg bones (above, right).

checking stations that are set up along roads during the hunting season. At these stations the biologists weigh each deer. They measure its antlers if it is a *buck,* or male deer. By seeing how much the deer's teeth are worn down, they can tell its age. From this information, the scientists have discovered how a lack of food affects deer.

Biologists in Michigan have found that one-and-a-half year old (*yearling*) bucks from areas where the food supply is low weigh about 30 pounds less than those from areas where there is plenty of food. Less than a third of the yearling bucks from areas where food is short have large, branching antlers. In areas where food is plentiful, almost all yearling bucks have branching antlers.

While working at checking stations, I have seen hunters bring in two-and-a-half year old bucks with hardly more than little knobs for antlers. These deer came from an area where there was a very poor food supply. Knowing this, sometimes the biologist at the station would amaze a hunter by telling him where his deer came from.

The food a deer eats also affects the number of young it has. Deer breed in autumn, and the young deer, called *fawns,* are born in early summer. So the unborn young develop within the females, or *does* (rhymes with *nose*) during the winter. If there is little food available for the does, the unborn fawns do not get enough nourishment. Many fawns then die before birth or shortly after. In areas where food is plentiful, however, biologists have found that many does have twin fawns.

When North America was first settled by people from Europe, the number of deer was probably kept in check by large meat-eating animals, like wolves and Mountain Lions. The deer may never have become so plentiful in an area that they died for lack of food. Then, as people spread across North America, they killed many of the wolves, Mountain Lions, and other animals that eat deer. How did this affect the number of deer?

A good example of what happened is the story of the Kaibab Plateau of Arizona (north of the Grand Canyon). Sixty years ago there was a healthy herd of some4,000 deer on the Plateau, and plenty of food. Large meat-eating animals, called *predators,* were common.

Then, in 1906, deer hunting was stopped and a war was waged on wolves, coyotes, and other predators. By 1931, thousands of predators had been killed. Where once there had been about 4,000 deer, there soon were 100,000! Then the deer began to starve by the tens of thousands. The shrubs and grasses upon which the deer fed were almost completely ruined. Even though hunting seasons were opened and most of the killing of predators was stopped,

PROJECT

Look in books about mammals to find out what kind or kinds of deer live in your area. Is deer hunting allowed in your state? Can hunters take does and fawns, or just bucks? To find out, get a copy of the game laws from your town clerk or the local office of the state conservation or fish and game department.

thousands of deer starved to death each winter for many years. Today there are about 13,000 deer living on the Kaibab Plateau. Their numbers are kept in check by hunters and predators, and the plants have a chance to grow again.

In most areas today, man is the only animal that can keep deer numbers down. There aren't enough predators to do the job. Game biologists think that hunters should take a large part of the deer herd each fall. This would save enough food for the deer that are left. Then the deer should have a healthy crop of young the next spring.

Game biologists tested this idea in New York. They examined some dead does from an area that was not hunted very heavily, and counted the unborn young. Then they allowed a special season in which a large number of deer were killed. When they examined does after this season, they found that there were 20 per cent more fawns than before. This meant that many deer could be killed each fall without danger of wiping out the animals entirely.

People Are the Problem

Despite the findings of biologists, several states still keep hunters from shooting does and fawns. (By the time of the hunting season, fawns are six months old and nearly as big as adult deer.) Killing only bucks was a good idea years ago when there were very few deer in many areas. Then it was important to save the does to produce young and build up the deer herds.

Today, most areas have all the deer they can handle. The deer sometimes do great damage by eating crops and chewing on twigs in orchards and forests. In these areas, the problem is to harvest more deer. To do this, does and fawns must be hunted too. When hunters can take only bucks, no more than 12 out of 100 deer are killed. About twice as many should be shot each year.

The biggest problem for the scientists who study deer is the "people problem." The people who set the state hunting laws sometimes do not believe that there are too many deer, or do not know what to do about it. To solve this problem, biologists hold meetings where they discuss their ideas with hunters and other interested people. Sometimes the biologists take these people into areas where deer are starving so they can see the problems for themselves.

In most states where deer are plentiful, the laws have been changed to allow more deer to be killed. Until other states do this, however, deer will continue to damage crops, and thousands will starve when food is scarce ■

■ Two books that have information on the kinds of deer in North America are: **Mammals**, a Golden Nature Guide, by Herbert Zim and Donald Hoffmeister, Golden Press, N.Y., 1955, $1; **The Mammal Guide**, by Ralph Palmer, Doubleday & Co., Inc., N.Y., 1954, $4.95. **The World of the White-tailed Deer**, by Leonard L. Rue, III, J. B. Lippincott Co., Philadelphia, 1962, $4.95, has more information on how deer live and includes many fine photographs.

Each deer eats about six pounds of leaves, twigs, and buds a day. In this forest (below), deer have eaten all of the twigs and leaves that they can reach. When deer have plentiful food, many females have twin fawns (right). When food is scarce, the females usually have one fawn or none.

SCIENCE WORKSHOP

EXPLORING THE SOIL

You may call it "dirt," but your life depends on it. With simple equipment, you can investigate the soil in your neighborhood.

■ The next time you are in a field or forest, pick up a handful of soil. Look at it. Let it trickle through your fingers.

Many people call soil "dirt." But if you look closely at some soil, you'll see much more than "dirt." There are bits of rock, plant roots, decayed leaves, tiny animals. All of these things together make up what we call soil. The soil in your hand is full of "life"—not just tiny animals—but the minerals and water that plants need for life. Without soil, few plants and animals, including humans, could survive.

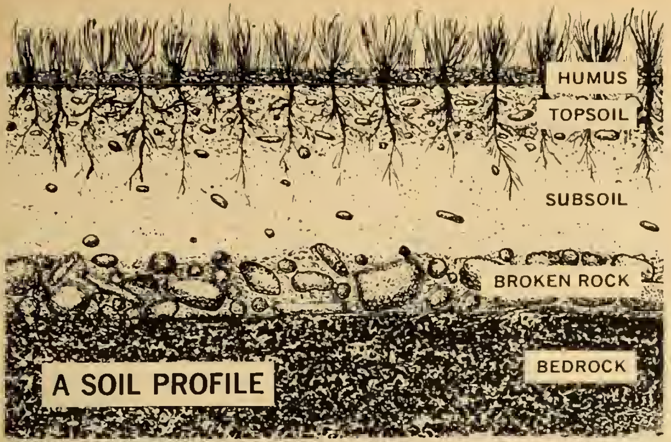
When the Earth first formed millions of years ago, there were no soils. The Earth's surface was rocky and bare. Over the years, however, rocks were split apart and broken down into smaller and smaller parts—by freezing and thawing, by glaciers, by the beating rain, and by plants. The first land plants lived on rocks. They gave off acids that ate into the rock surfaces, loosening and breaking off tiny particles. When a plant died, its decayed parts mixed with the rock particles. In this way, soil was formed.

Today there are thousands of different kinds of soil covering the Earth. The sand you see on beaches is one kind. However, there are many different kinds of sand, and sand is also a part of other kinds of soil.

Layers of Soil

The depth of soil varies too—from a few inches to many feet. You may be able to find the depth of the soil in your area. Look for a *profile,* or cross-section of the soil along roadsides, stream banks, or holes dug for new houses. These profiles show that soil is divided into layers *(see diagram).* The top layer, called *topsoil,* is usually only a few inches deep. It is usually dark colored because it is rich in *humus*—the remains of decayed plants and animals.

Below the topsoil is a lighter layer called *subsoil.* It may be several feet deep. Subsoil is not as fertile as topsoil because it contains less humus. Nevertheless, it is important to plants. The long roots of plants take water and minerals from it. Below the subsoil is a layer of broken rock, and below that is solid rock, or *bedrock.* Can you find a soil



profile that shows the bedrock in your area? How far below the surface is it?

Case of the Vanishing Topsoil

Next time you are in a woods, carefully remove the leaves from one spot on the forest floor. Peel them off layer by layer. Notice how much each layer is decayed. Can you find where the leaves end and the soil begins? You may not be able to find the exact border between the leaves and the soil. The leaves gradually decay until they are the dark humus of topsoil. This is a slow process. Scientists estimate that it takes between 300 and 1,000 years to form an inch of topsoil.

PROJECT

Measure the depth of the topsoil in several places near your home or school. (Do this by looking for soil profiles, or by digging holes with a trowel or shovel.) Where do you find the deepest topsoil? In woods? In fields? Is the topsoil deeper on the side of a hill or on flat land? Why? What is the average depth of topsoil in your area?

About 200 years ago there was an average of nine inches of topsoil in the United States. Today the average is only six inches. Those vital three inches have been worn away, or *eroded,* by wind and water. Wherever water flows, soil is carried with it. Tons of topsoil have been carried to the bottom of lakes and oceans and are now useless for raising crops.

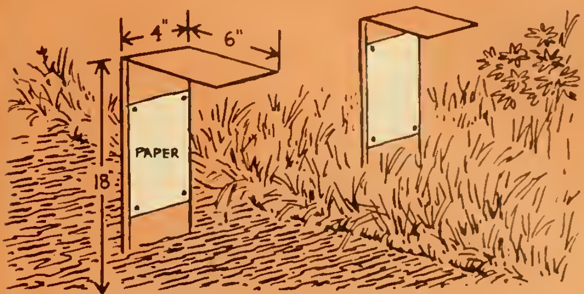
Look for signs of erosion in your neighborhood—on school grounds, in parks, fields, even your own backyard. After a rainstorm, you may see brown-colored water in a stream, or soil washed onto a sidewalk from a field or lawn. What could you do to stop the soil from being washed away? The investigations may give you some ideas.

—Laurence Pringle

INVESTIGATIONS

HOW SOIL SPLASHES

Have you ever seen soil splashed on the side of a house after a rainstorm? To see how raindrops splash soil, make several splashboards out of scrap lumber (see *diagram*). The boards should be at least 18



inches long and four inches wide. Make one end of the board pointed so it can be easily driven into the soil. Tack a sheet of paper onto the board, and nail a piece of tin or another piece of wood (about four by six inches) to the top of the board to protect the paper from falling raindrops.

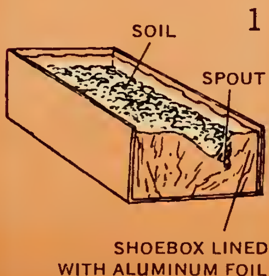
When a weather forecast predicts rain, drive the splashboards into the soil in several different places—on a lawn, under a tree, on bare garden soil, on a ball diamond, and so on. After the rain, look at the paper on the boards. Measure the height that the raindrops splashed soil onto the paper. Where was the soil splashed the highest? Do some of the splashboards have no soil splashed on them? Does this give you ideas for protecting the soil from splash erosion?

SOIL ON A SLOPE

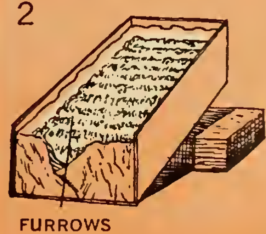
Cut an end out of each of two shoeboxes. Line the boxes with aluminum foil so there is a spout at the open end (see *diagram 1*). Then fill the boxes about half-full of soil, using the same kind and amount for each box. Put a rock or stick under the closed end of one box so that it is raised about one inch. Raise the end of the second box about two inches. Then put a jar or plastic container under the spout at the open end of each box. Sprinkle water from a laundry sprinkler onto the soil in the boxes. Be sure that you use the same amount of water for each. Which box loses the most water? The most soil? How can you tell?

How could you stop soil and water from running down the slope in the boxes? What would happen if you put some leaves on top of the soil, or if you made furrows running across the slope? *(See diagram 2.)* Try it and see.

1



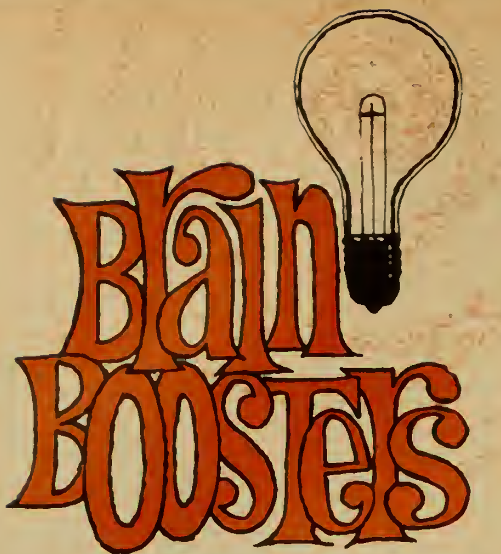
2



THE LAND WHERE

WE LIVE

At first glance, the two valleys shown on these pages may seem alike. But only their shape is the same. Read the captions in both valleys. See how people have used the soil, water, forests, and other natural resources. In which valley would you like to live? In which valley *do* you live?



prepared by **DAVID WEBSTER**

MYSTERY PHOTO

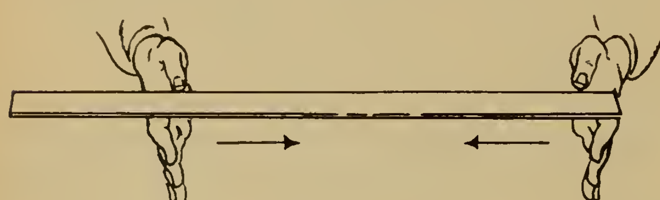
This block was made from just two pieces. Notice the reflection of the back sides of the block in the mirror. All four sides of the block look the same. Can you see the problem of putting two pieces of wood together to make a block like this? How was it done?

Can You Do It?

Can you get a tin can exactly *half* full of water without using a ruler or scale?

What Do You Think Would Happen?

Place a yardstick on your hands as shown in the sketch. Then slowly move your hands together until they touch. What will happen to the yardstick?



For Science Experts Only

When the famous Karl Gauss was 7 years old, his teacher gave him the following problem: What is the sum of all the numbers from 1 to 100? To the teacher's surprise, he had the answer in a few seconds. What was the answer and how did Karl figure it so quickly?

submitted by Kirk Dale, Waverly, Pennsylvania

Fun with Numbers and Shapes

Fingerprints are identified according to their shape. There are three main types as illustrated below. What type of print have you on each finger of your right hand? Are they all the same type? Look at your left hand. Are the fingerprints of both hands the same? Have you "finger" prints on your toes, too?

Have You Heard This One?

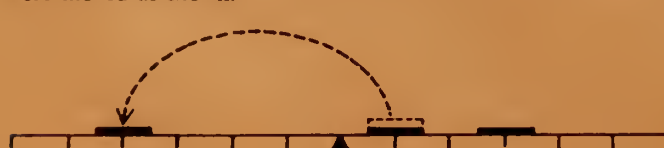
What gets wet as it dries?

Answers to Brain-Boosters in the last issue

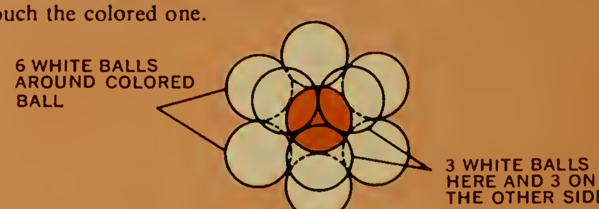
Mystery Photo: The photograph is of a small section of an armadillo's shell.

What Do You Think Would Happen? If the board is not slanted too much, the jar of Karo will roll down quite slowly. What would happen with water or molasses? How would a full jar of Karo roll?

For Science Experts Only: The stick would balance if the penny were moved as shown.



Fun with Numbers and Shapes: 12 white balls could be made to touch the colored one.



Can You Do It? To make an egg float in the middle of a glass of salt water, put three tablespoons of salt in a fairly tall and clear glass. Pour in half a glass of water and stir. Put the egg in, then add more water slowly to fill the glass. The egg should float in the middle of the salt water.

WATER WATER EVERYWHERE BUT...

by Laurence Pringle

The world needs more and more fresh, clean water, but we are spoiling lakes and rivers with a great outpouring of wastes.

■ The 22,000 people who live in Gloversville, New York, were in trouble last summer. After three years of little rain, the water level in the city's reservoirs had sunk dangerously low. People were warned to use as little water as possible. Some of the city's factories had to shut down one day a week to save water.

Yet, if you visit Gloversville, you will see a good size stream flowing right through town. It carries four million gallons of water through the city each day—enough to fill two-thirds of its needs. Why doesn't the city use this handy water supply?

To answer that question, just step to the creek's edge. You will see and smell the cast-off wastes, or *sewage,* of the city—everything that goes down the drains of toilets, sinks, and bathtubs. You will also see and smell the wastes —grease, flesh, hair, dyes, chemicals—from factories that make leather from the skins of animals.

Gloversville is one of about 3,000 communities in the United States that dump part of their sewage into nearby streams. There are about 2,000 other towns and cities that dump *all* of their sewage into waterways. Many factories, canneries, and mines also pour their wastes into streams. To this, add tons of soil that wash off the land, and the result is filthy, *polluted* water. In some areas, the water is so polluted that it cannot be used for watering crops—it kills the plants.

Polluted water also kills fish and other animals that live in lakes and streams *(see photo).* The wastes in the water gradually decay, and this process uses up the oxygen that animals need for life. The first fish to die are usually the kinds that are valuable for food and sport, like trout and bass. Fifteen million fish were killed by water pollution in 1961, according to the United States Public Health Service.

You risk your life if you drink or swim in filthy water, or if you eat fish or other animals from it. Doctors have discovered that a serious liver disease (called *hepatitis*) is sometimes caused by eating oysters and clams that grow in polluted water.

Cleaning Dirty Water

When the United States was first settled, wastes from men and farm animals were often thrown into ditches or left on the ground. (Your nose told you when you were coming near a town.) As towns grew into cities, underground pipelines called *sewers* were used to dispose of wastes. The sewers usually led to the nearest river, and the sewage was carried away downstream.

A running stream can clean itself if its load of wastes is not too great. First, the sewage is *diluted,* or thinned out, as it mixes with the stream's water. Bacteria (which are microscopic plants) make some of the wastes *decay,* or break down, into harmless chemicals. The heavier wastes settle on the bottom and are eaten by worms, some kinds of fish, and other water animals.

In this way, a small stream can "digest" a small amount of sewage after flowing for a mile or two; a mighty river can clean itself of the same wastes in a few yards. Unfortunately, there is so much sewage today that few streams —large or small—have a chance to become clean as they flow from one town to the next.

Since about 1900, some cities have tried to clean their used water. The water is first passed through screens which trap some of the wastes. Then the water is allowed to stand

(Continued on the next page)

Some kinds of detergents cannot be broken down. They keep making suds in streams, lakes, and in sewage treatment plants (left). They will soon be replaced by detergents that can be broken down by bacteria. When insect poisons get into water, they may affect animals like fish and Bald Eagles (right), which feed on the fish.

Water, Water, Everywhere, But . . . (continued)

so that some wastes float to the top while other wastes settle to the bottom. The water between these layers is then drained off. Finally, a chemical called *chlorine* is added to the water to kill harmful bacteria, and the water flows into a nearby waterway. About 35 percent of the wastes are removed by this method.

Some cities give their sewage a second treatment that takes up to 90 per cent of the wastes from the water. Cities are becoming so large, however, that even cleaning out 90 per cent of the wastes is not enough. The part of Chicago's sewage that is not removed from the city's used water equals the wastes of one million persons. This sewage is dumped into the Illinois River.

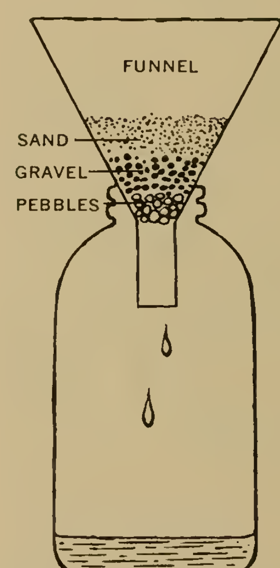
A Chain of Death

Pollution from sewage is an old problem that is getting worse. A newer problem is water polluted by insect poisons. About 55,000 different kinds of insect poisons are now used on farms, orchards, lawns, and forests. Some of them are harmless after a few days. Others, such as DDT, do not break down quickly. When it rains, these poisons may be washed into streams and lakes.

In the water, the poisons are taken into the tissues of plants and are then passed along a *food chain*. This means that the plants may be eaten by small fish, which are eaten by bigger fish, which may be eaten by fish-eating birds or mammals. The food chain can become a chain of death.

For example, scientists have noticed a drop in the number of Bald Eagles in the eastern half of North America. In recent years, few of the eggs of these birds have hatched. Scientists have found DDT inside the eggs and bodies of the eagles. Bald Eagles often eat dead fish that wash onto shore. It seems that insect poisons have traveled through food chains until they now threaten to wipe out the Bald Eagle in parts of the United States.

PROJECT



Find out how clear you can make muddy water by passing it through a filter. To make the filter, put a layer of small pebbles, a layer of gravel, and a layer of sand in a funnel (see *diagram*). Set the funnel in a jar and pour muddy water into it. How clear is the water that drips into the jar? Would the water be clearer if you put a layer of cotton below the pebbles? Try it and see.

Do you think that the water in the jar is clean enough to drink? Is clear-looking water always safe to drink?

One Battle in a Long War

Have you ever seen bubbles of foam come from a faucet? A few years ago, people in some areas began noticing fluffy white foam in their drinking water and on rivers and lakes *(see photo)*. This foam is the *detergent* that you use to wash dishes. Unlike soaps, detergents are not made from animal fats. Scientists studied the chemicals that make up detergents. They discovered that bacteria in streams and in water cleaning plants could not break down detergents as they could soaps. The detergents just kept making suds.

PROJECT

Get the facts about the water in your town or city. Where does the water come from? Is it polluted before it reaches your town? How much of the wastes are removed from the used water? Where does the used water go? Your local health department or water department can answer these questions.

Fortunately, chemists discovered how to make a detergent that can be broken down by bacteria. Before the end of 1965, all detergents on sale will be this kind.

This is just one battle won in a long and costly war for plentiful, clean water. The Earth's population is growing faster than ever before and the need for water grows with each baby born. You use about 150 gallons a day—not just for drinking and for washing yourself, but for washing your clothes, preparing food, flushing toilets, and so on. Industries need more and more water too. About 375 gallons of water are used in making a pound of flour, about 70,000 gallons for a ton of steel, about 100,000 gallons for one automobile.

Scientists all over the world are seeking ways of satisfying the world's thirst. Some of the fresh water of the future will be ocean water, with its salt removed *(see the project on page 16).* However, the handiest supply of water is all around us—in polluted streams and lakes. Before this water can be used, cities and industries must stop polluting waterways, and billions of dollars must be spent to build sewage treatment plants. Scientists must also find better ways to clean dirty water if humans are to win this battle against their own filth ■

Look in your library or bookstore for these books on water: **Water: Riches or Ruin,** by Helen Bauer, Doubleday & Co., Inc., 1959, $3; **Water for America: The Story of Water Conservation,** by E. H. Graham and W. R. Van Dersal, Henry S. Walck, Inc., 1956, $3.75; **The First Book of Water,** by F. C. Smith, Franklin Watts, Inc., 1959, $2.65.

WHAT CAN I DO?

■ Soil is being washed away. Water is becoming more and more polluted. Forests are cut and not replanted. "What can I do?" is a question often asked by people who want to save soil, forests, water, wildlife, and other natural resources.

The first step in *doing* something about these problems is *learning* about them. Find out what is being done to help save natural resources in your area. Read stories about natural resources in newspapers and magazines. Subscribe to the magazine published by your state conservation or fish and game department (located in the state capital). There may be groups in your town or city (such as Boy Scouts, Girl Scouts, or a school science club) that are already helping to save natural resources.

This list of projects may give you some ideas of how you can help.

- Clean tin cans, bottles, and other junk from the edges of streams and ponds in your area. Plant young willows or other plants along the edge of streams to help keep soil from being worn away.
- Plant grasses, shrubs, and young trees on land where soil is being washed away *(see photo).* Plants for this purpose are often available free or at low cost from state conservation departments.
- Build and put up bird houses and bird feeders. Send for the pamphlet, *Homes for Birds,* Conservation Bulletin No. 14, 10 cents, available from the Superintendent of Documents, Washington, D.C. 20402.
- Make piles of brush to give shelter for rabbits and other wildlife. Also plant shrubs that give wildlife food and shelter ■

For more information about these and other projects, see: **Field Book of Nature Activities and Conservation,** by William Hillcourt, G. P. Putnam's Sons, New York, 1961, $4.95; **Soil and Water Conservation and Wildlife Management,** Merit Badge booklets published by the Boy Scouts of America, New Brunswick, N.J., 35 cents each.

ARE WE RUNNING OUT OF ENERGY?

Coal and oil may someday be very rare. Before that happens, scientists must learn how to get more energy from the atom and the Sun.

by David Whieldon

The students laughed as they looked at the museum display case. Their teacher chuckled, too. Inside the case were models and photographs of ancient automobiles. "Long ago," said the teacher, "back in the 20th century, automobiles were moved by engines that burned a liquid called gasoline. Gasoline was made from *petroleum,* a kind of oil that was pumped out of the ground. The Earth once held trillions of gallons of petroleum, but now there are only traces of it left."

■ Today, the story above seems like science fiction, but that is just the way things may be in a few more centuries. Petroleum, natural gas, and coal will be mostly used up. What will life be like then? Where will the people of the future get the energy they need to run machines, light and heat their buildings, and carry themselves and their goods from place to place?

Where Do We Get Our Energy?

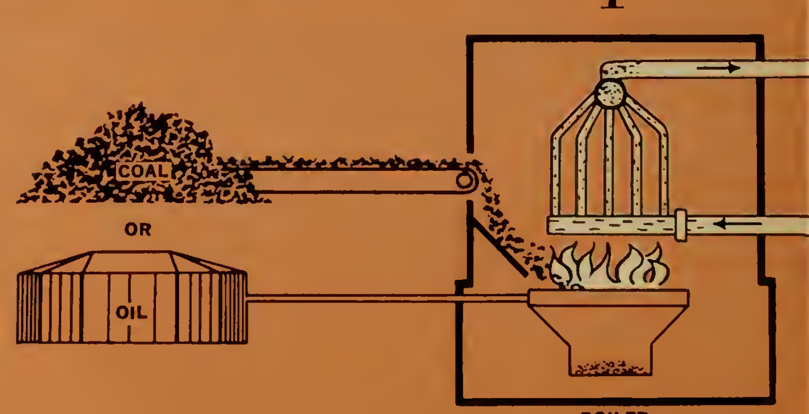
No one knows exactly what energy is, but we do know what it does. Energy does *work*—that is, it moves things and it changes things. It takes energy to move a train, or your eyelid. It takes energy to change chemicals into plants or into plastic. In fact, it takes energy to do just about anything. Where does energy come from?

Most of the energy used on Earth comes from the Sun. *Solar energy* in the form of sunlight is soaked up by the leaves of plants. There, solar energy is changed into *chemical energy* which is stored in stems, leaves, seeds, fruits, and vegetables. You get the energy you need to work and play by eating parts of plants or parts of animals that feed on plants.

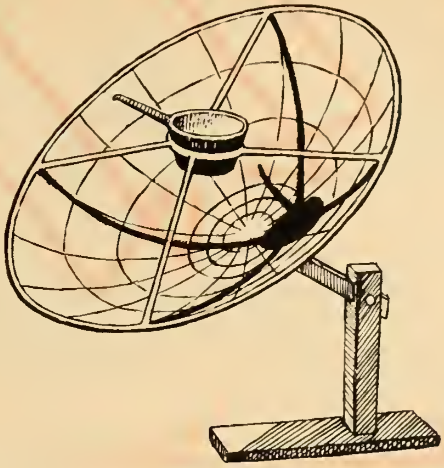
It takes tremendous amounts of energy to run all of the

Electrical energy can be made at one place and carried to homes and factories through wires. Most power plants make electricity by burning coal or oil to heat water and make steam *(diagram 1)*. The steam turns a turbine wheel which turns a generator that makes electricity *(diagram 2)*. In atomic power plants, heat from splitting uranium atoms is carried off by water to a heat exchanger *(diagram 3)*. This water heats other water to make steam for the turbine wheel. A hydroelectric power plant (not shown) uses falling water from a dam to turn the turbine wheel and generator.

1



This solar cooker (left) has a curved mirror that brings rays of sunlight together at one point. Heat energy from the sunlight will boil water in a pan at that point. The Explorer satellite (right) has small solar cells on its "paddlewheels." When sunlight strikes these cells, they make electricity for the satellite.



machines in the world today, to light and heat our homes, and to make all the things we use. A few hundred years ago, when people began using steam engines to do work, they got energy from trees. When wood is burned, the chemical energy stored in it changes into heat energy, and heat changes water into steam. If we had not found other sources of energy, we might have burned up most of our trees long ago.

Fortunately, there were vast amounts of chemical energy stored in the ground—in coal, petroleum, and natural gas. These are called *fossil fuels* because they were formed over millions of years from the remains of plants and tiny sea animals that lived even before the dinosaurs roamed the Earth. The United States now gets more than half of its energy from petroleum and natural gas, and about one-third of its energy from coal. But once these fuels are burned, they cannot be replaced.

Scientists are not able to tell exactly how long the world's fossil fuels will last. Sometimes new sources of petroleum are discovered. Some countries don't know, or won't say, how much oil or coal they have. Also, new and better ways may be found to bring up every last bit of fossil fuel or to get energy from it.

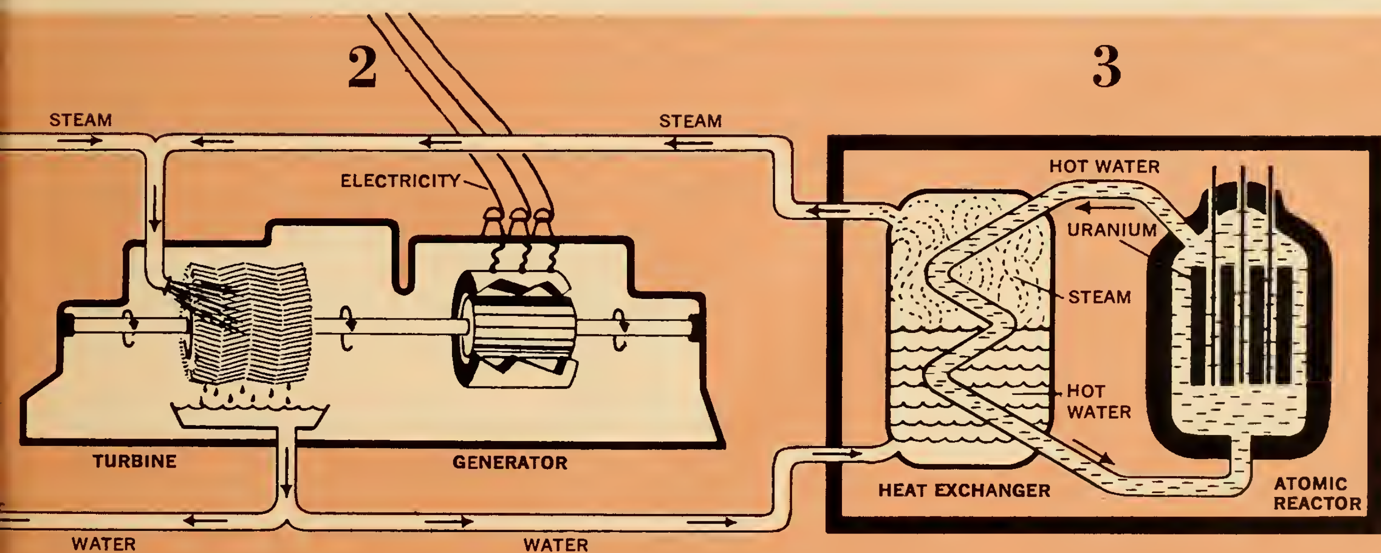
Even so, the Earth's supply of fossil fuels will probably be used up within a few centuries. What will the many billions of people who will be on the Earth then use for fuel?

Using the Sun's Energy

If we could use all of the sunlight that reaches the Earth, it would supply as much energy in a few days' time as is stored in all the fossil fuels. But the problem that scientists face is how to get large amounts of energy from sunlight by a way that is not too expensive.

One important way to use solar energy is to make electricity from it. Space satellites already do this. The outsides of these satellites are covered with many thin *solar cells (see photo)*. When sunlight strikes a chemical coating on a

(Continued on the next page)



solar cell, the cell produces electricity, which goes to radios or is stored in batteries.

Have you ever used a magnifying lens to focus the Sun's rays and set paper afire? Most solar cookers and furnaces focus the Sun's rays, too, but by reflecting them from curved mirrors *(see page 15)*. Small cookers, about the size and shape of a large umbrella, can boil water in a few minutes. Solar furnaces with large mirrors can raise temperatures to 6000° F to melt metals.

Perhaps you have noticed how the Sun's rays warm up a room or an automobile, even on cold days. The rays pass through glass but are trapped inside. Experimental solar houses have large glass windows facing south to collect solar rays. Then the Sun-warmed air is pumped through the houses. The heat can be stored in water or in chemicals and then used to warm the air after dark or on cloudy days.

Energy from Atoms

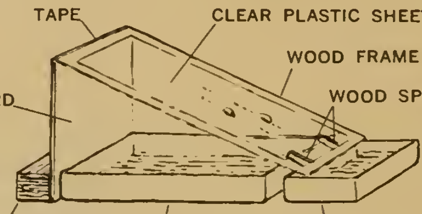
The first atomic bombs were exploded in World War II. Since then, scientists have found ways to control the *fission,* or splitting, of *nuclei,* or cores of atoms to get energy for peaceful uses. This energy comes from a very heavy element called uranium. When an atom of a special kind of uranium known as *uranium 235* is struck by particles called *neutrons,* the nucleus of the atom splits and gives off large amounts of energy. The heat energy from splitting uranium is used to make steam, which drives a ship's propellers or turns a generator to make electricity.

When uranium atoms are split, the material that is left is highly radioactive. This makes it poisonous to all living things. At present, these wastes are packed in heavy tanks, encased in concrete, and dumped into the ocean. But as more energy is produced by fission, getting rid of the wastes without endangering living things gets to be more and more of a problem.

This problem may be solved if scientists can learn how to control the process of *atomic fusion.* Fusion can produce even more energy than fission, and there are less radioactive wastes to dispose of. This process uses the lightest of all the elements, *hydrogen.* Atoms of certain kinds of hydrogen are crushed together at temperatures of millions of degrees. The hydrogen atoms form heavier atoms of the element helium and give off energy. If the hydrogen atoms in a ton of water could be fused in this way, the energy would equal that of 100 tons of coal. Fusion takes place in an exploding hydrogen bomb. It is also the source of energy in the Sun and stars.

PROJECT

The Sun's energy can be used to separate fresh water from the salt in seawater. You can make a solar evaporator and find out how this process works. Collect the parts shown in the diagram. Coat the inside of the cake pan and wood board with black paint. Make a frame of thin wood strips and glue the clear plastic sheet to it. Tape the frame to the board, then tape the board to the block, as shown. Put the cake pan under the frame. Glue wood spacers under the lower edge of the frame so there is at least a quarter inch of space between the frame and cake pan rim.



Set the solar evaporator in a place where the Sun will shine on it for a long time each day (the south side of a building is best). Fill the cake pan with salt water, which you can make by adding a heaping teaspoonful of salt to each cup of warm water. Put a collecting pan under the lower edge of the plastic.

After your evaporator has been in the Sun awhile, you should see some water droplets running down the plastic sheet into the collecting pan. Where are the droplets coming from? Taste the water. Is it salty?

Would the evaporator work faster if you put cardboard over the openings on each side? Or if you set up sheets of aluminum foil so that they reflected sunlight on the plastic sheet? Try it and see.

You may have seen a dam that makes electricity from water backed up behind the dam. Surprisingly, falling water now makes less than one-twentieth of the world's energy. Someday, nations may make electricity with energy from the oceans. They can do this by building "dams" offshore to trap water at high tides. Then, at low tide the water will rush through generators to make electricity.

These are a few of the ways that men can use to satisfy the growing need for energy. You may be among the scientists who discover new ways to keep the world from running out of energy ■

■ Look in a library or bookstore for these books on energy: **The Story of the Atom,** by Mae and Ira Freeman, Random House, Inc., 1960, $1.95; **The Peaceful Atom,** by Bernice Kahn, Prentice-Hall, Inc., 1963, $3.25; **Energy and Power,** by Robert Irving, Alfred A. Knopf, Inc., 1958, $3.09; **The How and Why Wonder Book of Atomic Energy,** by Donald Barr, Wonder Books, 1961, 50 cents.

nature and science
TEACHER'S EDITION
VOL. 2 NO. 14 / APRIL 19, 1965 / SECTION 1 OF TWO SECTIONS

Why Must We Teach Conservation?

by Matthew J. Brennan

■ Conservation means many things to many people, and something different to each. We might say on that basis that it is not possible to teach conservation. But we can agree that conservation involves man's attitudes and actions toward the world in which he lives. Hopefully, we can say that conservation involves man's attempts to use his world in such a way that he lives in harmony with it.

Why is it important that we learn about the things that will enable us to use the world in an attitude of harmony with it?

Man is a living thing. That is, he is aware of his environment—the things around him—and reacts to it. He reproduces his kind. He requires energy to carry on his functions.

Man is an animal, a special kind of living thing. He is dependent on his environment as the source of his energy, his food, his water, his air. If he does not have adequate amounts of each, he will die.

Man is a special kind of animal, a thinking, reasoning, choice-making animal. He is capable of varying his reactions to his environment. As a result, man has the power to change his environment to suit himself, or to meet his needs for life. Of course, the beaver changes his environment when he dams a stream and floods a forest area. But the beaver does this by instinct, not by choice.

Man is the only living thing that can consciously control its environment, his world. He can transform it. He can destroy it. He can preserve it. He can use it so that it will continue to produce the products he needs for his life. If he so wills, and if he knows how, man can live in harmony with his world. To do this, he must learn all he can about his environment, his own and other men's relations to it, and its relations to them. This is the task of teaching conservation. What will it involve?

Man's Place in His World

People have been studying their environment since the beginnings of man. They have learned much about it, its size, its shape, it texture, its inhabitants. They have, however, neglected to study man's place in his world. As you will see in this issue of *Nature and Science,* scientists know how to reduce soil erosion. They know how to eliminate most kinds of water pollution. They know how to grow bigger, faster-growing, more disease-resistant trees, food plants, and animals. They know how to increase water supplies. In short, they know how to control much of their environment. Unfortunately, they have also developed the means of destroying it.

Since man has the ability to destroy or to wisely use his world, the knowledge of these possibilities should be considered an essential element of human understanding and an essential part of our education. So far, it is neither. As a result, we are rapidly destroying the environment we need to live.

Many of our major problems in conservation are relatively new—the results of new scientific discoveries with social, political, economic, and esthetic implications that are not widely understood. Indeed, the results of using many of these scientific discoveries have not even been researched.

Our lakes and streams—even the remote seas—are polluted with chemicals, factory wastes, detergents, sewage, pesticide residues, and other byprod-

(Continued on page 4T)

Matthew J. Brennan is Director of Field Studies for the Pinchot Institute for Conservation Studies, Milford, Pa.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Too Many Deer**
Conservation is more than just *preservation.* Deer are now so plentiful in some areas that they starve to death. To prevent this, hunters must kill more deer.

● **Exploring the Soil**
With this SCIENCE WORKSHOP to guide them, your pupils can find out how soil is formed, how it is worn away, and how to stop erosion.

● **The Land Where We Live**
The results of careful and careless land use are compared in this WALL CHART that will help your pupils to evaluate the use of the land around them.

● **Water, Water, Everywhere, But . .**
How pollution of our waterways affects living things, and what can be done about it.

What Can I Do?
A list of conservation projects for young people.

● **Are We Running Out of Energy?**
Today's common fuels are being used up, so scientists are seeking ways of harnessing the energy from the Sun and the atom.

IN THE NEXT ISSUE

Is the Moon a "planet" that was "captured" by the Earth? A piece of the Earth that "escaped"? Where did the Moon come from? . . . What scientists are doing to bring back the American Chestnut, nearly wiped out by a fungus . . . SCIENCE WORKSHOPS on raising brine shrimp and finding out how magnets work . . . Winners of the Brain-Boosters Contest.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Too Many Deer

This article may shock pupils who learned about deer from *Bambi*. It illustrates the point made by Matthew Brennan on pages 1T and 4T: If man is to live in harmony with his world, he must understand it.

In most areas of the United States, man has wiped out the large predators that once preyed on deer. Since deer have few other natural enemies, man must take the role of predator. Luckily, deer are a challenge to hunt and good to eat; otherwise, state governments would probably have to spend millions of dollars to control them.

Topics for Class Discussion

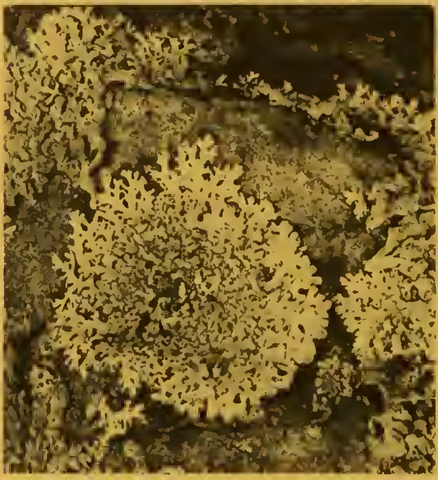
- *Does a "population explosion" occur in other animal populations if predators are killed?* Not necessarily. Because of their size, animals like deer, moose, and elk have relatively few natural enemies compared with smaller animals like rabbits and mice. An "explosion" is unlikely among rabbits, mice, and the like because they are part of so many food chains. If one kind of predator is wiped out, there usually are a dozen or so others that continue to prey on rabbits and mice.
- *How do scientists tell the age of deer?* For the first year and a half, a deer's age can be determined by stages in its change from milk dentition ("baby teeth") to adult dentition. Thereafter, the degree of tooth wear reveals its age. The age of a deer cannot be determined by the number of points on a buck's antlers, as many people believe. As the article points out, a deer's diet has a tremendous effect on antler size.
- *How long do deer live?* Deer may live a dozen years or more in the wild, and even longer in zoos. However, in areas where hunting pressure is great, a deer's life expectancy is only about one and a half or two and half years.

PAGE 6 Exploring the Soil

As more and more people become city or suburban dwellers, they tend to lose whatever appreciation they had for soil and its effect on their lives. But milk still comes from cows, not bottles, and bread still comes from wheat, not paper packages. Have your pupils list the food, clothing, shelter, and other necessities that grow in the soil, or that depend on plants that grow in the soil.

Topics for Class Discussion

- *Was there soil erosion before North America was settled?* Yes. Soil erosion began when soil itself began. Wind and water have always moved soil particles, but the rate of erosion has increased as humans have cleared and misused the land. Soil is eroding faster than it is forming in many areas.
- *Is soil being formed today?* Yes, rocks are still breaking into bits, and leaves are still rotting into humus. Your pupils can see one of the early stages of soil formation by examining rocks covered with lichens *(see photo)*.



THE AMERICAN MUSEUM OF NATURAL HISTORY

If you scrape some lichens from a rock, you may find bits of rock on the underside of the plant. These rock particles have been loosened by the plant's acids and are the beginnings of soil.

Activities

- Compare the fertility of topsoil with subsoil by getting several potfuls of each from different locations. Plant seeds (such as beans) in each pot and give the pots the same amount of water and sunshine. Your pupils can make measurements, keep records, and make graphs of their findings.
- Look for life in the soil by digging soil samples (about a foot square and six inches deep) from a woods, a meadow, the edge of a swamp, an eroded field, and so on. The samples can be examined in the field or wrapped in newspaper or plastic bags and brought back to the classroom. Break the soil into bits (or sift it through a screen), making a list of the kinds and numbers of different plants and animals found in each sample. How do the numbers and varieties of organisms change with the location of the soil?

PAGE 11 Water, Water

Unfortunately, you can probably find examples of water pollution not far from your school—mute testimony that water pollution is one of the most serious conservation problems in the United States. Here are some ways you can help your pupils become more aware of this problem and its effect on their lives.

Activities

- Find out what part water has played in the development of your community. Also find out what ways water is used in local industries. It may be used for cooling, mixing with other raw materials, cleaning, and as a source of energy, to name a few.
- Visit the sewage treatment plant or waterworks in your community and find answers to the questions in the project on page 13. Your class might build a model of the water system.
- Have some pupils look for articles in magazines and newspapers about the International Hydrological Decade, a world-wide research effort to learn more about water resources.

(Continued on page 3T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue...
(Continued from page 2T)

Others might study the different methods being used to desalt ocean water

PAGE 8 Where We Live

With your class, compare the two valleys shown in this WALL CHART. It might be difficult to find a single area as abused as the one on the right. On the other hand, few areas are as ideal as the one on the left. Compare the conditions in these valleys with those in and around your own community. What might be done to use natural resources more wisely? You might begin with your own school grounds.

Discuss the meaning of the word "conservation." Don't be surprised at disagreements *(see "Why Must We Teach Conservation?" page 1T)*. Some pupils may think that it means only *preservation*, and wonder why state conservation departments allow hunting. The article "Too Many Deer" shows that hunting can be a part of conservation.

A common definition of conservation is "the wise use of natural resources." But what is "wise"? For an industrialist, it may seem wise to dump factory wastes into a stream. How would your class define conservation?

PAGE 14 Energy

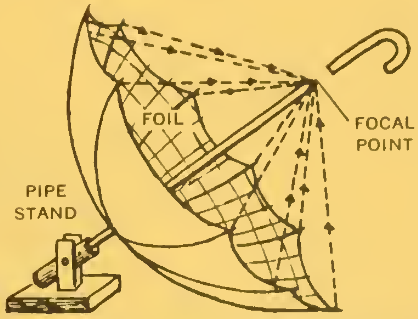
There is energy in every bit of matter in the universe. Why, then, should there be any question of our "running out of energy"?

Suggestions for Classroom Use

- Point out to your pupils that the problem is really one of running out of energy that is easy to get, and therefore inexpensive. When the fossil fuels are used up, they cannot be replaced. We have not yet learned how to use solar energy well enough to provide the vast amounts of energy needed today. The energy that can be obtained by splitting atomic nuclei (or fusing them, if scientists find out how to control the process) should meet most of our needs, but so far it costs more to get than energy from the fossil fuels.
- Ask your pupils what happens to the energy they get from food. Does it enable them to move their arms and legs? Does it help change chemicals from food, water, and the air into living matter for their bodies? Does some of it go off into the air in the form of heat when they run?
- Some of your pupils may ask if there is a difference between "atomic" and "nuclear" energy. Strictly speaking, the energy released by splitting (fission) or joining (fusion) the nuclei, or cores, of atoms is *nuclear* energy, though it is widely referred to as "atomic" energy. However, the energy released by burning a piece of coal is actually *atomic* energy. When one atom of carbon combines with two atoms of oxygen to make one molecule of carbon dioxide, a tiny amount of the energy that held electrons in the carbon and oxygen atoms is released in the form of heat.

Activities

- Have the class make a list of the appliances in their homes that use energy (furnaces, stoves, lights, TV sets, automobiles, etc.) and where the energy comes from. Have someone find out what kinds of energy are used to make the electricity for the community.
- Make a solar furnace from an old umbrella lined with aluminum foil *(see diagram)*. When you have located the focal point, try broiling a hot dog.



To make a solar furnace, glue aluminum foil inside an umbrella. Mount it so you can keep it turned toward the Sun. Find the hottest point (focal point) with your hand or a cooking thermometer, and cut off the handle there.

Reading Material and Films on Conservation

Books and Pamphlets

- *Field Book of Nature Activities and Conservation*, by William Hillcourt, G.P. Putnam's Sons, New York, 1961, $4.95.
- *Things To Do in Science and Conservation*, by B. Ashbaugh and M. Beuschlein, Interstate Printers and Publishers, Inc., Danville, Ill., 1960, $2.50.
- *Conservation*, a 32-page Cornell Science Leaflet, available from Leaflet Office, Stone Hall, Cornell University, Ithaca, N.Y., 25 cents.
- *Soil and Water Conservation* and *Wildlife Management*, Merit Badge booklets published by the Boy Scouts of America, New Brunswick, N.J., 35 cents each.
- *Conservation Experiences for Children*, by E. Bathurst and W. Hill, U.S. Department of Health, Education, and Welfare, Bulletin No. 16, 75 cents.*
- *An Outline for Teaching Conservation in Elementary Schools*, Soil Conservation Service, U.S. Department of Agriculture, free.*
- *Focus on Clean Water*, Public Health Service Publication No. 1184, 20 cents.*
- *Needed: Clean Water*, a cartoon-style pamphlet prepared in cooperation with the National Wildlife Federation, available from C.L. Bete Co., Inc., Greenfield, Mass. 01301, 25 cents.
- *Water Pollution Control*, an Audubon Nature Bulletin, available from the National Audubon Society, 1130 Fifth Avenue, New York 10028, 15 cents.

*Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Periodicals

- *Audubon*, bi-monthly, $7 a year, published by the National Audubon Society, 1130 Fifth Avenue, New York 10028.
- *National Wildlife*, bi-monthly, $5 a year, published by the National Wildlife Federation, 1412 Sixteenth St., N.W., Washington, D.C. 20036. The Federation also publishes inexpensive pamphlets for adults and children. Ask for the free publication list.
- *Bulletin on Conservation Education*, quarterly, free from The Conservation Foundation, 30 East 40 St., New York 10016.
- Nearly every state conservation or fish and game department publishes an inexpensive monthly or bi-monthly magazine. Also write to these departments and your state education department for materials on conservation and conservation teaching.

Films and Filmstrips

For an up-to-date listing of the best movies and filmstrips, write to The Conservation Foundation (address above), and ask for the free pamphlet, *A Critical Index of Films and Filmstrips in Conservation*.

Why Must We Teach...
(continued from page 1T)

ucts of civilization. Our population is expanding beyond the capacity of the Earth to support it. Our air is not fit to breathe in many places.

The body of every living thing, including your own, contains poisons that were once used to control insect populations. Even the remote Antarctic penguins show traces of poisons in their systems, carried to them from some farm or garden or forest in the populated sections of the world by unknown ocean currents. Scientists still do not know what cumulative effects these poisons in the bodies of living things may have. Some may kill. Others may cause a slower extinction by destroying the power to reproduce.

Science, and then science teaching, must provide the basis for an understanding of the environment of man. But environmental science also deeply involves the social sciences.

Most conservation decisions up to the present have been socially influenced. They have been decisions that were deemed economically feasible, socially desirable, or politically expedient. Most wars are struggles between men for a piece of the environment, its food, its water, or its space in which to live. Does our teaching emphasize man's eternal fight for resources—his needs?

Teaching the Outlook for the Future

We learn the dates of wars. Why not learn why they were fought, and how all of this is just a part of man's attempt to live in and control his environment? When we teach the economics and geography of the world, do we include the outlook for the future, and how it will affect us? How can we leave it out?

We have needed 150 acres for each person in order to reach our present level of life in the United States. We now face a doubled population, but there are only three acres left per person. Will we be able to maintain our standard of life? And what of the other living things? Will there be room for any of them? Is it important?

Do our children have enough contact with the out-of-doors to develop attitudes of esthetic appreciation of natural beauty? Will they really care about wild country? We must make sure that they will. We must bring them into contact with their environment, their world. Take them out, even if it's just to a city park. Make them aspire to see the other places in their world.

Our children must learn to understand their world, how man is related to it, and how it is related to man, the animal. We must teach them the importance of living in harmony with their environment. If we do not, future decisions on man's use of the land will continue to be made by the uninformed. You, the teacher, hold the key. Yours is the task of insuring the future of the world. If you could make a significant contribution to the nation's space effort, you would start on it today. Our conservation effort is much more important. Will you start today? ■

nature and science

VOL. 2 NO. 15 MAY 3, 1965

What Will Men Find on the Moon?

see pages 2 and 3

ABOUT THE COVER

What is the Moon's surface made of? This is a fascinating puzzle. Fine dust may cover most or many parts of the Moon to a depth of thousands of feet. Possibly the dust is only a few feet, or a few inches deep. Or there may be no dust.

As excellent as the Ranger VIII photographs of the Moon were, they tell us nothing about the structure of the Moon's surface. With luck, by the end of this year a small automatic laboratory will be gently landed on the Moon. One of the jobs to be done by such laboratories (the Surveyor Program) will be to take close-up television pictures and to drill into the Moon's surface. The findings will then be sent back to Earth by radio.

Soft landings on the Moon by Surveyor vehicles will have to be made before men can be landed on the Moon. To send men to the Moon before we know what its surface is like would be too much of a risk. Every effort must be made to make the journey as safe as possible. When that great day arrives, when men set foot on the Moon for the first time, they will be able to examine the surface in detail. What they find out may then lead to answers to the big questions about the Moon and the Solar System that are asked in the article beginning on the next page.

nature and science

VOL. 2 NO. 15 / MAY 3, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

CREDITS: Cover, p. 2, Hamilton Standard Div. of United Aircraft Corporation: p. 3, left, p. 5, upper right, and p. 13, drawings by Gaetano di Palma; pp. 3, 4, 5, other drawings by John Polgreen; p. 6, photo from The Connecticut Experiment Station, map by Graphic Arts Department, The American Museum of Natural History; p. 7, photo by Nick Drahos, New York State Conservation Department; pp. 8, 9, drawings by R. G. Bryant; p. 10, photo by George Cope, Educational Services Incorporated; pp. 10, 11, 14, 15, 16, drawings by Graphic Arts Department, AMNH; p. 12, shrimp eggs photo by Herbert R. Axelrod, from T.F.H. Publications, Inc.; p. 12, 13, 14, adult shrimp and other photos by Anthony S. D'Agostino, from Haskin's Laboratories, Inc.; p. 15, photos by Franklyn K. Lauden; p. 16, photos by Roy A. Gallant.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. **Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

WHERE DID THE MOON COME FROM?

by Roy A. Gallant

A new look at an old theory may hold the answer.

■ The question of where the Moon came from has puzzled astronomers for many years. Possibly it was once part of the Earth but broke away and started circling the Earth. Or it may have been a planet that was "captured" by the Earth several billion years ago. Where the Moon came from is part of a much bigger question: How were the Sun and its family of nine planets formed?

Many scientists in the past have tried to answer these questions, and scientists are still trying to answer them. In the 1700s, the French scientist Comte de Buffon told how he thought the planets were formed.

At one time in the distant past, he said, the Sun traveled alone through space. No planets circled it. The planets, he thought, were formed when a "comet" crashed into our star. Huge spinning droplets of gases were splashed off into space *(see Diagram 1)*. Millions of years went by. The gases forming each great spinning droplet packed tighter and tighter around the center of each droplet-globe. The globes hardened and eventually became the planets.

Astronomers found many things wrong with Buffon's theory. For one thing, a "comet" would be much too small to cause such large gas droplets to be torn from the Sun. But what if Buffon had meant "star" when he used the word "comet"? If the Sun crashed into another star, or brushed against one in passing, huge amounts of gas would be splashed out into space. But astronomers say that there is so much room in space that it is very unlikely that the Sun ever has, or ever will, collide with another star. For this and other reasons, the collision idea was put aside.

Telescopes in the 1700s were good enough to show great dark patches among the stars. These clouds, which we now know to be dust and gas, are called *nebulae*. Another French scientist, Pierre Simon de Laplace, said that the Sun, as well as the other stars, began as a huge nebula. The nebula that

(Continued on the next page)

Diagram 1

Buffon thought that a "comet" had collided with the Sun, splashing off gas droplets that formed the planets and their satellites.

Diagram 2

Most astronomers think that the Sun, planets, and satellites were formed out of a tremendous cloud of dust and gas *(see page 4)*.

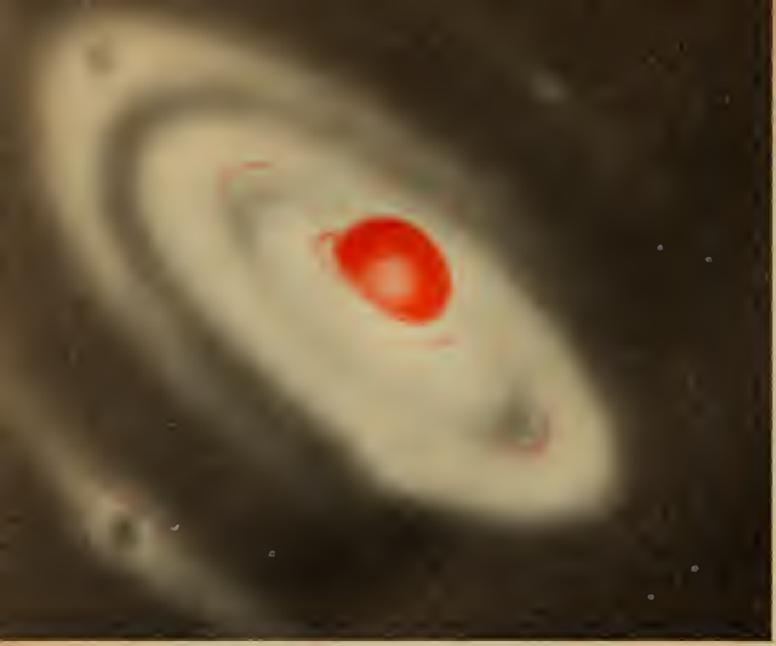


Diagram 3 **Laplace thought that the planets formed out of rings of gas that were left behind by a huge spinning gas cloud withdrawing toward the center. He also thought that the globe of gas at the center became the Sun.**

became the Sun and planets, said Laplace, stretched out beyond the planet Uranus. This would put the edge of the cloud some 2,000,000,000 miles out from its center.

Gradually the cloud closed in on itself. At the same time it began spinning faster and faster. This flattened the cloud into the shape of a disc. The more the cloud closed in on itself, the faster it spun. After a time, the disc was spinning so fast, and the gas and dust were moving toward the center of the cloud so fast, that the cloud left a ring of gas and dust behind.

This happened again and again. After many centuries there was a great central globe of dust and gas with several rings circling it.

The sphere of dust and gas at the center of the young Solar System packed itself tighter and tighter around the core. As it did, it became hotter and hotter. Eventually the sphere began to glow. It was becoming a new star. Meanwhile, according to Laplace, the dust and gas in the rings gathered together and formed solid spheres—the planets *(see Diagram 3)*. These dust and gas spheres did not remain gas and glow, as the Sun did. The reason is that there was not enough material packed into them.

As Buffon's crash-splash theory was challenged, so was Laplace's ring theory. In the early 1900s astronomers began to find several things wrong with the ring theory. First of all, they doubted that the great spinning gas cloud would leave rings behind. Even if it did, they doubted that the rings would ever collect into planet-size objects. They said that the gas and dust forming such rings would probably just drift off into space. So ended Laplace's chapter in the story of the Solar System.

After Laplace, What?

Since the year 1900, several astronomers have added new chapters to the story of the birth of the Sun, planets, Moon, and other natural satellites. The American astronomer, Gerard Kuiper, paints this picture:

The Solar System began as a cloud of dust and gas more than 4½ billion years ago. The cloud stretched about 9,000,000,000 miles from edge to edge. Gradually it closed in on itself, spinning and flattening out. Eventually it became a huge rotating disc. About 95 per cent of the cloud's gas and dust formed a sphere at the center of the disc. The sphere became the Sun. In its early days the the Sun was much larger and cooler than it is today. It glowed dull red, and it was large enough to fill the space within Mercury's present orbit.

Spread around the new Sun was a circular disc of "leftover" gas and dust. This great wheel of leftover material reached outward from the Sun's equator to a distance of about 3,000,000,000 miles—about the distance of the planet Neptune.

Like a phonograph record, the gas and dust that made up the disc spun around the young Sun. Within it whirlpools formed, broke up, and formed again. But some of the whirls—the larger and stronger ones—did not break up. Those that held together swept up more gas and dust around them. They grew larger and larger. At least eight such whirls formed and grew *(see Diagram 2)*. Eventually, each one formed into a sphere and, over millions of years, hardened and became one of the planets.

Just as the new Sun had a disc of gas and dust spinning around it, so did each new planet. Some of the gas and dust escaped into space. In other cases the material developed whirls. These whirls became the satellites of the planets. Just as the planets are spread out in line with the Sun's equator, most of the satellites lie in line with their planet's equators.

No one can say for certain if that is the way the Sun, planets, and satellites were formed. But many astronomers feel that until a better explanation comes along, Kuiper's idea is a good one.

The Mystery of Pluto

There are at least two puzzling exceptions that do not seem to fit the simple picture just painted. One is Pluto—the "end man" in the Solar System. Is Pluto a true planet? Pluto does not move in line with the Sun's equator *(see Diagram 4)*. Pluto may be a satellite that escaped from the giant planet Neptune when Neptune was being formed.

If so, Pluto was then captured by the Sun and revolved around it like a planet. Something like this has happened in recent times. At least 12 artificial satellites that have been shot at the Moon or Mars, or shot on other space missions, have missed their targets. When they did, they were captured by the Sun.

The other exception is the Moon. The Moon does not move around the Earth in line with the Earth's equator. Because it doesn't, it is possible that the Moon was on its way to becoming a planet when the Earth and other planets were being formed. But it came too close to the Earth and was captured.

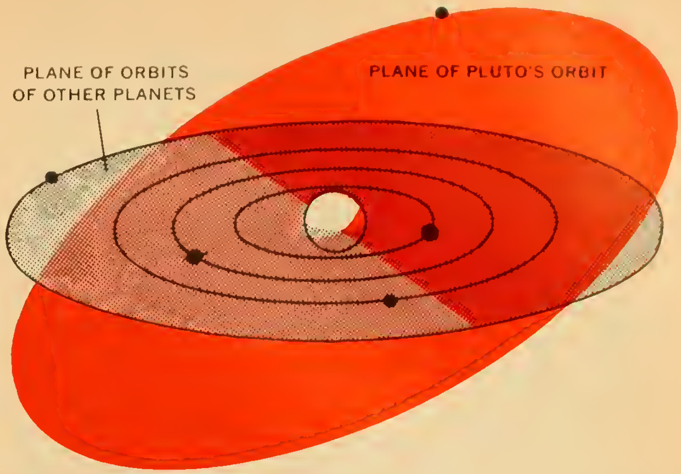


Diagram 4 **The plane of Pluto's orbit is far from the planes of the orbits of the other planets. Astronomers suspect that Pluto is not a true planet. It may be a satellite that escaped from Neptune.**

Mystery of the Moon

Like Pluto, the Moon is a puzzling object. In a sense, the Moon is too large to be a normal satellite. It has a diameter of about 2,000 miles. The Earth's diameter is about 8,000 miles. No other satellite in the solar system is as large, compared to its "parent" planet, as the Moon is compared with its parent, the Earth.

Another puzzling thing about the Moon is the shape of its orbit about the Earth. The Moon's orbit is nearly circular. When one object in space is *captured* by another one, the captured object usually follows a stretched-out orbit, not a circular one. Pluto's orbit is a good example. If the Moon was captured by the Earth, then the Moon's orbit *should not* be nearly circular.

In recent years scientists have been taking a new look at an old theory of how the Moon was formed. In the late 1800s George Darwin, son of the famous naturalist Charles Darwin, said that the Moon was once part of the Earth. When the Earth was young, he said, a great chunk of our planet broke away and became the Moon. The Pacific Ocean basin, said Darwin, is the "scar" left in the Earth's crust where the Moon broke away.

Diagram 5 **George Darwin, son of Charles Darwin, thought that early in the Earth's history a great chunk of matter broke away from the Earth and became the Moon. Few people now believe that this actually happened.**

To see how Darwin thought that this grand event came about, we'll have to go back about 4½ billion years, when the Earth was a newly formed planet. At this stage of its life, the Earth was a sphere of hot liquid rock and metal. Gradually the liquid surface rock hardened and formed a thin crust.

When this was happening, the Earth was rotating much faster than it is now. It was then rotating about once every 2½ hours, instead of once every 24 hours, as it does today. With a little extra force, according to this theory, the fast-spinning Earth could have thrown off some of its material—like mud flung from the rim of a fast-spinning wheel.

The "extra force," said Darwin, was provided by the Sun. At that time, the Sun raised tides in the molten Earth, just as the Moon and Sun cause ocean tides today. Acting together, the pull of the Sun *plus* the spinning of the Earth might have been enough so that a large chunk of the Earth broke away *(see Diagram 5)*. The great molten chunk then settled in orbit around the Earth and became the Moon.

If this actually happened, then the Moon should be made of the same kind of rock that we find at the Earth's surface and just below the surface.

Where the Moon came from, and how the Earth, Sun and other stars were formed are fascinating questions to think about. We *may* have an answer to the Moon puzzle fairly soon. Within the next five years or so the United States space program calls for landing men on the Moon. If enough samples of Moon rock can be studied by geologists, scientists then may be able to say that the Earth and Moon were formed separately, or that the Moon was once part of the Earth. The answer to this question may give us clues that could help answer the bigger questions ■

A mysterious disease nearly wiped out one of the most valuable trees in North America. Now scientists are trying to...

BRING BACK THE CHESTNUT

by Dan Welch

■ When your grandparents were growing up, they could go to the woods and gather all the chestnuts they wanted to eat. If you want to eat these tasty nuts today, you have to buy chestnuts that come from Italy.

The American Chestnut tree once grew from Maine to Georgia and west to Illinois *(see map)*. Not only did people like to eat its nuts, but wild animals did too. Turkeys, deer, squirrels, and other forest animals fed on the sweet nuts, especially in the winter when food was scarce.

The wood and bark of the American Chestnut contains *tannic acid,* which helps it resist decay much longer than other trees. Because of this, the Chestnut's wood was used for telephone poles, railroad ties, and houses. Tannic acid from the wood and bark was also used to tan leather. Of all the kinds *(species)* of trees found in North America, the American Chestnut was one of the most valuable.

The Deadly Blight

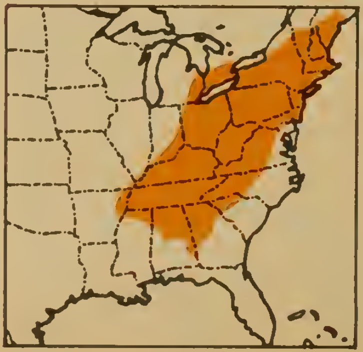
Then, in 1904 a forester in New York City found some dying Chestnut trees. Their leaves were turning brown, the tops of the trees were dying off, the bark was cracking.

Scientists who study plant diseases (called *plant pathologists*) tried to find out why the trees were dying. At the same time, they tried to keep the disease from spreading. They cut out the places where the bark was cracking. They injected chemicals into trees, hoping to kill the cause of the disease. Nothing worked. Finally, foresters cut down the sick trees to keep the disease from spreading to healthy trees.

In spite of these efforts the disease kept spreading. It was called the *chestnut blight*. Scientists kept studying the dying trees, but it was a race against time. Even as the scientists worked, the disease was infecting tree after tree—spreading from forest to forest, state to state—until it wiped out almost all of the American Chestnut trees.

What is the chestnut blight? How does it kill off these strong trees and how does it spread from tree to tree? Scientists have been able to answer these questions after many years of study.

The blight is caused by a *fungus*—a simple plant that



The area shown in color is the former range of the American Chestnut. If you live in this area, look for Chestnut trees that have survived the deadly blight.

does not make its own food, as green plants do *(see "Visit to a Plant Factory," N&S, April 5, 1965)*. The group of plants called *fungi* include bread mold, yeast, and mushrooms. The fungus that causes the chestnut blight gets its food by growing into the tree and feeding on *cambium*. Cambium is the layer of cells inside the bark that causes a tree to grow in width. The cambium soon dies and the tree stops growing wider. The fungus spreads up the tree into the twigs, where it kills the growing tips and the leaves. The fungus also produces a poison that kills living cells in the tree's trunk.

The roots of the tree are usually able to live longer. Sometimes a young Chestnut tree will sprout from the roots, but the blight soon kills it.

Once the fungus is growing on a tree, it starts producing seed-like *spores*. The chestnut blight fungus has two kinds of spores—both so small that you cannot see them without a microscope. One kind of spore is dry and powdery. It is blown about by the wind until it lands in a crack in the bark of a healthy Chestnut tree. There the spore quickly grows into a fungus. The tree is doomed.

The second kind of spore is very sticky. It clings to insects and to birds, which may carry the disease hundreds of miles—infecting healthy trees as they go. One bird was found with over 7,000 spores on its feet!

Why did this fungus suddenly attack the American Chestnut and wipe it out over millions of acres of forest? It seems that the fungus came to North America when some young chestnut trees were brought from Asia to New York City. Through the years the Asian chestnut trees had lived with this fungus and had developed a resistance to it. The fungus spread from them to the American Chestnut trees.

The American Chestnut did not have time to develop a resistance before it was almost wiped out. This is the job of scientists today—to find or develop Chestnut trees that are able to survive the blight disease.

A New Chestnut Tree?

Scientists in the United States Forest Service are looking for the few American Chestnut trees that have survived the blight. So far, about 140 such trees have been found. The scientists cut off some of the parts of the trees that have buds and join them to a Chinese or Japanese Chestnut tree limb. If this joining together, or *grafting*, is successful, the resulting tree will be something like each of the trees used in the graft. Many of these trees are now almost 40 feet high. Some have tasty nuts and resist the fungus. But the scientists hope to develop an even better chestnut tree.

Other scientists are trying a different approach. They expose the seeds of American Chestnuts to radiation from a metal called *cobalt 60*. Such radiation has caused changes in the seeds of other plants, such as oats and peanuts. When one of these seeds sprouts and grows into a plant, it is different from its parent plant. In this way, some plants have been changed so that they fight disease better. Perhaps this will work with the American Chestnut, and you can gather tasty chestnuts in the woods as your grandparents did ■

PROJECT

You can help bring back the American Chestnut. If you live in an area where Chestnuts used to grow (*see map on page 6*), look for a Chestnut tree that seems able to resist the blight. The tree should be at least eight inches in diameter. Collect a twig and a few leaves from it. Send them and a photo of the tree to the Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania, or to the Connecticut Agricultural Experiment Station, Box 1106, New Haven, Connecticut.

The photo on this page will help you identify an American Chestnut. There are some other trees—such as the Horsechestnut, Chestnut Oak, and Japanese Chestnut—that you may mistake for an American Chestnut. The books listed below will help you make sure that your tree is an American Chestnut.

Even if you find a large and healthy American Chestnut, it may not be able to fight the blight. There are so few American Chestnuts alive that there are also few fungus spores that can infect the trees. Some large Chestnut trees may survive just because spores haven't reached them yet. However, a tree you find may have survived an attack by the blight. It may be the tree that will help scientists bring back the American Chestnut.

Use these books to identify Chestnuts and other trees: **Trees**, a Golden Nature Guide, by Herbert Zim and Alexander Martin, Golden Press, New York, 1963, $1; **A Field Guide to Trees and Shrubs**, by George Petrides, Houghton Mifflin Co., Boston, 1958, $4.50.

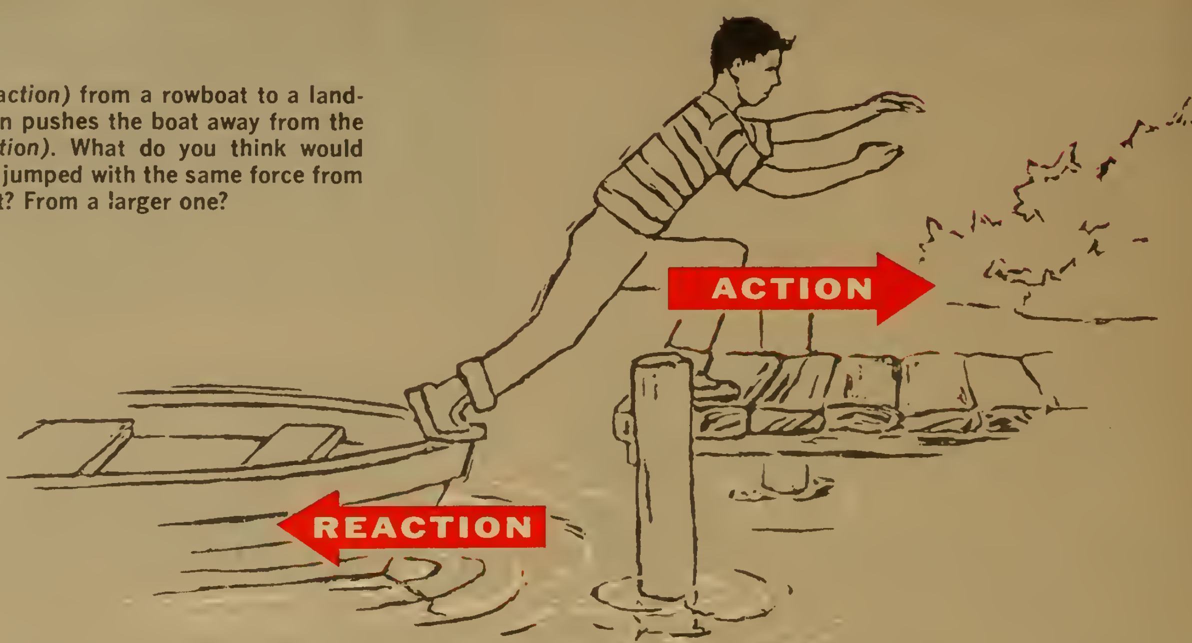
The leaves of American Chestnuts are four to eight inches long and have toothed edges. The nuts are in spiny husks.

WHAT MAKES I

■ Every rocket fired at Cape Kennedy "obeys" certain laws of motion. One of these laws deals with *action and reaction*. Every time there is a push or pull (a force) acting on something, another force acts just as strongly in the opposite direction.

The first force is called *action*, and the second one is called *reaction*. The illustrations on these two pages show some of the ways action and reaction work. Can you think of others? ■

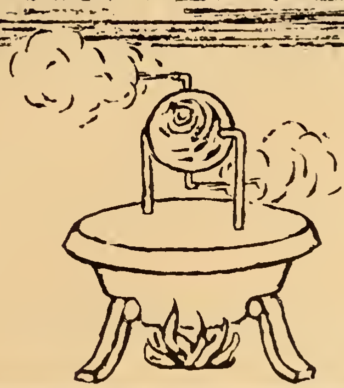
1 If you jump *(action)* from a rowboat to a landing, this action pushes the boat away from the landing *(reaction)*. What do you think would happen if you jumped with the same force from a smaller boat? From a larger one?



3 Air pushes in all directions against the inside of a balloon. If you let the balloon go, air escapes from the neck *(action)*. Air pushing against the inside surfaces of the balloon now moves the balloon *(reaction)*.

4 A bottle with vineg
a simple reaction
make carbon dioxid
from the bottle (acti
tle *(reaction)* over t

T GO?

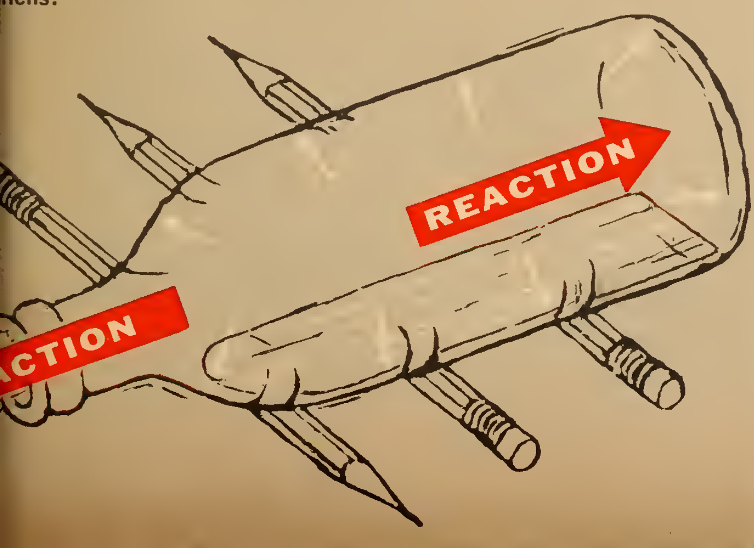


HERO'S AEOLIPILE: Hero, a scientist of ancient Greece, designed this toy engine. Can you explain how it works? Water inside the boiler is heated and changed to steam. The steam enters the globe through hollow supporting pipes and leaves the globe through the two nozzles.

Vhat about a gun?

2 In this lawn sprinkler, water squirts out of the nozzles *(action)*. The force of the water *(reaction)* pushes in the opposite direction, making the sprinkler spin around.

d baking soda in it is
e. The two chemicals
When the gas escapes
ts force moves the bot-
ncils.



5 In a rocket engine, burning gas pushes in all directions on the inside walls. Some gas escapes through nozzles at the rear *(action)*. Gas pushing against the upper surface of the engine moves the rocket *(reaction)*.

prepared by **DAVID WEBSTER**

MYSTERY PHOTO

What happened to the rock to give it this strange shape?

CAN YOU DO IT?

Tie a short piece of thread to make a loop. Now float it in some water. What can you do to make the loop into a perfect circle without even touching it?

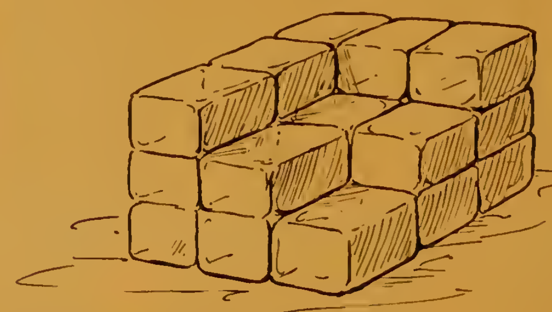
WHAT DO YOU THINK WOULD HAPPEN?

If an ice cube is placed in a glass of salad oil or cooking oil, it will sink to the bottom. What will happen as the ice cube melts? Where will the water go? Try it.

FUN WITH NUMBERS AND SHAPES

How many cubes are there in this pile? (There are none missing from the sides you can't see.)

submitted by Shari Klein, Van Nuys, California

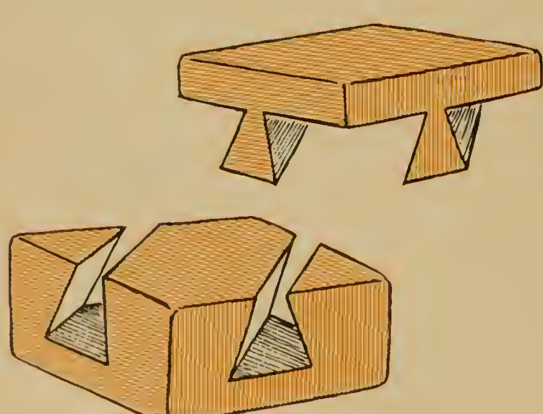


FOR SCIENCE EXPERTS ONLY

Suppose you were riding on a fast train. In which direction could you jump farther, toward the front of the train, or toward the back?

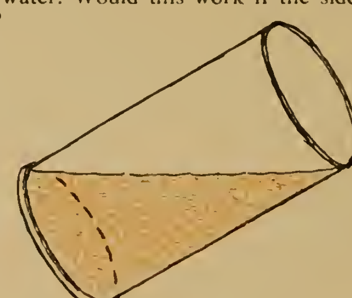
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: This diagram shows how the block was made.



What Do You Think Would Happen? Usually when the hands come together they will be beneath the 18-inch mark on the yardstick. This is the middle of the stick, so it will balance and not fall off.

Can You Do It? Here is one easy way to get a can exactly half full of water. First pour water in the can until it is more than half full. Tilt it slowly and allow the water to run out until the surface of the water is as shown in the sketch. The can is now half full of water. Would this work if the sides of the can were not straight?



For Science Experts Only: Young Karl Gauss saw that the numbers could be paired as follows: 1 and 100, 2 and 99, 3 and 98, and so on, until 50 and 51. Since the sum of each pair is 101, and there are fifty such pairs, it becomes a simple multiplication problem of 50 times 101, or 5,050.

Have You Heard This One? What gets wet as it dries? A towel.

BRAIN-BOOSTER CONTEST WINNERS

Here are the winners of the Brain-Booster Contest that was announced in *Nature and Science* for February 15, 1965. A total of 1,452 young people sent in their answers to the seven contest questions. In the adult division, there were 24 entries. The winners were selected by the way they answered all seven questions. The answers printed on this page were taken from the entries of the five young winners.

WINNERS

(Prize: A 10-power or 100-power student microscope or a telescope, courtesy of Bausch & Lomb Incorporated).

William Askin, Pittsburgh, Pa.
Gary Field, Danvers, Mass.
David Garfinkel, Rockville, Md.
Michael Pershing, Xenia, Ohio
Mark Ungar, Chicago, Ill.

HONORABLE MENTION

(Prize: A science investigation book)

Cecilia Beamish, Sacramento, Calif.
Tom Brown, Stewartsville, N.J.
Randy Fry, Castro Valley, Calif.
Alison Kemper, Williamstown, Mass.
Janet Kleespies, Lynbrook, N.Y.
Jeffrey Pohl, Garden City, N.Y.
Eleanor Pupke, Boonville, N.Y.
Robert Simmen, Wayne, Pa.
Peter J. Verdin, Jr., Anchorage, Alaska
Christina Zander, Eureka, Calif.

WINNERS (adult division)

(Prize: A set of *Astronomy Highlights* booklets)

Clifton A. Dukes, Jr., Atlanta, Ga.
George R. McLaren, Taft, Calif.
Karl H. McLaughlin, Toledo, Ohio
Clifford L. Miles *(no address given)*
Mrs. David L. Stallard, Los Angeles

Answers to the contest questions from the winners

1. Question: *What was done to make the fish in a doughnut-shaped tank all swim around in the same direction?*

Answer: "I thought it had something to do with the current, but I didn't know if the fish swam with or against the current. So I called the aquarium and they said fish swim against the current. The fish are swimming against a current you made."—MARK UNGAR

2. Question: *Can you make three loops of string so that all three will come apart if any one of the three is cut?*

Answer: "This I found the hardest. I knew that each loop would have to depend on the two others in order to stay attached to the formation without slipping out *(see diagram)*."
—DAVID GARFINKEL

3. Question: *Will the stick still balance after the candles have burned for awhile?*

Answer: "Since the candles are shown as being two units and three units away from the center, and since on the opposite side the candle is five units away, the candles must be of equal weight. If the candles burn at the same rate, the stick will stay balanced."—GARY FIELD

4. Question: *If you put several heavy books on your bathroom scale and stood on top of them, the scale would show your weight plus the weight of the books. If you took the books off the scale and held them in your arms, what weight would the scale show?*

Answer: "The scale would show the same weight, because even if the books are held at arm's length, your body still supports the books and the weight is the same on the scale."
—WILLIAM ASKIN

5. Question: *Does ice ever get colder than 32° F?*

Answer: "Ice gets colder than 32° F. Ice freezes at 32° F., but then acquires the temperature of the surrounding air."
—WILLIAM ASKIN

6. Question: *If a gear with 12 teeth turns clockwise once a minute, how would a smaller adjoining gear with 6 teeth be turning?*

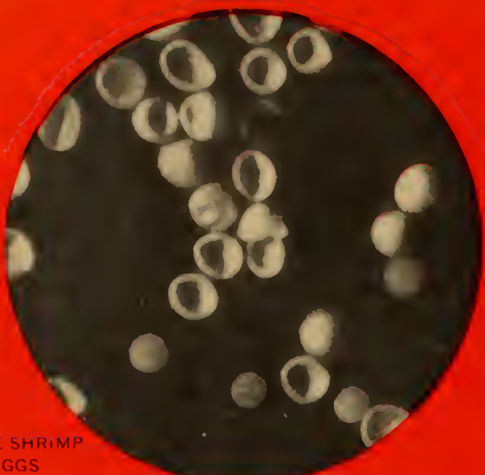
Answer: "The smaller gear will turn counterclockwise at once a half minute, because it has half as many teeth as the larger gear and has to turn twice for each turn of the larger gear."—MARK UNGAR

7. Question: *What is wrong with this experiment and how would you do it better? "I tested my dog to see his reaction to music. Every night after his dinner, for two weeks, I put him in my room and turned on some music. On almost every night he was asleep in 10 minutes. It seems that music makes my dog go to sleep."*

Answer: "The person that did the experiment did not use the same music and didn't test his dog without music. The experiment shouldn't have been done after the dog ate, because he would be tired anyway. The correct way to do the test would be to do it at a regular time every day and not after his dinner. You should be sure he has the same activity every day, and you should play a record with the same music every day for the same amount of time. Also you should do the test the same way and for the same length of time without music."—MICHAEL PERSHING

RAISE YOUR OWN BRINE SHRIMP

by Raymond E. Barrett



BRINE SHRIMP EGGS

ADULT BRINE SHRIMP

With some dried eggs from a pet shop, some salty water, and a hand lens or microscope, you can find out how these fascinating little animals hatch and live.

■ What kind of pet do you have? A cat? A dog? Perhaps some tropical fish? How would you like to have about 100 more pet animals? You can watch these pets as they hatch from eggs and grow right before your eyes.

To get some of these animals, go to a pet shop or aquarium supply store. Ask for a small bottle of *Brine Shrimp* eggs. Brine Shrimp are small relatives of lobsters and crabs. Full-grown adults are only about a third of an inch long. By watching them through a hand lens or microscope, you can learn a lot about the lives of these fascinating animals.

You can buy hundreds of Brine Shrimp eggs for about 50 cents. Be sure to ask for plain eggs, not bottles of eggs with salt and food included. Once you have the eggs, you can start raising your 100 pets.

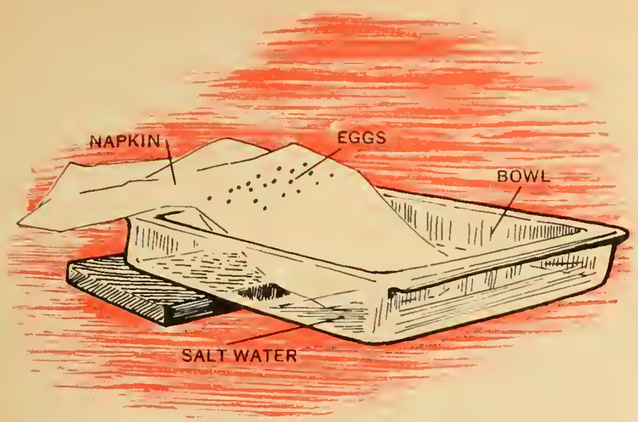
Setting Up Your Shrimp Hatchery

Start your investigation into the life of the Brine Shrimp by sprinkling a few of the eggs on a sheet of white paper. Look at them with a hand lens. Or put them on a microscope slide and look at them under a low-power microscope lens. The eggs look like tiny balls with a dent in one side *(see photo)*. What color are they? Measure the eggs now and later on to see how they change in size *(see "Measuring with a Microscope,"* N&S, *March 15, 1965)*.

To raise Brine Shrimp, first fill a wide-mouthed quart jar or a bowl with water. Use water from a stream or pond if possible. If the water is from a faucet, let it stand about 24 hours to let the chlorine in the water escape into the air. Then dissolve two teaspoonfuls of salt in the water. Use *non-iodized* salt (if iodine has been added, the label on the saltbox will say so). You can also use *sea salt,* which you can buy at a drug store.

Now put about 20 Brine Shrimp eggs in the water and put the container where sunlight will reach it. Try to keep the temperature of the water between 70 and 80 degrees F.

While you are hatching eggs in this way, you can start some more eggs on a piece of absorbent paper, such as a paper napkin. Put the napkin on the bottom of a bowl and tip the bowl slightly. Add salt water to the bowl until one end of the napkin is covered by the salt water



(see diagram). Water will move through the paper until the whole napkin is wet. Sprinkle a few eggs on the damp paper (not in the water).

Hatching eggs in this way makes it easier for you to watch the Shrimp hatch. Use a hand lens or, if you want a really close look, tear off a piece of the damp paper that holds some eggs and put the paper on a microscope slide. For the best view, use *top lighting*—put a piece of black paper under the slide and have strong light shining on the top of the microscope stage (see *"Exploring with a Microscope,"* N&S, *December 7, 1964).*

Examine some of the eggs after they have been in the water (or on the damp napkin) for about an hour. What effect does the water seem to have on the eggs? Does water just soften the eggs, or is some of the water taken into the eggs? Have the eggs changed in size or shape?

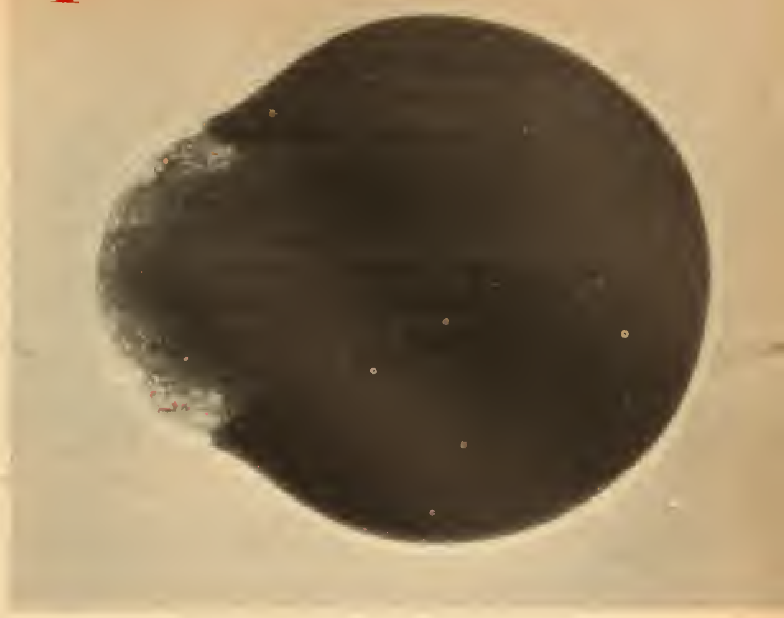
Watching Shrimp Hatch

Some of the eggs may start to split open six to eight hours after they are placed in the salt water. You may see a Shrimp forcing its way through the crack in the egg *(photo 1).* At this stage, the Shrimp is called a *nauplius.* If you look at an egg at this stage under the low-power microscope lens, you will notice that the nauplius is enclosed in a thin, clear covering.

After a few more hours, the pear-shaped nauplius squirms free of the egg, but it is still wrapped in the covering. If you look closely, you should see a red "eye spot," as well as the beginnings of "legs" *(photo 2).* These "legs" are really *antennae;* later on the Shrimp

(Continued on the next page)

1



2

3

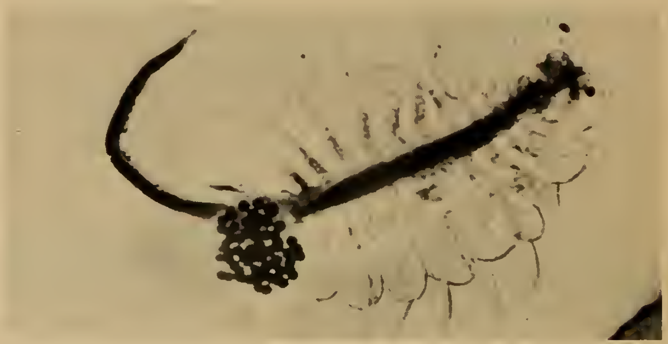
After a few hours in salt water, a Brine Shrimp begins forcing its way out of its egg (photo 1). As it squirms free, it is enclosed in a covering that partly hides its antennae and eye spot (photo 2). The Shrimp's antennae (photo 3) help it break free of its covering and are used as oars until the animal's legs develop.

will develop 11 pairs of real legs. The motion of these antennae helps the Shrimp to breathe. It also helps it to break out of its clear covering. The Shrimp will probably escape from its covering between 18 and 24 hours after the egg was put into the water. Then the Shrimp's three pairs of antennae serve as oars to move the animal quickly about in its salt water swimming pool *(photo 3)*.

To get a better look at a Shrimp, slow it down by draining its swimming pool. First, pick it up with a medicine dropper. Do this by squeezing the rubber bulb of the dropper as you bring the dropper's open end near a Shrimp. Then stop squeezing the bulb and the Shrimp will be sucked into the dropper along with some water.

Squeeze the Shrimp and some water onto a microscope slide, and soak up some of the water with a bit of napkin. Now the Brine Shrimp is free enough to wiggle but not to swim. You should be able to see it clearly with a hand lens or low-power microscope lens. How big is it?

Brine Shrimp are especially interesting to watch for the first few days after hatching. They shed their skins two or three times as they grow. You may even be able to keep the Shrimp alive until they produce more eggs. Keep only about 10 Shrimp to a quart of water. Remove the extras by picking them up with a medicine dropper and putting them in another container. For food, put about one grain of dried yeast in the container each day ■



This photo taken through a microscope shows a female Brine Shrimp with a cluster of eggs within her body. You may be able to keep Brine Shrimp until they produce eggs.

INVESTIGATIONS

● Some animals are attracted to light. Others turn away from light. How would you test the reaction of Brine Shrimp to light?

● Try putting about 10 or 20 Brine Shrimp eggs in several different kinds of water. Do you think that the eggs will hatch in *fresh* water? In water that has *iodized* salt in it? Also put the same number of eggs in water with half a teaspoon of salt, or with two *table*spoons of salt. You may think of some other mixtures. Keep all of the solutions at the same temperature.

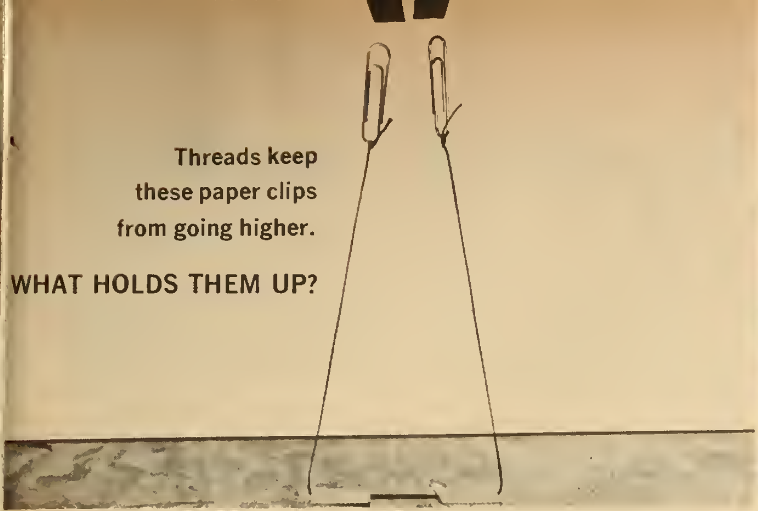
Do all of the eggs hatch? In which solution do the greatest number hatch? Do they hatch more slowly in some solutions than in others?

● Do you think Brine Shrimp would hatch in the dark? Or in cold water? Must they have air to hatch? To find out, set up six containers with two teaspoonfuls of salt (or sea salt), dissolved in a quart of water. Put about 20 eggs in each one. Then number the jars 1 through 6. Put jar 1 in a warm, light place. Put jar 2 beside it, but carefully pour salad oil on top of the water to shut out the air.

Put the next two jars beside the others, covering the surface of one with salad oil. Then cover both of them with black construction paper to keep light from the eggs. Finally, cover jar 5 with black paper and put it in a refrigerator. Pour salad oil on the surface of jar 6, cover it with black paper, and put it in the refrigerator too (see *diagram)*.

Check the jars every day for about two weeks. Which one seems best for hatching eggs? In which container do the eggs hatch first? Do they hatch in all of them?

Compare the containers that were warm with those that were cold. Does temperature seem to make any difference in hatching of eggs? Compare those in darkness with those in light. Is light needed for the eggs to hatch? Also compare those containers that were exposed to air with those that had oil on top of the water. Do the eggs need air to hatch? Did all of the shrimp that hatched stay alive the same length of time?



THE INVISIBLE PUSH AND PULL OF MAGNETS

SCIENCE WORKSHOP

■ The two photographs above might have come out of some magic book, but they are neither tricks nor magic. They simply show some of the fascinating things that you can do with magnets. You might even start a new art craze, called "magnart," by dropping iron filings on a sheet of paper with magnets arranged beneath it *(see page 16).*

You have probably played with one magnet before. But have you ever tried playing with two magnets? When you hold them one way, the magnets push away from each other. Held another way, they pull each other together. Yet the ends that push each other apart can pick up certain things. With a magnet, try picking up bits of wood, glass, rubber, paper, iron (nail or washer), steel (safety pin), copper (penny), and aluminum (foil). Write down what happens in the table below.

With a pocket compass you can find out certain things about a magnet. Tie a string to a magnet, then make the magnet spin around above a compass *(see diagram).* What happens to the compass needle?

Put a compass on a table and hold the magnet about three feet from it. Point one end of the magnet at the compass and slowly bring the magnet closer to the compass.

WILL A MAGNET PICK UP—	YES	NO	WILL A MAGNET PICK UP—	YES	NO
WOOD?			COPPER?		
STEEL?			PAPER?		
GLASS?			IRON?		
ALUMINUM?			RUBBER?		

Why do you suppose that a magnet *attracts*, or pulls on, some materials but not others?

The best place to find magnets for these experiments are hobby shops and hardware stores. You can also buy magnets by mail from Edmund Scientific Co., Barrington, N.J. 08007; Turtox Biological Supply House, 8200 South Hoyne Ave., Chicago 20, Ill.; Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, N.Y., or Ward's of California, P.O. Box 1749, Monterey, Calif; or Central Scientific Co., 1700 Irving Park Road, Chicago, Ill.

What does the compass needle do? Do the same thing again, but this time point the other end of the magnet toward the compass. What happens this time?

How Magnets Work

Take a close look at your compass. One end of the needle is colored, probably blue or red. This is the end that points north. This end is called the *north-seeking* end, or *north pole*. The other end is the *south-seeking* end, or *south pole*. The compass needle is a magnet, and every magnet—no matter what its shape—has a north and a south pole.

Mark the end of the magnet that attracted the north pole

(Continued on the next page)

of the compass needle. Mark it with a letter S. This end of the magnet is its south pole, because opposite poles attract each other. Mark the other end of the magnet N (for north pole). Did this north pole attract the south pole of the compass needle?

If you have another magnet, mark the ends (N and S) in the same way. Now bring the two north poles together, end to end. What happens? Hold the two south poles together, end to end. What happens? Now try to put one magnet on top of the other with the two north poles at the same end. This shows that magnetic poles of the same kind *repel*, or push away from, each other.

The tiniest particles, or *atoms*, of iron and certain other metals seem to have north and south poles, too. When these particles in a piece of iron are lined up, with their north poles pointing in the same direction, then the iron is magnetic. If the iron is heated or hammered, its atoms are knocked out of line and the iron loses its magnetism. So, never heat or hammer a magnet.

The Earth behaves like a huge magnet, with a North Magnetic Pole and a South Magnetic Pole. This is why a compass needle points north and south. The North Magnetic Pole is located in northern Canada and the South Magnetic Pole is in Antarctica. (The magnetic poles are not located at the North and South Geographic Poles.)

You can make your own compass by magnetizing a sewing needle. Hold a needle flat on a table and stroke the needle with one end of a strong magnet *(see diagram)*. Stroke the needle about a dozen times—always in the same direction. The needle is now magnetized. Stick the magnetized needle to a flat piece of cork or wood with a small piece of chewing gum or wax. Float the needle in a dish full of water. Does the needle point north and south?

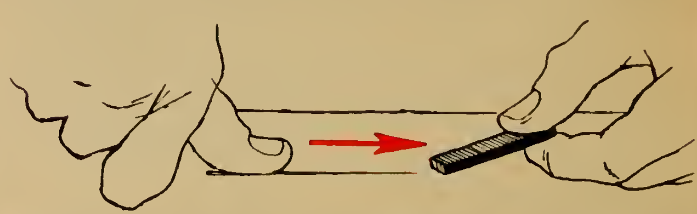
Make several of these small magnets and float them in the water. Push them close to each other. How do they act on each other? Do they act like the magnets you tried before? Find the north pole of each needle and color it.

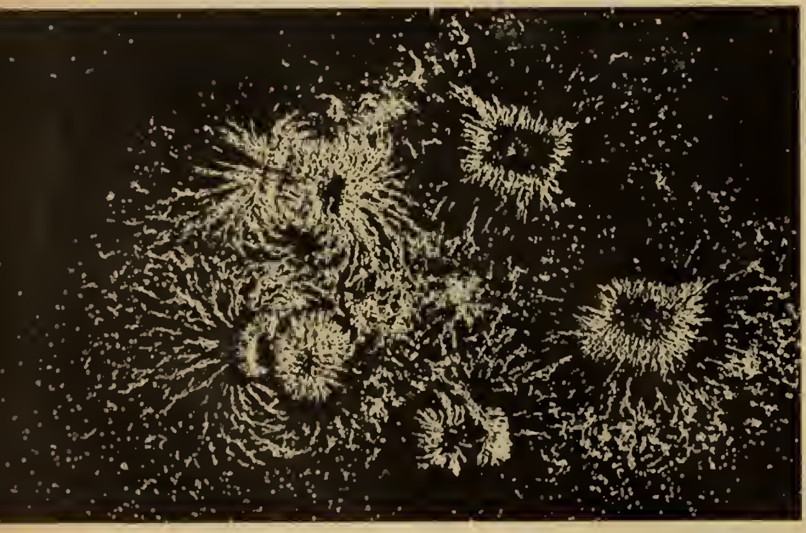
"Magnart"

You can also make magnet "maps," using a magnet and iron filings. Get some iron filings from a metal shop or by filing a large nail. You will need a lot of filings. Lay a sheet of smooth paper over a bar magnet and sprinkle the filings over the paper. Tap the paper lightly with your finger. What shape do the filings take?

When filings are put close to a magnet, they become temporary magnets, with temporary north and south poles. The filings line themselves up—north pole to south pole—along curved lines around the magnet. These curved lines are called *magnetic lines of force*. These lines of force surround a magnet and connect its north and south poles.

You can make many fascinating magnetic "maps," using two magnets in different positions under the paper. Preserve the "maps" by spraying the filings and paper with a clear plastic spray. Be careful not to spray too close. If you do, you may blow some of the filings out of place ■





You can make "magnart" pictures like these with several magnets, some iron filings, and paper. The pattern on the black paper was made with five disc-shaped magnets. The one on white paper was made with two horseshoe magnets.

nature and science
TEACHER'S EDITION

VOL. 2 NO. 15 / MAY 3, 1965 / SECTION 1 OF TWO SECTIONS

Science Clubs in Elementary Schools

by Lloyd Ulmer

■ Science clubs are an effective means of enriching classroom science experiences. While many people think of science clubs only in terms of the high school level, elementary school clubs have been operating successfully throughout the country.

Club activities such as individual experimentation, visits with scientists, science fairs, community projects, and field trips all help to give the developing youngster a real feel for science, rather than the "I'll take your word for it" attitude which often results from limited classroom experiences.

A science club may meet during the regular class period or after classes—at the school, or in a library, museum, laboratory, or private home. At some meetings, the members discuss old and new business and report on progress in both group and individual projects. The main program may be anything from individual experimentation by the members to a seminar led by a guest scientist. For special meetings and trips, discussions of club business are usually omitted.

One of the most successful activities of the elementary school science club is individual experimentation. At this age level, one is not required to work with the most complicated materials. Simple activities like planting seeds, watching them grow in different soil and light conditions, and collecting,

(Continued on page 4T)

Lloyd Ulmer is the Executive Secretary of Science Clubs of America.

PHOTO BY SCIENCE SERVICE

Each science club member experiences the joy and hazards of learning by doing.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

IN THE NEXT ISSUE

An amateur ornithologist tells how to study the little-known bathing habits of birds . . . The function of flowers and their parts . . . A WALL CHART shows how flowers are pollinated by wind, insects, birds, and —of all things—bats.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 Moon

For centuries men have tried to explain the origin of the Earth, Sun, Moon, and stars. The earlier attempts to do so were formalized as myths. Creation stories are found in nearly every culture that developed a mythology—from the Egyptian god Atum, the creator of all life, to the Zuni Indians' Sun-god myth.

Although some of the Greek scientists helped lay the foundations of modern cosmogony, it was the development of the telescope and the discovery, by Kepler and Newton, of certain laws of motion and force that provided the knowledge necessary to found present-day cosmogonic concepts.

As the article brings out, so far we have no fully satisfactory account of the origin of the Solar System. Among astronomers a number of theories are currently held, and are continually being revised or discarded as new findings are made.

Topics for Class Discussion

- *In what ways are myths different from scientific theories? How are the two alike?* Both are attempts to answer "big" questions. The events in myths are not meant to be verified, challenged, or contradicted. In origin, myths are imaginary and obscure, and in substance, they are generally unalterable.

A theory is founded on the basis of phenomena that can be observed and measured, and is subject to change in the light of new observations and measurements.

- *What is a "captured" planet or moon?* In astronomy, to be "captured" means to enter the gravitational field of another body and go into orbit around it.

- *Is it possible that one of the theories already advanced is true?* Yes, in principle, if not in detail. The dust-cloud theory described in the article is widely held.

Activity

To demonstrate the increase in rotational velocity of a gaseous spinning body, bring a revolving piano stool into the classroom and let the children take turns spinning themselves on it. Have them start with their arms outstretched, holding a book in each hand, and then have them pull their arms close to their sides. They will find that this makes them spin faster.

PAGE 12 Brine Shrimp

Brine Shrimp make ideal subjects for the ecological investigations described in this workshop. They are inexpensive and easy to obtain, develop rapidly, and require only simple equipment.

The class as a whole may profit from dividing up the experiments and working in teams. One group might concentrate on timing the hatching process, one on conducting the salinity test, another on carrying out the light, air, and temperature test.

Another group might experiment with vinegar, baking soda, and alcohol solutions. Your pupils may thus put their energies into careful observation and record-keeping. By drawing up charts and reports, each group can share its findings with the class.

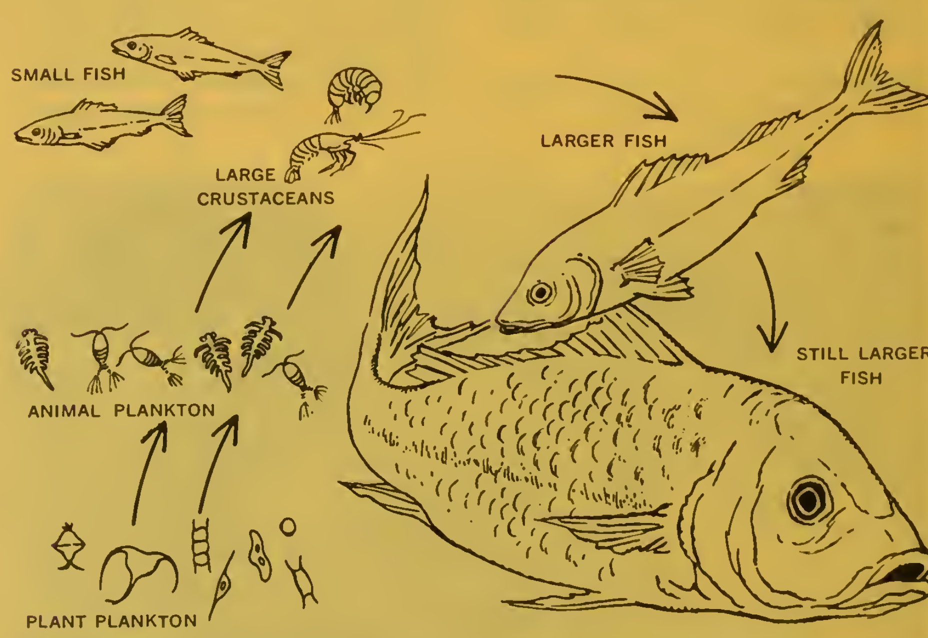
If no medicine droppers are available for transferring the Shrimp, drinking straws will do. Placing one's forefinger over the top end of the straw will draw up Shrimp along with a little water. Lifting the forefinger will release them again.

Topics for Classroom Discussion

- *What does "brine" mean? Is it an appropriate name for these Shrimp?* Brine is salt water. The class should learn from these investigations that brine is the ideal environment for these organisms.

- *What good are Brine Shrimp?* Aquarium keepers hatch the eggs to provide living food for their fish. In the ocean (and in salt lakes), Brine Shrimp serve a much more important function: They are a vital link in the food chains that change Sun energy into food energy in the form of large fish and other aquatic animals *(see diagram).*

(Continued on page 3T)



This diagram shows how Brine Shrimp and other small crustaceans fit into aquatic food chains. The tiny organisms at the start of the chain are called plankton.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . .
(Continued from page 2T)

• *Why should you keep no more than 10 Shrimp in a quart of water?* An excessive number of Shrimp would use up the oxygen supply and cause some to suffocate.

• Throughout the work encourage guessing by asking questions such as these: Do you think the eggs will hatch in all containers? Which ones do you think the eggs will hatch in first? Why? Have pupils record their guesses. Discuss the value of hypothesizing in science. Refer to the lead article in this issue. Then have your pupils compare the results of the experiments with their guesses.

PAGE 6 American Chestnut

In many respects, the conservation of our natural resources is like the practice of medicine. As your pupils read this article, encourage them to make comparisons between the work of plant pathologists and medical doctors. They will see that familiar elements of human disease are to be found in plant disease as well—infection, contagion, the search for a cure, and the need to develop resistance.

Topics for Class Discussion

• *Why are foreign insects and other organisms often more destructive to our native plants than to those of their own country?* Their native victims usually develop resistance through adaptation over a long period of time. Also, in their native homes, these organisms are kept under control by parasites and other natural enemies. These are usually left behind when the organisms are introduced to a new area.

Your pupils may have heard their parents complaining about Japanese Beetles. Parasites of these insects are being imported to help control them.

• *Does the chestnut blight fungus attack other kinds of trees?* Some plant diseases are associated with one species, some with several. The chestnut blight affects other trees, such as Post Oak and the Asian chestnut species, but usually does not kill them.

• *Are tree diseases really a serious problem in America?* Children hear a great deal about forest fire damage. Actually, the losses from forest insects and diseases are greater than those from fire. Many scientists believe the increase in world travel and trade is largely responsible. Foreign organisms can enter this country in furniture woods and packing materials as well as on live plants.

• *Why don't we just plant Asiatic chestnut trees, which are already resistant?* The foreign species may have no virtues other than their resistance to disease. Chinese and Japanese Chestnuts, for example, tend to have crooked trunks. Some species have small, bitter-tasting nuts. Some cannot survive winters in the northern United States. Botanists want to develop the best possible strains to suit local conditions and economic needs. By crossing them with American Chestnuts we may get an ideal tree.

Activities

• Investigate plant quarantine laws in your state by calling the Public Health Service. Can you legally transport house plants from state to state or bring home a wild shrub you might find in another part of the country?

• Investigate human fungus disease (ringworm and athlete's foot). How can it be prevented and treated?

PAGE 15 Magnets

Most of your pupils probably have had some experience with a magnet, but feeling the "push" or "pull" of two magnets held close together may be a new and surprising experience for them. By manipulating two magnets as suggested in this article, they can find out some of the basic principles of magnetic force.

In making the floating compass, have each pupil test the magnetism of his needle before sticking it to the cork. If the needle will not pick up some steel pins or paper clips, the rubbing process should be repeated. Make sure the pupil is not rubbing the magnet on the needle in both directions.

To achieve variety in the patterns of the magnetic "maps," use U-shaped horseshoe magnets as well as bar magnets. Try different combinations.

If you have difficulty getting enough iron filings to go around, you can use the same ones over and over by reproducing the patterns on blueprint paper. After the filings are lined up, put the paper in the sunlight for several minutes. Then remove the filings, wash the paper in water, and hang it up to dry.

Topics for Class Discussion

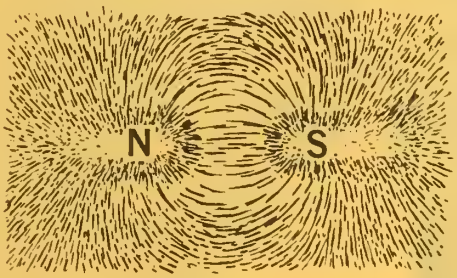
• *What made the sewing needle become a magnet when it was rubbed with another magnet?* We think that the strength of the magnet made the tiny particles of iron in the needle line up a new way, with their north poles all pointing in the same direction. (A broken magnet still works because each piece continues to have a north and south pole.)

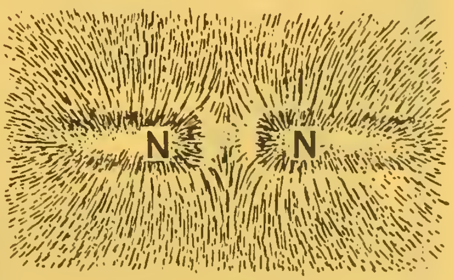
• *Why does the Earth seem to behave like a magnet?* Let your pupils speculate freely. Actually, no one knows for sure. One theory is that the core of the Earth may be made up of iron and nickel. Another holds that the rotation of the Earth has lined up all the iron molecules in one direction. Still another is that the core of the Earth may be rotating faster than the outer part, setting up electromagnetic currents within the planet.

Activities

• Have your pupils make "maps" of a bar magnet resting on each of its sides. Do the patterns look the same? Is the magnet *surrounded* by "lines" of magnetic force?

• Have your pupils make a "map" with the north pole of one bar magnet and the south pole of another held about an inch apart *(see diagram)*. Then have them make a "map" with the north (or south) poles of both magnets held about an inch apart. Do these "pictures" suggest why like poles attract each other and unlike poles repel each other?





Iron filing "maps" show the lines of magnetic force between unlike poles (left) and like poles (right) of two bar magnets placed about an inch apart.

Science Clubs . . .
(continued from page 1T)

identifying, and displaying rocks and fossils are most effective.

Inexpensive, self-contained experimental kits can be an invaluable aid. Working with his own materials, each member experiences the joys and hazards of learning by doing. A scientific self-confidence is developed as the youngster faces and answers problems without outside aid or dictated instructions. These experiences often lead to other investigations of the member's own choice.

Members of almost every elementary school science club participate in science fairs. Their projects are naturally less sophisticated than those of high school students, but they often indicate the basis of scientific thinking. The opportunity to show the results of their work to parents and friends is vitally rewarding to the youthful science club members.

The elementary school science fair is often held at PTA meetings, or at school assemblies where the club members present scientific skits or demonstrations. Several clubs report holding scientific "shows" with a small admission charge. The money is then used for club and school science equipment or for community projects.

Community projects in which these clubs engage include such things as landscaping, tree planting ceremonies, clean-up campaigns, setting up and maintaining aquariums and terrariums in the school and other public places, keeping daily records of weather conditions, and making and displaying posters dealing with health habits, safety, and scientific progress.

Members of junior or senior high school science clubs often help the sponsor with projects and activities for the elementary school club. Guest scientists give the young members first hand knowledge of how a scientist works and thinks. Later, when it is possible, the club may visit the scientist at work.

Many clubs have wooded areas within walking distance. Nature trails are laid out and marked by the club for the public to enjoy. In such an area, club members can observe the various kinds of insects and their different life stages, birds and their habitats, earthworms, trees, molds, other fungi, seed dispersal, types of weeds, ecology of the area, clouds, etc. Specimens are collected for later study.

Elementary school science clubs also take field trips to such places as the water purification plant, telephone exchange, creamery, bakery, fire and police departments, doctor's office, hospitals, industries, regional science fairs, zoos, museums, etc.

Many of the museums, in particular, offer special lectures, films, and exhibits for elementary school children. Some even lend specimens, models, and other aids to clubs for a week or more.

Science club members use libraries for research on individual projects and to compile reports on scientific subjects for presentation at meetings. Some libraries also lend films on scientific subjects for showing at club meetings.

Any teacher or adult working with a science club can affiliate, at no cost, with Science Clubs of America, Science Service, 1719 N Street, N.W., Washington, D.C. 20036 ■

nature and science

VOL. 2 NO. 16 / MAY 17, 1965

How do hummingbirds, bees, butterflies, and moths all help make more flowers?

see page 6

WHAT IS A FLOWER?

nature and science

VOL. 2 NO. 16 / MAY 17, 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

ABOUT THE COVER

The tiny bird hovering in mid-air on our cover is a Ruby-throated Hummingbird, one of about 12 kinds of hummingbirds living in the United States.

Hummingbirds sip sweet nectar from flowers with their long tongues. They also eat insects that are trapped in the nectar, or are attracted to it.

Sticky pollen from the flowers clings to the birds' bodies as they feed. They carry the pollen from flower to flower. When some pollen is accidentally rubbed off on a particular part of a flower, part of the pollen joins with eggs within the flower to produce seeds *(see page 6)*.

Hummingbirds are attracted to bright-colored flowers, such as the Trumpet Vine shown on our cover. Flowers that are pollinated by birds usually have no smell, since birds have a poor sense of smell. Such flowers also have no "landing places," since hummingbirds do not land to feed.

Hummingbirds are just one group of animals that carry pollen from flower to flower. Insects, especially bees, moths, and butterflies, pollinate many flowers. In tropical South America, there are even nectar-sipping bats that pollinate flowers.

To find out more about the amazing ways that pollen gets around, see the WALL CHART on page 8.

Contents

CREDITS: Cover, p. 2, drawing by R. G. Bryant; pp. 3, 4, 5, photos from U. S. Dept. of the Interior, National Park Service; pp. 4, 6, 7, 11, 12, 13, 14, drawings by Graphic Arts Department, The American Museum of Natural History; p. 8, photo by Lynwood M. Chace, from National Audubon Society; p. 9, corn photo from Standard Oil Co. of New Jersey, butterfly photo from AMNH; pp. 8, 9, drawings by Gaetano di Palma; p. 10, photos by Martin Slessers; pp. 12, 13, photos from Educational Services Incorporated; p. 16, photo by Joseph G. Abruzzo.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through December and February through May; monthly, September, January, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y. and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: **NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.**

THE MAN WHO SAVED THE YOSEMITE

by Vincent Edwards

Climbing high trees and high mountains was just one of the joys of John Muir. He loved the wilderness and helped save some of it for you to enjoy, too.

Yosemite Valley has many beautiful waterfalls and rock formations. This view shows Half Dome and the Merced River.

■ Quite a number of years ago, a young man stopped a stranger in the heart of San Francisco's business section.

"What is the quickest way out of town?" he demanded.

The other man looked at his questioner in surprise. "But where do you want to go?" he inquired.

The young man's answer sounded even more baffling: "To any place that is wild!"

This unusual remark would not have surprised anyone who knew the man who made it. In fact, it was quite typical of young John Muir.

Of all the men who have explored the American wilderness from the time of Daniel Boone to our day, probably no one ever loved the trackless wilds more than this sturdy Scotch-American.

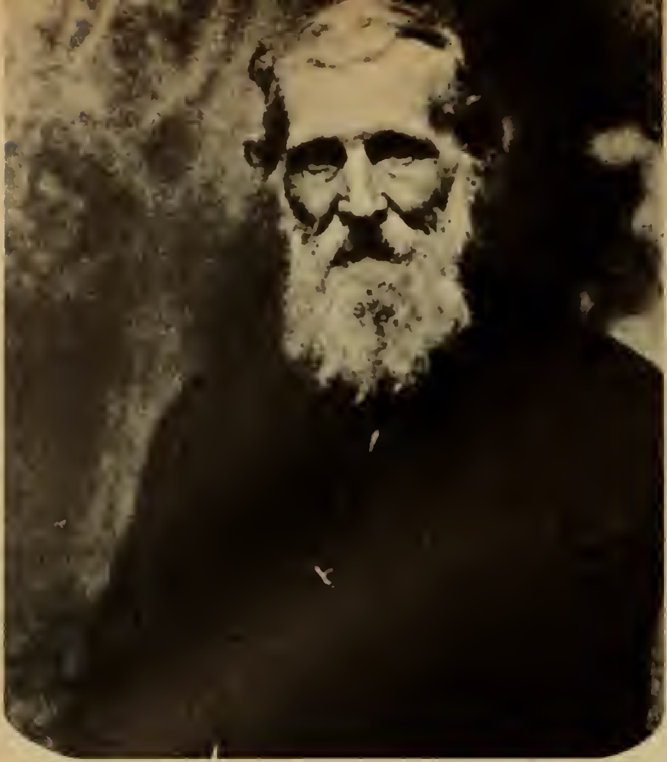
John Muir probably did more than any other citizen of the last century to help establish our national parks. Tens of thousands of people now visit Yosemite and Sequoia National Parks in California. But probably not one in 50 of the visitors is aware of what John Muir did to save these great wonders for the nation. If it had not been for him, the Coast Redwoods and the Big Trees, which are smaller Redwoods, might no longer be standing.

The Battle To Save the Redwoods

John Muir loved those mighty monarchs of the forest, and his anger was kindled when he saw them being destroyed rapidly by lumbermen. He knew that if the ruthless cutting of these trees went on, it would be only a matter of time before the country was stripped of its beautiful Redwoods. So he launched a fierce campaign to save them.

In his battle, Muir used many tools: books, articles, public speeches, and the influence of prominent people whom he knew. At first it was hard to get law makers to

(Continued on the next page)



This photograph shows how John Muir looked as an older man. He was born in 1838 and died in 1914.

The Man Who Saved the Yosemite (continued)

see his point of view. But a flood of petitions flowed into the nation's capital, begging Congress to stop the destruction of these majestic trees. As a result of this, Yosemite and Sequoia National Parks were created to be preserved for all people for all time. Other national parks and forests were set aside, especially after Theodore Roosevelt, an outdoor enthusiast himself, became President in 1901.

John Muir had won a great victory, but he took fame as casually as he did his long hikes through the woods. Nature lovers are delighted by his various books, *The Mountains of California, Our National Parks, My First Summer in the Sierra, The Yosemite,* and others.

People who made a hobby of outdoor living went out of their way to look him up, including such men as the famous naturalist, John Burroughs, and Theodore Roosevelt. To all these visitors the distinguished naturalist with his long beard and his sharp, twinkling blue eyes seemed like a stern but kindly father.

He was always glad to voice the philosophy that had been his lifelong enthusiasm. "I love the heights," he once declared, "where the air is sweet enough for the breath of angels, and where I can feel miles and miles of beauty flowing into me."

Climbing into the Wind

John Muir was never bothered by nature's changing moods. He once climbed to the top of a swaying pine in the midst of a terrific gale in order to feel the force of the wind as it struck. Then there was that moonlit evening when he was awakened by a severe earthquake. The sensation to him seemed "a strange, thrilling motion." But when he rushed outdoors upon the rocking ground, he came upon a man who was almost beside himself with panic.

"Come now, you must cheer up!" the naturalist cried. "You should smile and clap your hands, now that kind Mother Earth is trotting us on her knee to make us good!"

When Muir took off on one of his mountain journeys, he sometimes wandered for days without a gun and with no other provisions than bread, tea, a tin cup, a pocketknife, and an ax. The naturalist said that he could live on only $50 a year amid such surroundings.

One day he decided to take a walk near Mount Shasta. Before he started out, his landlady asked how long he would be gone.

"Oh, not long," Muir answered, "I expect I'll be back for luncheon."

He walked up to the timberline, then back again, and once more started up the mountainside. Before he knew it, night came, forcing him to find shelter on the lee side of a big log. The next day new snow formations near the summit attracted him. On the third day it was snowing, but Muir still did not want to go back. He began walking around the mountain. He came upon a Mexican sheepherders' camp where he was given food, and then he continued his journey around the mountain. By the time he returned he had been gone seven days and walked a total of 120 miles.

That feat, however, hardly compares with the trip he once took to study the trees of Siberia. He made a side trip up the Nile River, and visited Lebanon to see its famous cedars. On the way home by way of India, he spent another six weeks traveling into the high Himalaya Moun-

This map shows the locations of some of the places in California where John Muir roamed the wilderness.

tains. At Hong Kong he took another "little side trip"—this time to Australia. There, after a 2,600-mile journey by rail, boat, stagecoach, and foot, he visited the great forests of Eucalyptus trees.

Growing Up in the Wilds

John Muir was born in Scotland, but when he was only 11, his father came home one evening and announced to his family, "Bairns, you needna learn your lessons the night, for we're gan to America the morn!"

What excitement that news caused! The boy's head must have whirled at all the sights he saw in the next few weeks. First, there was the big ship that carried them across the wide, rolling ocean. Then, at last, they came to a city with a big harbor and ships and crowded streets. It was different from any place they had ever seen in Scotland. After that, there was a long trip westward by river boat and wagon to a great wooded country.

Mr. Muir brought his family to the new state of Wisconsin. It was lonely out in that wilderness, but young John loved it. He felt perfectly at home in the snug cabin of oak logs that his father built deep in the forest.

John was a sturdy lad, and was expected to do a man's work along with the others. Long before sunup, Mr. Muir would wake his wife and the children, and the toil for the day would begin. The forest had to be cleared, the fields had to be sown and hoed and harvested, a well had to be dug, and wood had to be gathered and chopped and piled up. Always, it seemed, there was something to do.

But John managed to find time to explore the woods. He never forgot the day that he and his brothers came upon a Blue Jay's nest with three green eggs. Then, at another time, the boys discovered a woodpecker's hole. There was no end to the wonders and surprises of the great outdoors.

John Muir never got over that spell. As long as he lived, he always felt at home in the wilderness. It was a hard life for so young a chap, toiling those long hours, from sunup to sundown, beside his father and his older brothers. But he found such delight in those outdoor wilds that his love for the woods became a lifelong passion.

When John Muir grew older, he attended the University of Wisconsin, but he did not stay to graduate. He could not resist the call of the out-of-doors. His first walking tours took him through Wisconsin, Iowa, Illinois, and Indiana, and into Canada. Then he hiked all the way to Florida, sleeping on the ground when night overtook him.

West to the Mountains

It seemed quite natural that John Muir would find his way at last to the land of the Big Trees. "Fate and flowers took me to California," he said in later years. He was only 30 when he went to California, but this new region became his supreme love. As long as he lived, the high mountains always held a magic spell.

The Redwoods are the largest trees on the Earth. One famous tree is 273 feet high and 3,500 years old.

At the age of 42 he married, and he spent the next 10 years managing a California fruit ranch. He was so successful during those 10 years that he was able to provide a permanent income for his family. Then he set out to travel.

His fame as a mountaineer spread far and wide. In the lonely climbs of his youth, in his daring explorations of Alaska's glaciers, he was without fear. He seemed to take dangerous chances, but he was always a careful man. "A true mountaineer never gets reckless," he once declared. "He knows or senses with a sure instinct what he can do."

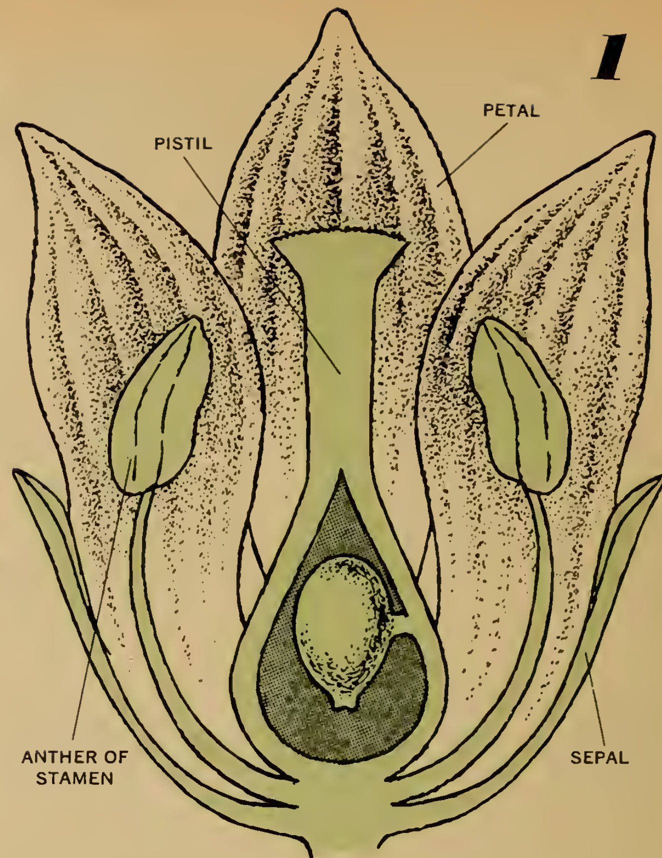
Although John Muir has now been dead for 50 years, nature lovers will long cherish his memory. He was well aware of what is today recognized by many people.

"Wilderness is a necessity," he wrote. "Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and cheer and give strength to body and soul alike."

Perhaps no man did more than John Muir in his time to awaken Americans to the beauty of their own country ■

■ To find out more about John Muir, look in your library or bookstore for these books: **Muir of the Mountains,** by William O. Douglas, Houghton Mifflin Co., 1961, Boston, $2.60; and **John Muir, Protector of the Wilds,** by Madge Haines and Leslie Morrill, Abingdon Press, 1957, Nashville, $2.25. Many of John Muir's fascinating experiences are told in his own words in **The Wilderness World of John Muir,** edited by Edwin Way Teale, Houghton Mifflin Co., 1954, Boston, $6.

WHAT IS A FLOWER?



The beauty and sweet smells of flowers sometimes makes us forget their real "job" —to produce seeds.

by Richard M. Klein and Michael Wirth

■ We are all familiar with flowers. We grow them in our homes and in our gardens, buy them at florists, and admire their beauty. But flowers are more than pretty things. Their beautiful colors and sweet smells have one "job"— to help plants produce seeds from which new plants grow.

The earliest plants had no flowers. They reproduced by *spores,* as mosses and ferns do today. The first plants with flowers developed about 180 million years ago. Most flowers have four main parts *(see diagram 1).*

The *sepals* are usually green and leaf-like. They protect the delicate inner parts from too much sunlight, from rain, and from other injury. In some plants, such as tulips and lilies, the sepals may be brightly colored.

The petals are the most noticeable parts of many flowers and are often brightly colored or white. The next time you see some flowers, count the number of sepals and petals. There are often the same number of sepals as there are petals. Scientists who study plants (called *botanists*) sometimes use the number of sepals and petals to separate different kinds *(species),* or even different families, of plants. The tulips and lilies have three petals and three sepals. Members of the mustard family, including the cabbages, have four petals and sepals.

Dr. Richard Klein is Curator of Plant Physiology and Dr. Michael Wirth is Research Associate in Quantitative Taxonomy, The New York Botanical Garden.

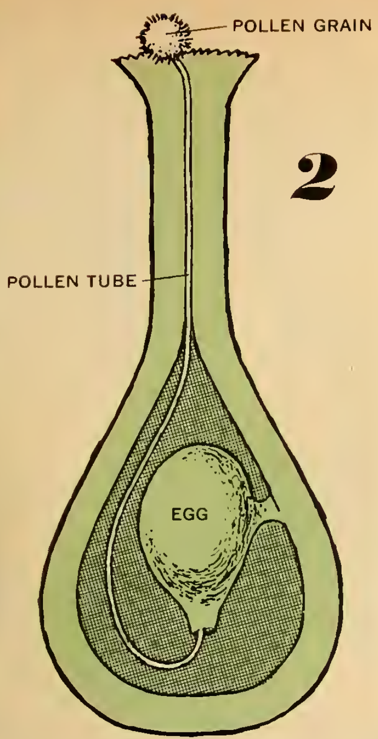
In some plants, such as poinsettias, the showy white, pink, or red structures are not petals, but leaves. The true flowers are small, yellow structures inside the colorful leaves. In chrysanthemums and other members of the daisy family, each "petal" is really a whole tubular flower. You can see this easily by breaking open a marigold when it blooms.

Where the Seed Begins

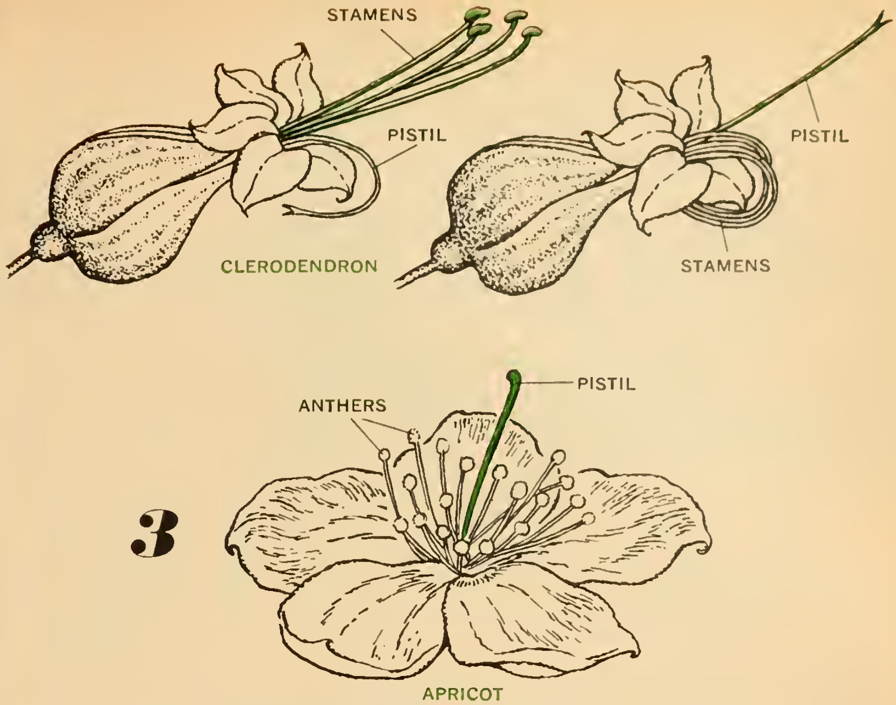
The seed-producing parts are inside the sepals and petals. There are two types, male and female. The male parts are called *stamens,* and are made of little knobs, called *anthers,* on top of thin stalks *(see diagram 1).* If you rub an anther, you will get a thin film of fine yellow powder on your fingers. This yellow dust is *pollen.*

The female part of the flower, called the *pistil,* is usually in the center *(see diagram 1).* The top of the pistil has a sticky surface that catches any pollen grains that fall on it. When a pollen grain from the same kind of plant lands on the sticky surface, the plant is said to be *pollinated.* The pollen grain grows into a tube that starts to grow down the stalk of the pistil *(see diagram 2).* When the pollen tube reaches the lower part of the pistil, some parts of cells, called *nuclei,* are released from it. When a nucleus enters *(fertilizes)* an egg within the pistil, the fertilized egg begins to develop into a seed.

Not all flowers look like the one shown in diagram 1.



3



A pollen grain grows down the stalk of a pistil until it reaches an egg *(diagram 2)*. When a nucleus from the pollen tube enters the egg, a seed begins to form. Diagram 3 shows two ways in which flower parts are arranged so that they are not pollinated by their own pollen. In Clerodendron *(top)*, the stamens and pistils ripen at different times. In Apricot *(bottom)*, the anthers and the top of the pistil cannot touch each other.

Some kinds of flowers are "incomplete"—with female parts in one flower and male parts in another. The pollen from the males is carried to the females by wind, water, insects, or birds. Even in flowers that have both male and female parts, the female parts are often located so that they cannot be pollinated by pollen from the same flower *(see diagram 3)*. When a flower is pollinated by pollen from another flower of the same kind, this is called *cross-pollination.* Early botanists discovered that cross-pollinated plants are usually bigger and more healthy than self-pollinated ones.

The Pollen Carriers

The form, color, and even the smell of a flower varies with the way it is pollinated. Many plants have special parts, called *nectaries,* which produce sweet liquids or odors that attract insects. As bees, butterflies, and other animals gather nectar or pollen for food or other use, some pollen grains stick to their bodies. The pollen is carried from flower to flower as the animal moves about and some of it is left on the pistil.

Nectaries give some flowers their pleasant smell, but remember that some insects are attracted to odors that we don't like. The Skunk Cabbage may smell awful to us, but its odor attracts the insects that help pollinate it.

Some flowers are small and inconspicuous and do not have brightly colored sepals and petals. Some may not have sepals and petals at all. These flowers do not attract insects. They are pollinated by pollen grains that float on the wind. These flowers usually produce huge amounts of pollen. Their pollen-catching parts are large and feathery so that they can catch and hold the wind-blown pollen.

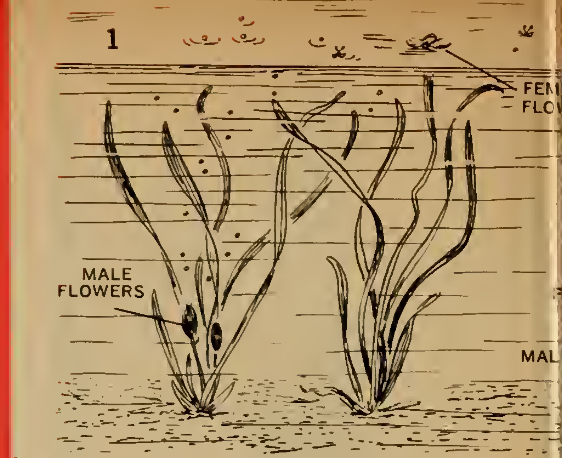
As flowers have developed over the years, some of them have changed until they are pollinated only by a certain kind of animal. Thus there are bumblebee flowers, butterfly flowers, and bird flowers, among others. The WALL CHART on the next page shows some of the fascinating ways in which flowers are pollinated ■

PROJECT

Look at the flowers of several different kinds of plants. Can you find the stamens and pistils? Try to find out how the plant is pollinated—by wind, water, insects, birds, or other animals. Does the shape and color of the flower's parts give you any ideas?

If you want to learn more about flowers, read these helpful books: **The Secret Life of the Flowers,** by Anne Ophelia Dowden, Odyssey Press, New York, 1964, 95 cents; **Plants of Woodland and Wayside,** by Su Zan Swain, Doubleday & Co., New York, 1958, $2.95; **Flowers: A Guide to Familiar American Wildflowers,** by Herbert S. Zim and Alexander C. Martin, Golden Press, New York, 1950, $1 (paperback); and **This Is a Flower,** by Ross E. Hutchins, Dodd Mead, New York, 1963, $3.50.

HOW POLLEN GETS AROUND

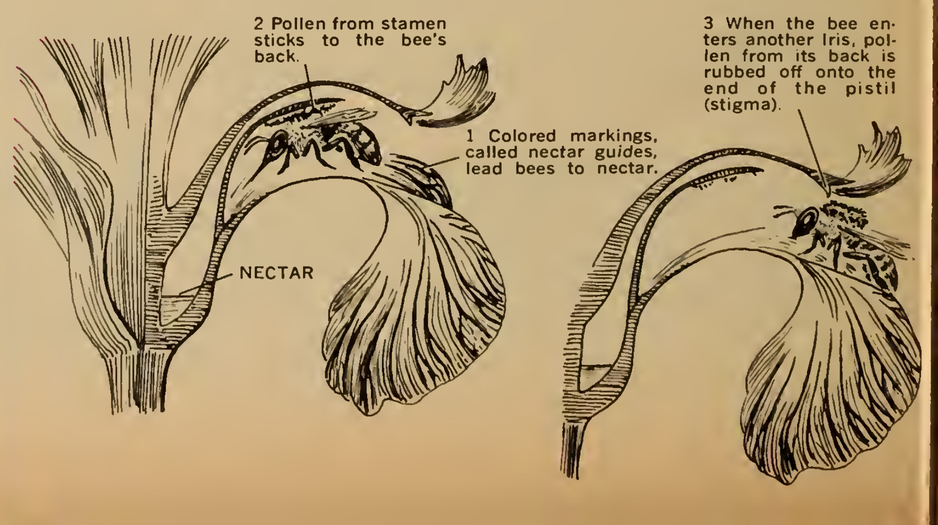


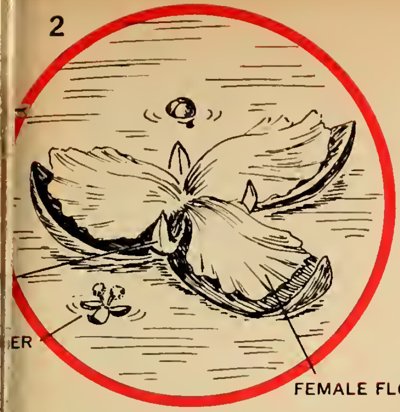
■ **Before a flower can produce seeds, a tiny pollen grain from another flower must land on it. Moreover, the pollen must land on a particular part of the flower, called the *pistil* (*see page 6*). Even then, the pollen tube will not grow unless the pollen is from the same kind (*species*) of flower.**

With all of these "rules," it doesn't seem likely that the right kind of pollen would reach many flowers. But it does, and the drawings and photos on these pages show the amazing ways in which pollen gets around. After studying this WALL CHART, try to figure out how the different flowers you see in gardens, woods, and fields are pollinated ■

ROTTING MEAT attracts some kinds of insects. They pollinate flowers that have the color and smell of decayed meat.

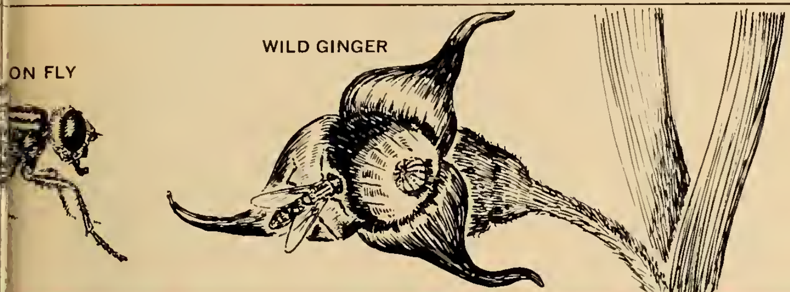
BEES pollinate many flowers. They have "hairy" bodies that pick up lots of pollen (*left*). They also visit many flowers in a short time. Bee-pollinated flowers have lots of sweet nectar and their petals have markings that lead the bees to the nectar. The drawings below show how a bee pollinates Wild Iris.

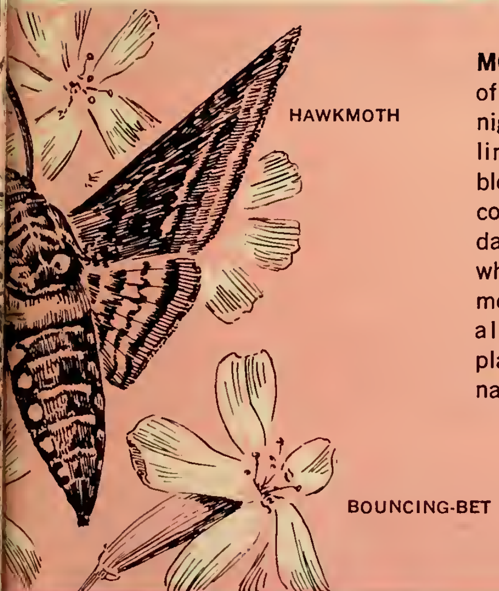




POLLINATION BY WATER is rare. These diagrams show how water plays a part in the pollination of a common aquarium plant called eel-grass (*Vallisneria*). Male flowers grow in underwater clusters (*diagram 1*). They break off one by one, rise to the surface and open. A female flower is pollinated when a male flower floats into touch with its pistil (*diagram 2*).

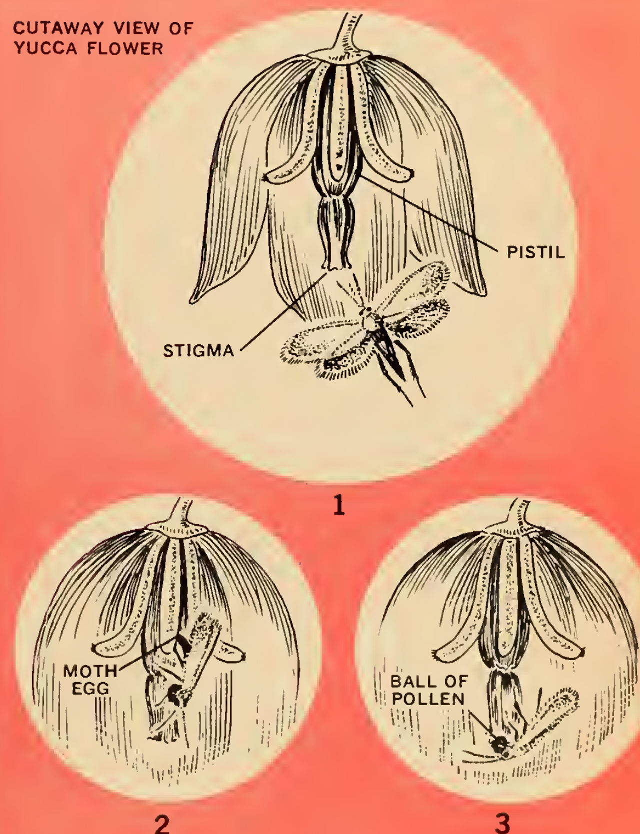
THIS MONARCH BUTTERFLY is sipping nectar from Orange Milkweed flowers. Butterflies are attracted by bright colors, especially red and orange. A butterfly must perch to sip nectar, so butterfly-pollinated flowers have landing places—large petals or many small flowers clustered together. As the butterfly sips nectar, pollen sticks to its legs and body and the pollen is then carried to other flowers.





MOTHS have a strong sense of smell and usually fly at night. The flowers they pollinate have strong odors, bloom at night, and are light-colored (easy to see in the dark). Moths feed on nectar while hovering in mid-air, so moth-pollinated flowers usually do not have landing places, unlike flowers pollinated by butterflies.

THESE FAMILIAR TASSELS atop corn plants are male flowers. Pollen from them is carried by wind to the female flowers, which is the "silk" you see on the top of ears of corn. Nearly all trees and grasses are pollinated by the wind. Their flowers usually have no bright colors, sweet odors, or nectar to attract insects. The petals and sepals are small or absent, so the lightweight pollen is easily carried from the stamen of one flower to the pistil of another flower.



ONLY ONE SPECIES OF INSECT, the Yucca Moth, can pollinate the Yucca plant of the southwestern United States. The female moth first gathers a ball of pollen. Then she enters a Yucca flower (*diagram 1*) and lays an egg inside the base of the pistil (*diagram 2*). Next she climbs to the end of the pistil and puts some of the pollen on its end, the *stigma* (*diagram 3*). She then flies to other Yucca flowers and repeats the process. Seeds develop in the pistil, and when the moth egg hatches, the larvae feed on some of the seeds until they are ready to escape.

How Does a Bird Take a Bath?

by Martin Slessers

I discovered that different birds bathe in different ways. Here is how you can study bird bathing habits and perhaps discover something new to science.

■ One bright March day I was hiking in the snow-covered hills of Maryland. Turning my back toward the wind, I climbed down a steep slope into a swampy valley. The valley is the source of a stream called Oxon Run.

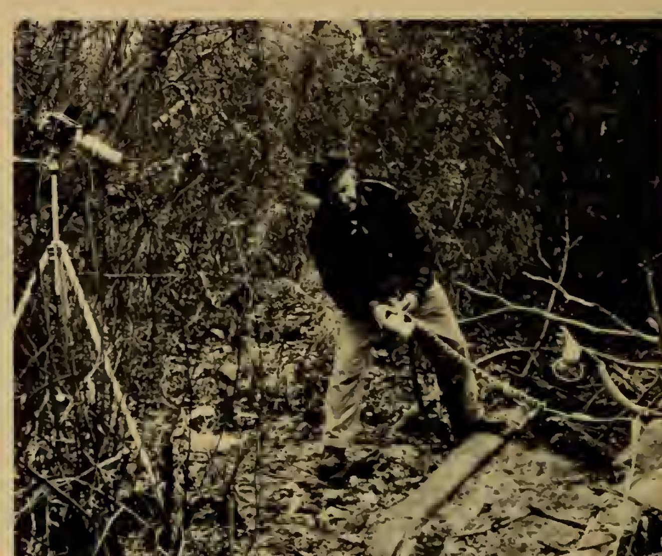
Suddenly, I heard water splashing. To my surprise, I saw a Song Sparrow bathing in a pool of water. Later that day I saw another Song Sparrow, a Cardinal, and two White-throated Sparrows bathing in water pools. Birds bathing in winter? It didn't seem possible.

I began searching in books and magazines to learn more about the bathing habits of birds. However, I could not find any information. It seems that very little is known about the bathing habits of birds. I decided to try to discover more about them myself.

How Birds Bathe

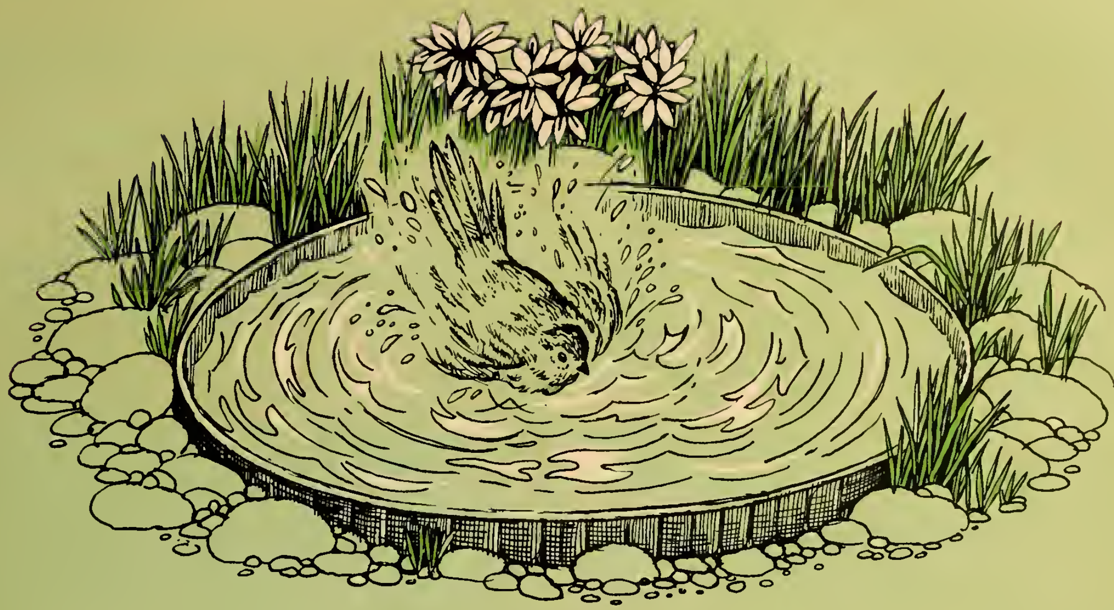
I started roaming the fields and woods in winter, spring, summer, and fall. Every weekend, holiday, and vacation was spent at the source of Oxon Run, at a lake in Ontario,

(continued on page 12)



Besides watching the bathing habits of birds, the author set up camera and flash equipment to photograph birds as they bathed. He hid about 30 feet away from this bathing pool and tripped the camera shutter by remote control.

Observe Bird Bathing in Your Area



So little is known about the bathing of birds that you may make some important discoveries. Spring is the best time to start your studies. You can make observations all through the summer.

First, find a good location for your observations. Roam the fields, parks, and woodlands near your home. Pay special attention to small water basins, such as springs, streams, ponds, and muddy water pools. Remember that birds usually bathe in a protected area.

If the surroundings offer good protection for birds but the water is more than three or four inches deep, make it shallower by putting gravel or sand on the bottom. You can also use a ring of rocks or a log to separate the selected spot from deeper water. If you find a good bathing place for birds that is not well protected, add some branches or brush for shelter.

When you have picked a spot, find a hiding place in nearby bushes or trees. Improve it if necessary by adding a few branches or some inexpensive cloth. The closer you are to the bathing place, the better you should be hidden and the less you can afford to move. In partly open places, you should not be closer than 30 feet to the bathing place. You might spread seeds on the ground near the bathing spot to attract birds.

If you want to observe bird bathing in your own yard, make a bird bath yourself. Any large-size tray made of clay, metal, or even plastic can be used. A top from a garbage can makes a fine bird bath *(see diagram).* The depth should vary from one to two or three inches. Select a well protected place or add a few branches to make the area attractive for birds. Use sand or gravel to regulate the depth in the bath. Find out which kinds of birds use shallow water and which use the deeper spots.

Place one or several sticks in a horizontal or slanting position near and slightly above the water. The distance between the sticks and the water may vary from one to 10 or more inches. Watch to see how different kinds of birds use the sticks. Do they use them as springboards for diving and dips, or as resting places?

Keep records of your observations in a notebook. Jot down the kinds of birds you see in the area, the time of day they bathe, and how long they bathe. Do some birds bathe more often than others? Count and jot down how many times the bird rolls in the water and pauses.

Keep a record of the time of day when birds bathe. Also keep notes on the temperature and weather to see how this affects bird bathing. Notice the ways in which different kinds of birds bathe. (For information on identifying birds, see the article "How To Spy on Birds," N&S, October 19, 1964, and the books listed with it.)

Find out the name and address of the bird study group in your area. Many such groups publish magazines and they may be interested in publishing the results of your observations.

Canada, or at a muddy cattle pond on Long Island, New York. With time, I learned to find the places that birds chose for bathing. I also learned how important a bath is to some birds. During dry spells, or in areas where water is scarce, the birds use any type of water for bathing, even muddy pools.

Birds seem to prefer clean water running over gravel and pebbles, especially if the water is well protected with bushes or trees. If clean water is not protected, the birds are apt to bathe in muddy water that is protected. Thus "safety first" is the rule. The photographs I have taken at speeds of from 1/2,500 to 1/6,500 of a second show that the eyes of birds are closed for a few seconds as they bathe. They cannot see what happens around them, so protection from their enemies is important.

I have also learned something about the ways in which different birds bathe. Most birds, like sparrows, finches, Cardinals, Mockingbirds and others, first land on the ground or on a root at the water's edge. Then they wade into water. If it is shallow, they settle down and let the water cool the lower parts of their bodies. Then they fluff their feathers so the water reaches their skin.

At other times the birds whip the water gently with their wings and roll their head and neck in the water for a few seconds. When a bird is ready for a deeper plunge, its whole body is rolled from one side to the other in the water.

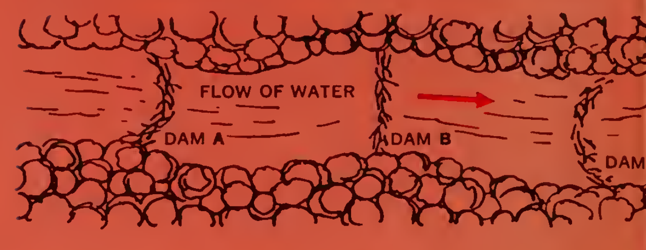
The feathers of birds do not cover their whole body, like shingles on a roof. Instead, the feathers are arranged in groups with bare spaces between groups of feathers. When the body is dipped into the water and rolled, the water flows through the bare spaces and among the groups of feathers. Then the bird pauses for a few seconds and shakes the feathers back and forth, or *vibrates* them. The water is squeezed through them and rinses the skin. The bird repeats the rolling of its body and the vibration of its feathers until its skin is clean. The water is then shaken off. As the feathers dry, the bird oils and arranges them with its bill. The oil is taken from glands above the base of the bird's tail.

A different type of bathing is practiced by White-eyed and Red-eyed Vireos. They alight on a branch of a tree or bush near the water and use it as a springboard for diving into the water. Chickadees and Yellowthroats take short and rapid dips into water. They leap from one pebble or root to another, now in, now out of the water. Some other birds, such as woodpeckers and swallows, seldom bathe.

These are a few of the things I've learned after six years of part-time study. There are still many unanswered questions about the bathing habits of birds. Perhaps you can discover something new about bird behavior this summer ■

brain

1. Beavers build most long dams in a certain shape. Wh of the three dams below would be the best? Why?



2. What is it? (Hint: It is a part of some animal.)

3. Most of an iceberg is beneath the surface of the wa *(see diagram)*. Make some drawings to show how an i berg would look if . . .

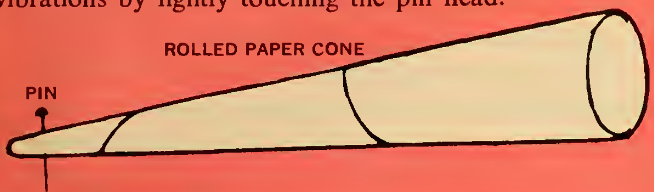
a) ice contracted when it froze instead of expanding.
b) ice expanded to twice its size when freezing.
c) the iceberg were in fresh water instead of the ocea

boosters

These Brain-Boosters are based on articles that have appeared in the past seven issues of *Nature and Science*. You may have to experiment, though, to answer some of the questions.

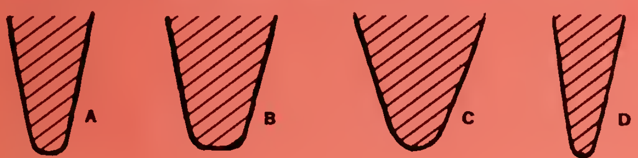
prepared by **DAVID WEBSTER**

4. You can make a speaker for a record player from a paper cone and a pin *(see diagram)*. Put an old, worn-out record on a moving record player and hold the pin point in a groove. Can you hear anything? See if you can feel the vibrations by lightly touching the pin head.

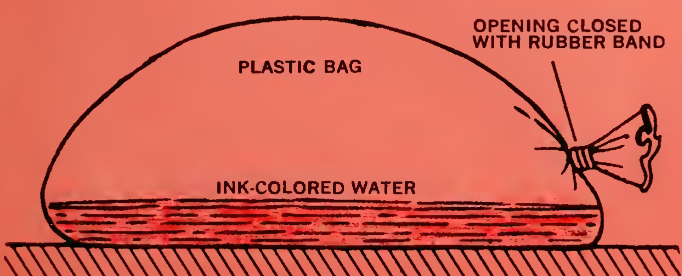


5. What makes the hands of this clock move?

6. Here are some drawings of points seen through a microscope. Can you identify them? If you have a microscope, look at different kinds of points yourself. Which is: a pin? a rose thorn? a ball-point pen? a sharp pencil?

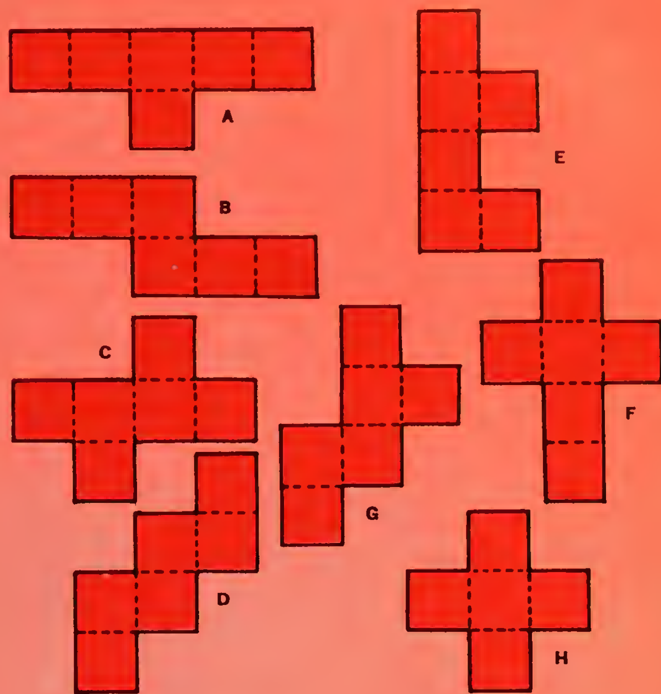


7. The sketch shows a plastic bag with a little water in it. When the bag was put in the Sun, little drops formed on the inside of the bag. If the water had been colored with ink, would the drops be clear or ink-colored? If you are not sure, try it.



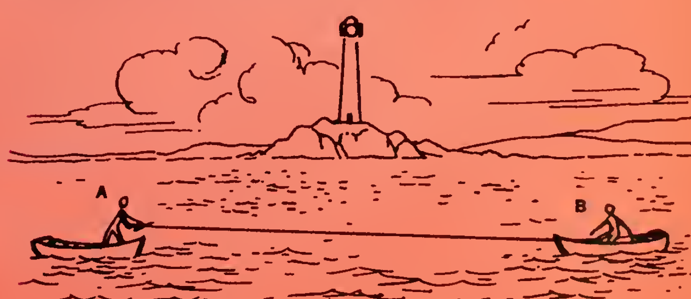
8. What would happen to some soil if you left it overnight in your freezer? What is in soil that causes this change?

9. Did you try making any of the polygons described in issue No. 12? Below are different ways of folding paper into a cube. Can you figure out which of these will fold into a cube and which will not? If you are not sure about some, get some paper and try them.

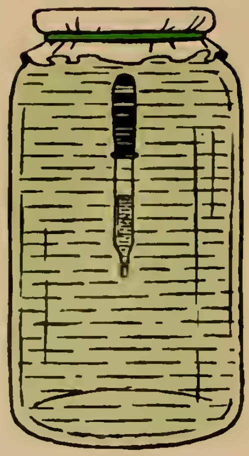


10. How can you remove mud from water without filtering? To find out, make some muddy water and let it sit for a few days. What happens?

11. Two boys are in different boats and have a rope between them. Suppose the boy in Boat A pulls in the rope while the boy in Boat B just holds on. Where would the two boats come together? What would happen if each boy had pulled in the rope at the same time?



NOW IT SINKS, NOW IT FLOATS



■ Have you ever wondered how a fish can "float" at any depth in a fish tank without moving its fins even the slightest bit? By making something called a *Cartesian diver* you can find out.

Get a clear, wide-mouthed glass bottle that holds about a quart, and fill it with water. Then draw some water into a medicine dropper so that the glass part of the dropper is about half full. Lower the dropper gently into the jar of water. If it sinks, lift it out and squeeze two or three drops of water out of it. If it floats too high, lift it out and draw a little more water into it.

You want the dropper to just barely float. You can tell when it has just the right amount of water in it, because a very gentle poke will make it sink, then it will slowly rise by itself. Your medicine dropper, by the way, is the Cartesian diver, named after the 17th century French scientist Rene Descartes.

Stretch a piece of thin rubber, from a balloon or the flat part of a rubber glove, over the mouth of the jar. Hold the piece of slightly stretched rubber in place with a strong rubber band around the mouth of the jar *(see diagram).*

Now press gently on the rubber over the mouth of the jar. What happens to the diver? When you take your finger away, what does the diver do? Why does this happen? Hint: There is some air in the diver. Air can be squeezed, or *compressed,* so that a given amount takes up less space. Water cannot be compressed so that a given amount takes up less space.

What happens when you press the covering? What does this do to the water in the jar? What does the water do to the air in the diver?

A fish has an air bladder inside its body and can control the amount of air in its bladder. In what way is your Cartesian diver like a fish? ■

ANSWERS TO BRAIN-BOOSTERS IN THIS ISSUE (page 12)

1. Dam C is the strongest shape. As water pushes against a dam of this shape, it is forced tighter together. What shape are man-made dams?

2. The photograph shows part of a beaver's tail.

3.

4. You should be able to feel the vibration of the pin caused by the grooves on the record.

5. The face of the clock is made of clear plastic and has gear teeth on the edge. (The teeth are hidden by the metal frame.) A small gear in the base of the clock moves the plastic disc at a speed of one turn per hour. The minute hand is attached to the disc. Behind the middle of the disc is a gear and balance arrangement which moves the hour hand at the proper speed.

6. The points are: A–pin; B—sharp pencil; C—ball-point pen; D—rose thorn.

7. The water drops in the bag of ink water would be clear. Can you find some way to color the water to make colored drops?

8. Soil in a freezer becomes extremely hard because the water in the soil turns to ice. If soil were completely dried out before being frozen, would it still get hard?

9. These patterns can be folded into a circle: B, C, D, F, and G.

10. Mud can be removed from muddy water by allowing the water to sit awhile undisturbed. The clear water on top can then be skimmed off.

11. The two boats would meet about in front of the lighthouse, whether one boy pulled or both boys pulled. What would happen if one boat were a lot bigger than the other one?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The rock was worn down by sand blown by the wind. In which direction do you think the wind usually came from? Can you guess in what part of the country the rock was found?

Can You Do It? To make the loop of thread circular, place a drop of soap on top of the water enclosed by the thread. The loop should immediately become perfectly round.

What Do You Think Would Happen? As the ice cube in the cooking oil melts, the water stays on the bottom. Why doesn't the water float to the top of the oil?

Fun with Numbers and Shapes: The pile contained 22 cubes.

For Science Experts Only: If you measured the distance you could jump in the moving train on the floor of the train, it would be about the same whichever direction you jumped. If you measured the distance on the ground, however, you would go farther when jumping in the direction that the train was traveling.

nature and science

INDEX

July 1964 through May 17, 1965

(Volume 1, Numbers 17, 18; Volume 2, Numbers 1-16)

WALL CHARTS

SCIENCE WORKSHOPS

HOW IT WORKS

Moving Pictures

■ The pictures you see on a movie screen show people and things moving as they do in real life. But if you look at a strip of movie film, you will find it is made up of many little "still" pictures, called *frames (see photo).* What makes these still pictures seem to "come to life" when they are shown through a movie projector?

The frames next to each other on a strip of movie film seem almost alike. But if you look closely at the frames of movie film shown on this page, you can see that the donkey's legs are in slightly different places in each frame. These pictures were taken just one-sixteenth of a second apart as the donkey walked along the street.

With a snapshot camera, you could take a single still picture of the donkey at any instant in his walk *(see "How It Works—Camera and Eye,"* N&S, *Oct. 5, 1964).* But by the time you were ready to take another picture, the donkey would have taken several more steps. A home movie camera has a wind-up spring, or a battery-driven electric motor, that makes it take one picture after another. It takes 16 separate pictures each second!

When you press the trigger of a movie camera, the spring or motor pulls a "fresh," or *unexposed,* part of the film into place behind the lens. When the film stops moving, the shutter opens to let the light coming through the lens strike the film. Then the shutter closes and the film is moved again. (The shutter is a metal disc with holes around the edge. It turns just fast enough to let light reach the film only when the film is not moving.) The pictures are taken so rapidly that they show the donkey's legs in several different positions during each step.

After all of the film has run through the camera, it is taken out and developed.

When you see a movie film projected on a screen, your eye seems to see motion. But here is what actually happens: A very bright bulb shines light through the film and out the lens to a screen. The film moves through the projector in 16 quick jumps each second, so that one frame is flashed on the screen at a time. A shutter like the one in a movie camera blocks out the light while the film is moving. If the projector ran slow enough, you could see the screen go black between frames. Because the projector shows the pictures one after another in such quick jumps, your eyes don't see the black between frames. And to your eyes, the slight movement of the donkey's legs from one frame to the next becomes a smooth, "real life" step ■

nature and science
TEACHER'S EDITION

VOL. 2 NO. 16 / MAY 17, 1965 / SECTION 1 OF TWO SECTIONS

SUDDENLY–it's vacation time. For three months, the young people you have been teaching will have many more hours each day to spend as they please. Many of the articles published in N&S this year suggest activities that can be pursued with fun and satisfaction during the summer. Your pupils might get some useful ideas from the following "bulletin board" list.

Things To Do This Summer

HAVE YOU TRIED–

- WATCHING how different kinds of spiders spin their webs and capture insects in them? Collecting different kinds of webs? (N&S, *Oct. 5, page 3*)
- EXPLORING a rotten log to see what kinds of animals live in and on it? (N&S, *Oct. 5, page 12*)
- FINDING out what kinds of birds, and how many of them, live in your neighborhood? Watching birds to see how they get food, build nests, lay eggs, care for their young, take baths, and behave toward other birds? (N&S, *Oct. 19, page 10, and May 17, page 10*)
- LOOKING for animal tracks, drawing pictures of them, and finding out what kinds of animals made them? (N&S, *Dec. 7, pages 6 and 8*)
- CATCHING some treefrogs and setting up an aquarium home for them over the summer? (N&S, *April 5, page 10*)
- KEEPING turtles and studying how they live and behave? (N&S, *Jan. 18, page 6*)
- RAISING Brine Shrimp from eggs? (N&S, *May 5, page 12*)
- GETTING and using a microscope to study parts of leaves, flowers, insects, and other tiny creatures? (N&S, *Dec. 7, page 10; March 15, page 14*)
- EXAMINING different kinds of flowers to find out how their parts are shaped? Figuring out how different kinds of flowers are pollinated? (N&S, *May 17, pages 6 and 8*)
- EXPERIMENTING with plants to find out how light and gravity affect the way they grow? (N&S, *Nov. 2, page 3; Jan. 18, page 13*)
- EXPLORING the soil in different places to see what kinds of things are in it, and how deep the top soil is? Finding out what rain and flowing water do to soil? (N&S, *Feb. 15, page 15*)
- INSPECTING the land, streams or lakes, and air in your neighborhood and around your town to see whether they are being used in ways that will save them from erosion or pollution? (N&S, *April 19, page 8*)
- CLEANING up the land in your neighborhood? Planting trees along a stream to stop the banks from washing away? Making bird feeders and animal shelters? (N&S, *April 19, page 13*)
- LOOKING for American Chestnut trees that may have survived the chestnut blight, to help scientists develop trees that will resist it? (N&S, *May 5, page 6*)
- MAKING a sundial? (N&S, *Oct. 19, page 15)* A water clock? (N&S, *March 1, page 16)* Regular polygons? (N&S, *March 15, page 11)* Your own codes and ciphers? (N&S, *Jan. 18, page 10)* Magnet maps? (N&S, *May 15, page 15)* An electroscope? (N&S, *Feb. 1, page 15)* Wave patterns with a pendulum? (N&S, *Nov. 2, page 13)*
- TESTING colors to see which ones soak up the most heat? (N&S, *Sept. 21, page 11)* Testing your sense of touch? (N&S, *March 15, page 16)* Measuring how much water is in a piece of apple? (N&S, *Feb. 15, page 14)*

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● The Man Who Saved Yosemite
The story of John Muir will help awaken your pupils to the natural beauties of their country and the pleasures of outdoor life.

● What Is a Flower?
Flowers produce the seeds from which new plants grow. This article explains how the process takes place.

● How Pollen Gets Around
This WALL CHART shows some of the ways different kinds of flowers are pollinated and suggests an interesting investigation for your pupils.

● How Does a Bird Take a Bath?
Little is known about the bathing habits of birds. Your pupils might discover something new.

Now It Sinks, Now It Floats
By making a Cartesian diver, your pupils can find out how a fish floats at different depths.

How It Works—Moving Pictures
A movie camera takes many "still" pictures of a moving object. When the pictures are shown in rapid succession, your eyes see "motion."

A REMINDER...

The two special summer issues of *Nature and Science* contain many fascinating and instructive summer activities for your pupils. The first issue ("Astronomy") and an order blank were sent to you with issue No. 13. The second issue tells how to explore life around a pond. To assure that your pupils receive their first summer issue on schedule, your group order should be in the mails by May 15.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 3 John Muir

While others have stressed the "wise use" or reclamation of natural resources, John Muir was concerned with the *preservation* of wilderness in its primitive state. It was his particular dream to lead men to the realization that they are children of nature.

In the fall of 1964, Dr. R. Dalton Muir, a naturalist in the National Parks Branch of Canada's Department of Northern Affairs and National Resources, voiced this thought in a lecture at the Smithsonia Institute: "This, then, is the reason and justification of national parks: to provide a secure refuge where the natural world can function undisturbed so that mankind will always have a true point of reference whenever questions arise as to his place in nature. Even if no question is at stake, man must have a place to go to re-establish his personal relation with the half of his being which is rooted in the natural world."

It is hoped that the story of John Muir will inspire your pupils to a greater awareness of the beauties and pleasures of outdoor life and to an adventurous approach to places off the beaten track.

Topics for Class Discussion

- *What is the difference between a national park and a national forest?* Your pupils will find that in a national forest some lumbering, grazing of domestic animals, and commerce is permitted; in a national park the plants and wildlife are less disturbed.
- *What is a "redwood?"* There are two species of redwoods–the Coast Redwood, and the Big Tree that grows in the Sierra Nevada. The Coast Redwood is the taller of the two. Until recently, the redwoods were thought to be the oldest living plants. However, some Bristle Cone Pines are older.
- *What problem threatens the redwood trees of northern California?* Only about 100,000 acres of redwood forests are in public parks, and they are threatened by highway construction and by floods. The trees in only about half of this area have never been cut. A Redwood National Park has been proposed. Current issues of conservation magazines, such as *National Parks,* carry information on this problem.

PAGE 6 What Is a Flower?

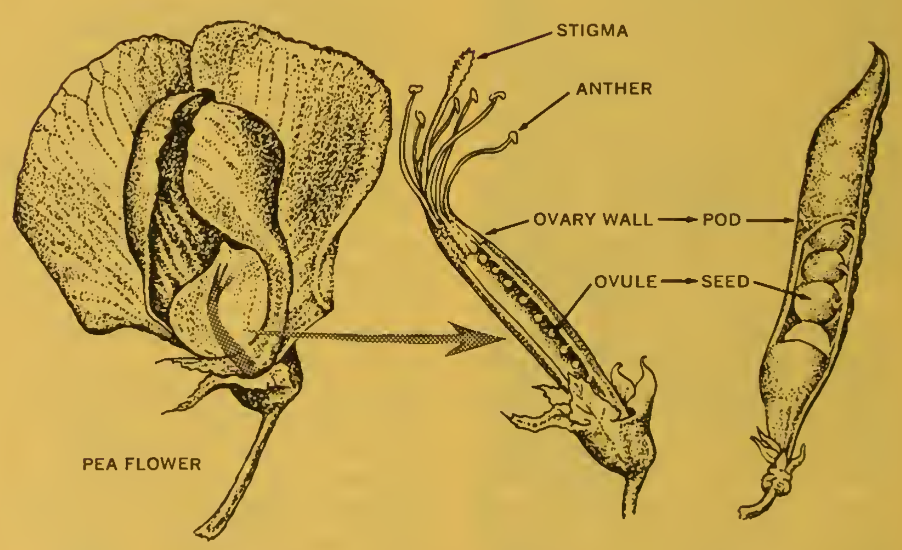
A study of pollination helps to emphasize the inter-relationships that exist between living things and their environment. Through this article and the WALL CHART on page 8, your pupils will see how certain plants become dependent upon certain insects or birds and how other plants may depend upon the wind for pollination. Point out that flowers have gradually changed, or adapted, to a particular kind of pollination. This has probably taken millions of years.

THIS IS THE LAST ISSUE of *Nature and Science* for this school year. All of us who have had the pleasures of creating and producing the magazines—advisers, consultants, editors, and authors — wish you a very pleasant and stimulating summer and hope to serve you again in your classrooms next September.

Suggestions for Classroom Use

- Before your pupils read the article, have them try to answer the question in the title. Although we take pleasure in flowers, their true function has nothing to do with man.
- A number of technical words have been introduced in this article. Help your pupils see that, once learned, they are the simplest way of describing the various flower parts—just as we have specific names for the parts of our faces (eye, nose, mouth, cheek, etc.). You may want to add these words to the week's spelling list. Some

(Continued on page 3T)



These diagrams show how parts of a pea flower develop into the seeds and pod. The wall of the ovary becomes the pod; the ovules become the peas (seeds).

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June, and July (June and July special issues). Second Class postage paid at Garden City, N. Y., and at additional office. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

Using This Issue . . .
(continued from page 2T)

pupils might look up their Greek and Latin meanings.

Topics for Class Discussion

• *What is the "job" of the sepals and petals?* Just as the "job" of the whole flower is to produce seeds, each part has its specific function. When present, the sepals and petals provide protection for the delicate reproductive organs. In cross-pollinated flowers, they usually attract insects or birds by their showy colors or inviting fragrance. *Have your pupils consider why some flowers, such as honeysuckle, become more fragrant at night.* (To attract night-flying moths.)

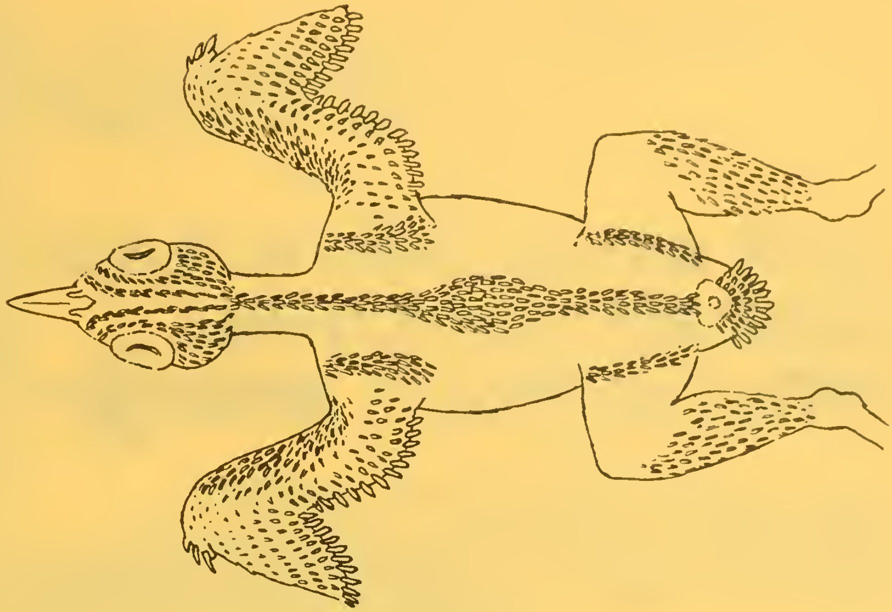
• *How can we tell if a flower is wind-pollinated?* These flowers are not especially colorful or fragrant. Usually they have no sepals or petals, and they have huge amounts of pollen to compensate for the hit-or-miss method of distribution. Many trees and most grasses are pollinated this way.

• *Do lawn grasses have flowers? How about potatoes, carrots, radishes, and lettuce?* These are all flowering plants, although most of them are usually cut or harvested before blooming.

• *Does a plant have to be pollinated to live?* No. The individual plant usually lives on (unless it is an annual), but produces no new plants through seeds. Some kinds of plants can reproduce themselves without seeds. Have your students look up information on *vegetative reproduction* (plants growing from bulbs, cuttings, leaves, and so on).

• *What does the weatherman's term "pollen count" mean?* A pollen count is frequently included in weather reports during the summer. It indicates the relative amount of pollen present in the air on any particular day, and is of interest to people who are allergic to the protein content of some pollens. This pollen comes from wind-pollinated plants, such as grasses.

• *What happens after a flower is pollinated?* As the article points out, the egg or eggs (ovules) within the pistil develop into seeds. The ovary that surrounds the ovules becomes the fruit. (In the botanical sense, the word "fruit" includes the things we call vegetables.) The diagrams on page 2T show how the parts of a pea flower become parts of the fruit.



Feathers grow in groups, called feather tracts, with bare spaces in between. As birds bathe, water reaches the bare spaces and is squeezed through the feather tracts.

Activity

• Look at pollen from a number of different flowers under a microscope. Are the particles smooth, or do they have spikes or little wings? Do the particles seem dry or sticky? Have your pupils cut open pistils and examine the ovules inside.

PAGE 10 Birdbathing

At one time ornithologists were most interested in the anatomy and physiology of birds, which remained the province of trained experts. Now, much attention is also given to the behavior of birds. In discussing this article, be sure to emphasize the possibility of some pupil's making a genuine contribution to this body of knowledge.

The activities described here will be more appropriately carried out on an individual basis than as a class activity. (Thirty children on a bird walk would surely spell failure.) However, you may offer your pupils some extra pointers to ensure their success at home *(see box)*. Have the children compare findings in class in a week or so.

TIPS FOR OBSERVING BIRDBATHING

1. When going on a bird watch, wear drab colors and leave your dog at home.
2. Choose calm, clear weather and early morning hours, if possible. For better visibility, keep your back to the Sun.
3. If you have no hiding place near a good birdbathing location, you might make a "blind" out of a piece of drab cloth stretched on a frame. Cut a peep hole. Or use a small tent.
4. Birds are attracted to moving water and trickling sounds. When rigging your birdbath, try to achieve these effects. One way is to suspend a bucket with a small hole in the bottom over the birdbath. Fill the bucket with water and let it drip out. One filling will last quite a while if the hole is not too big.
5. If possible, set your birdbath off the ground. This offers the birds some protection from cats and keeps other animals from using it and possibly fouling it. Give the birds a foothold in a smooth container by lining it with pebbles or ready-mix concrete.
6. Remember to watch for preening behavior (when birds oil and arrange their feathers after bathing).

YOUR NATURE AND SCIENCE SUBSCRIPTION EXPIRES WITH THIS ISSUE!

THIS IS YOUR LAST OPPORTUNITY TO RESERVE YOUR COPIES OF NATURE AND SCIENCE FOR THE COMING SCHOOL YEAR—AND RECEIVE A FREE GIFT WITH YOUR CLASSROOM ORDER.

The months slip by so quickly that September will be here before you know it. You'll want to be sure that your pupils next fall receive their issues of NATURE AND SCIENCE, with its many unique features for making the study of science more enjoyable for them —and the teaching of science easier and more effective for you.

But if you are to continue receiving NATURE AND SCIENCE throughout the coming school year, we must receive your renewal order at once. Just fill in the attached card and mail it today. If you are not sure how many pupils you will have next September, write down an estimate. You have until October 5, 1965 to revise and pay for your final order.

NATURE AND SCIENCE costs only $1.50 per pupil for the entire school year . . . or 85¢ for one semester (minimum order: 10). No need to send payment now; we'll bill you after your magazines arrive.

FREE...

with your classroom order for 15 or more subscriptions for the full school year . . .

this beautiful, full-color wall chart depicting "Familiar American Birds." Painted by a staff artist of The American Museum of Natural History, this large wall chart reproduces 32 of America's major species of birds in natural colors.

Display this colorful poster in your classroom and you teach your students to recognize American wildlife and to appreciate the simple beauty of our own native birds. It includes the familiar Blue Jay (whose feeding habits help plant our forests), the Purple Gallinule (one of America's noisiest birds), the Belted Kingfisher (whose female is more colorful than the male), the long-tailed Roadrunner (that runs as fast as a man), the House Wren (whose song is more exuberant than beautiful) plus 27 other species of birds common to our American landscape.

Reproduced on stock that is both coated for color fidelity and heavy for permanence, this large chart (950 square inches) makes a valuable, permanent addition to any classroom. Comes rolled in a heavy protective tube.

FAMILIAR AMERICAN BIRDS comes to you free, when you order 15 or more subscriptions for the full school year. Mail the attached card today.

nature and science

VOLUME 2 NUMBER 17

SPECIAL ISSUE

ASTRONOMY

PICTURES IN THE SKY

To men of ancient times the sky was a picture book. They imagined that certain of the stars formed patterns or shapes of people and animals. One such pattern is Orion, the great hunter shown above.

The pictures they imagined are, of course, impossible to see among the stars. But to men of ancient times it was important to be able to recognize certain stars. The easiest way was to clothe them in the form of people and animals who played important parts in myths, or stories, of the time. It was important to recognize the stars because their appearance announced the changing seasons. Also, the stars were used for navigation, as we use them today.

Astronomy books today rarely show the fanciful figures of Orion, the Crab, and other constellations, except as decoration. Instead they show the stars of a constellation joined by straight lines *(see diagram)*.

If you are a beginner in astronomy you will want to learn the 12 constellations of the Zodiac *(see Cover and p.9)* first, then learn some of the other star groups shown in the charts in this issue.

This special ASTRONOMY issue of Nature and Science carries dozens of activities that can be carried out the year around. Its purpose is to introduce young people to astronomy. The issue was prepared under the editorship of Roy A. Gallant with the technical assistance of Dr. Kenneth L. Franklin, Astronomer, The American Museum-Hayden Planetarium.

nature and science

VOL. 2 NO. 17 / JUNE 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

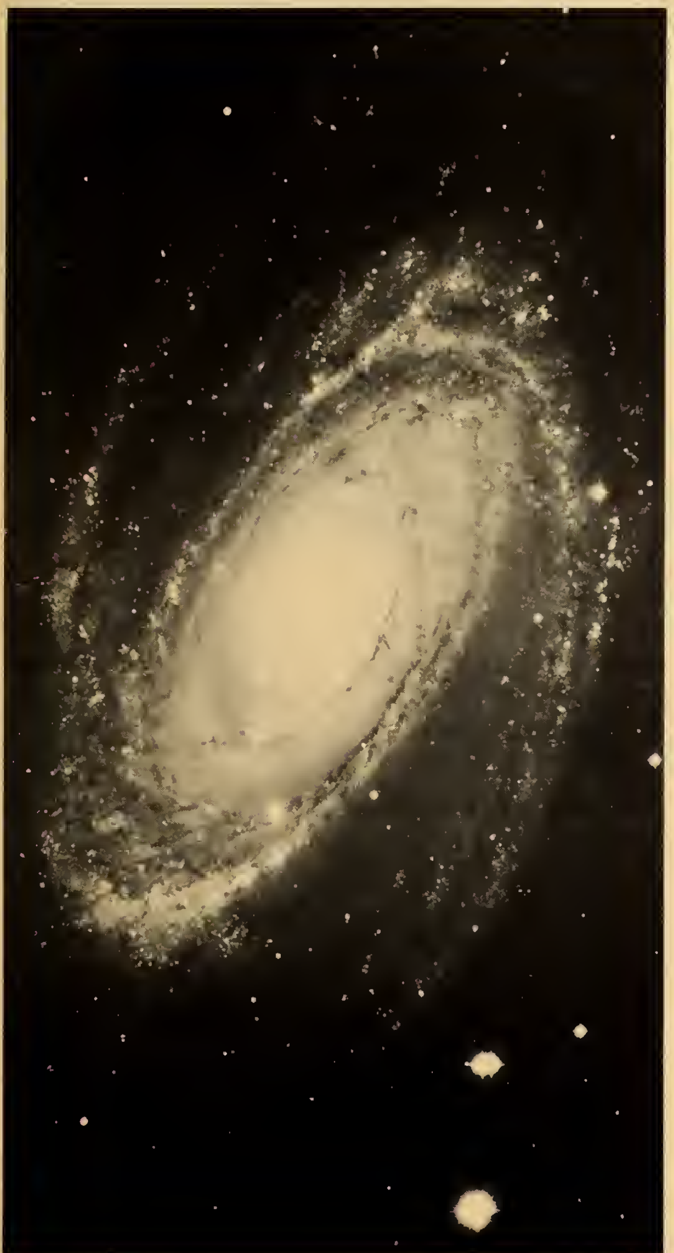
CREDITS: Cover, pp. 4, 5, star charts adapted from *Natural History* magazine; pp. 2, 5, 6, 10, 14, 15, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 3, 11, photos from the Mount Wilson and Palomar Observatories; pp. 4, 7, drawings by Gaetano di Palma; p. 8, drawing by R. G. Bryant; p. 12, Yerkes Observatory photos; p. 13, Lick Observatory photos; p. 14, hailstone photo by Keith Browning, U.S. Air Force Cambridge Research Laboratories, frost photo by Mrs. Carroll Williams, others by George Cope from Educational Services Incorporated; p. 16, crater lake photo courtesy of the RCAF, meteor photo from AMNH.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Copyright © 1965 The American Museum of Natural History. All Rights Reserved. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

FINDING YOUR WAY AROUND THE SKY

This article and others in the issue are your introduction to astronomy. They tell you how to look at the sky, where to look, and what to look for. by Kenneth L. Franklin



If we could see our home galaxy from some distant part of space it would look much like this galaxy seen in the constellation Ursa Major. There are billions of stars in this galaxy, and in our own.

■ During the day we can see only one star, the Sun. The other stars are in the sky, but they are too faint to be seen. If you have ever traveled at night in a car with a dirty windshield, you will know why the daytime sky is bright. As another car approaches you, its headlights shine on the dirt on your windshield. Each speck of dirt seems to light up so that the whole windshield appears bright. You can see only the bright headlights of the approaching car. Things along the highway become lost in the glare.

Why the Sky Is Blue

The Earth's atmosphere scatters the light from the Sun in the same way that the dirt on your windshield scatters the light from headlights. Because the air scatters blue light better than any of the other colors, the daytime sky looks blue. When the air is clean and dry, the sky is a deep blue.

On a day when the sky is deep blue, and there are practically no clouds, notice where the Sun sets. If the time is late March or September, the Sun goes down very close to west on your horizon. If it is the spring or summer, the Sun sets north of west. In the fall or winter the Sun sets south of west. If you have a clear horizon, you will notice a broad band of light begin to rise in the east soon after the Sun has set. It looks like a large,hazy rainbow. It is called the *twilight bow* and is noticeable only in clear air. If there are hills, mountains, or clouds against the eastern sky, you will notice that the Sun still shines on them after it has set.

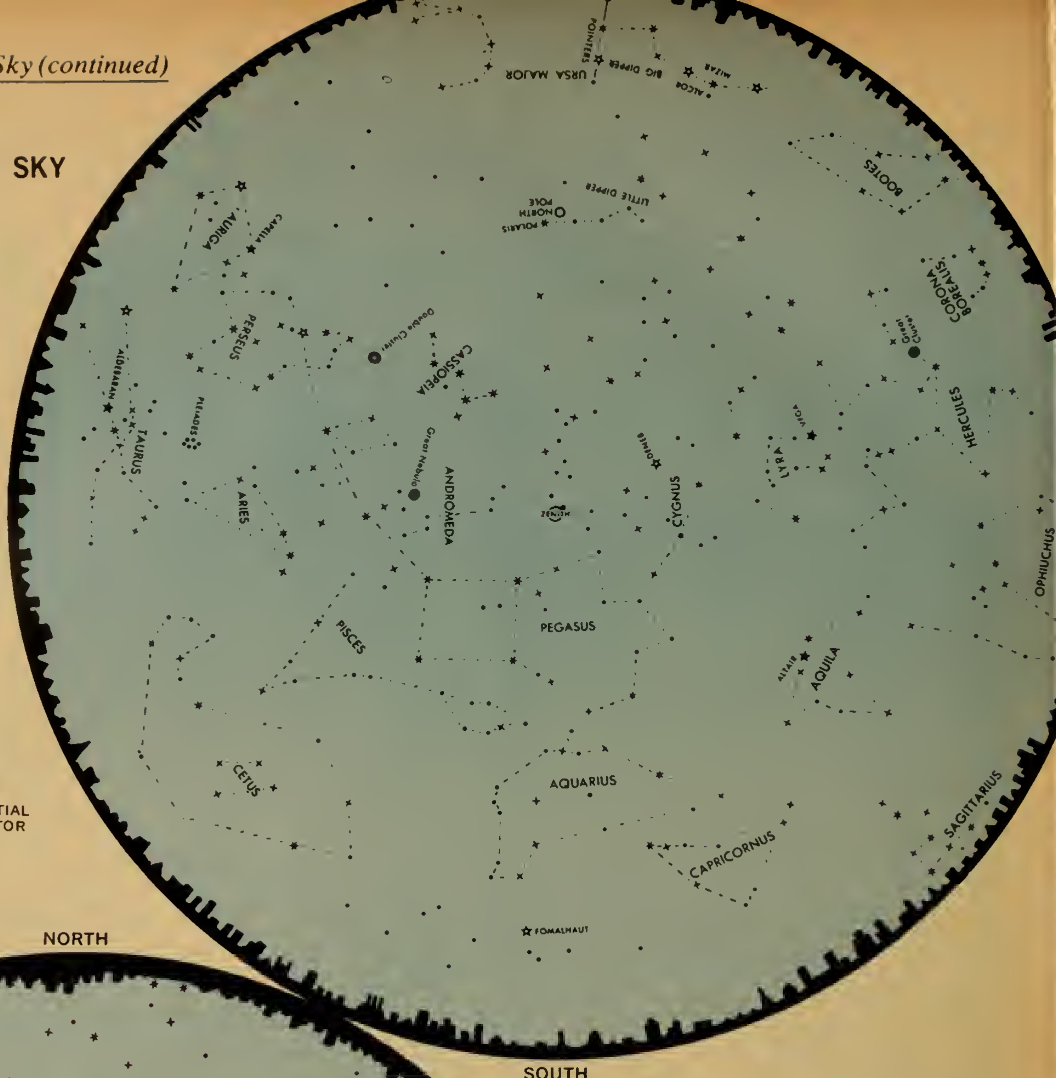
For an hour or two after sunset, the sky is still bright for a period of time known as *dusk,* or *evening twilight.* It does not become dark immediately after sunset because sunlight is still shining on the air above the mountains and above the clouds. Only after all the air above you is no longer lighted by the Sun is it *night.*

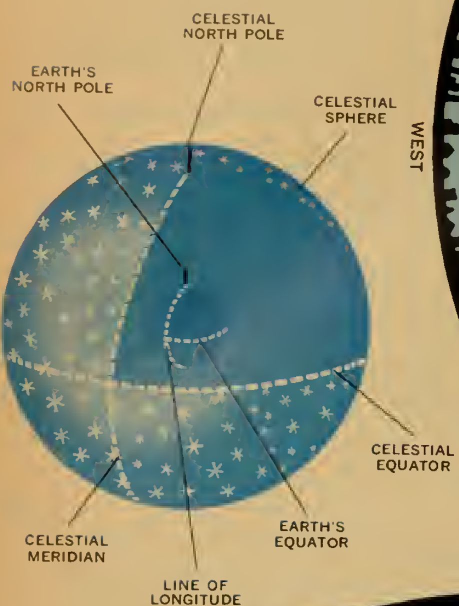
City Stars and Country Stars

As you watch twilight end, you begin to see the stars. Often you will see one bright star before you see the rest. In winter that bright star will be blue Sirius in the south, or yellow Capella high in the northwest *(see star charts).* In

(Continued on the next page)

THE AUTUMN SKY





THE WINTER SKY

HOW TO USE THESE CHARTS

The star charts on these two page and on the cover show where to fin many of the constellations, certai prominent stars, and "deep-sk wonders" *(see page 10)* throughou this and other years.

If you want to find a certain con stellation in the southern sky, hol the chart over your head so tha south on the chart is pointed towar the real southern horizon and loo up at the chart. If you are trying t locate a constellation in the east, fac east and point the "east" edge of th chart toward the eastern horizon When the charts are held in this wa constellations on each chart wi show the arrangement of the con stellations in the sky.

Notice that each of the four chart is to be used at a different time o the year. Notice also that some star on the chart are bigger than others The bigger the star symbol, th brighter a star will appear to you eye.

late spring it is orange Arcturus in the east. In late summer Arcturus will be found in the west, and blue Vega will be bright in the northeast. As the sky darkens, more and more faint stars will come out.

If you live in or near a city, the city lights will act like small suns and shine their light into the surrounding air. The sky of a city is never very dark, so most of the very faint stars are not visible. In the country or the mountains, however, there are no nearby lights, and usually the air is cleaner than city air. The sky can be black, and even very faint stars shine beautifully. Anyone who has learned the constellations by viewing them only from a city has seen only brighter stars. When he goes to the country, he often becomes confused because he sees too many stars—"so many they can't be counted." Actually, there are only about 9,000 stars in the whole sky that can be seen without a telescope. About 500,000 have been studied by astronomers in some way, and there are billions more.

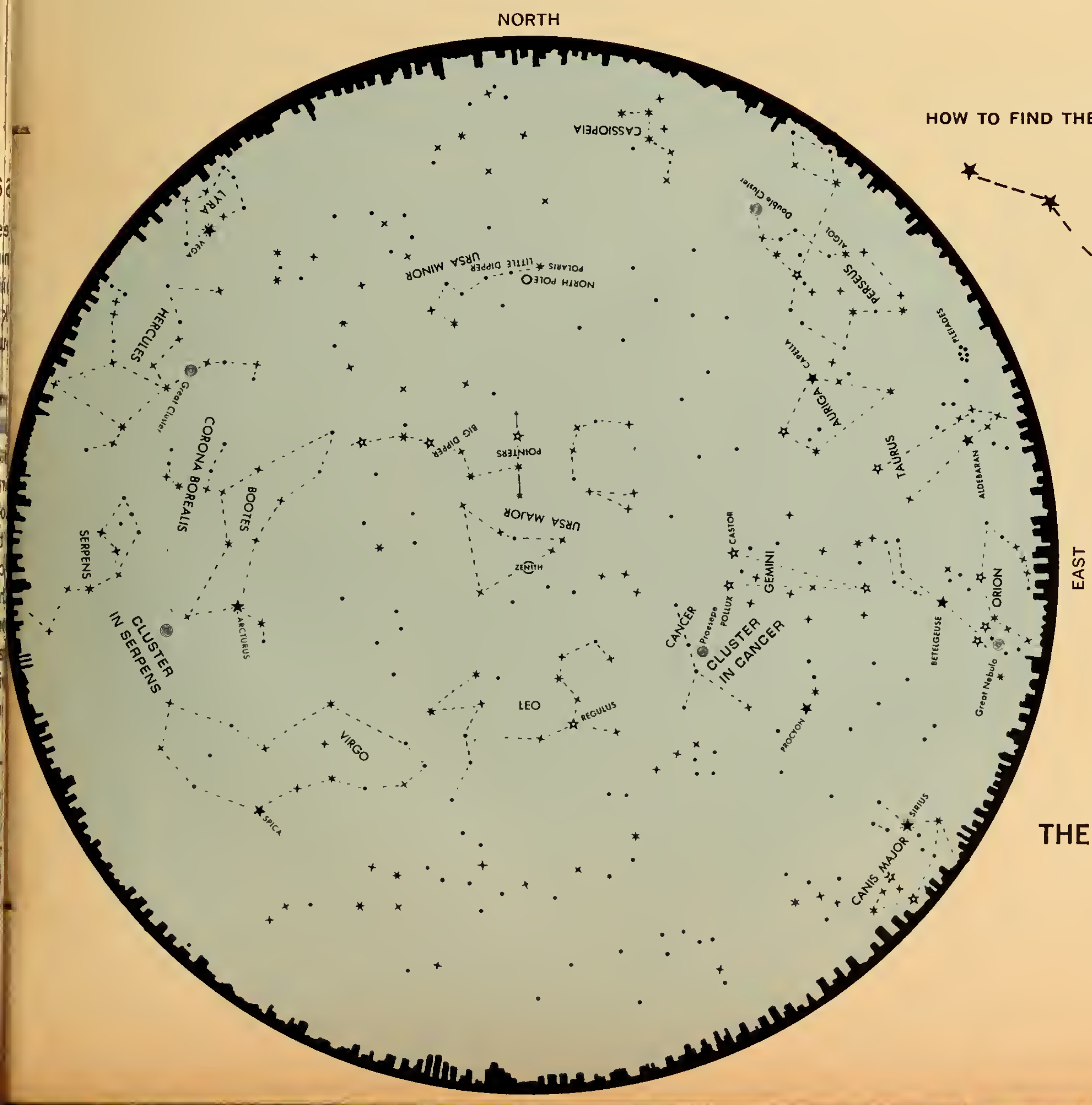
What has happened during the two or three hours you have spent watching the Sun set and the stars come out? The Sun is always shining on one side of the Earth as the Earth turns once every 24 hours on its axis. This motion, called *rotation,* is most noticeable at sunset when we are carried from the sunlit side of the Earth into shadow. If you watch the sky carefully for an hour or two some night, you will see that some stars set while others rise. This means that we get a different view from hour to hour.

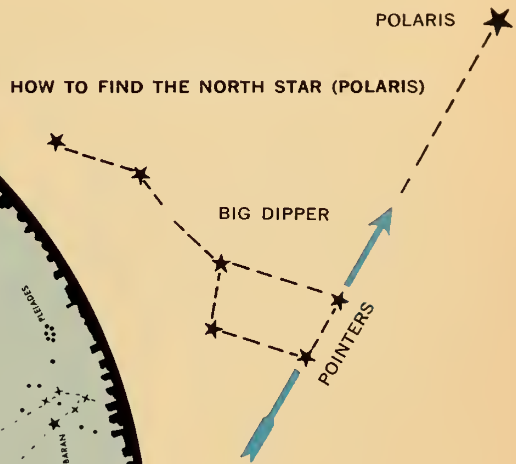
How the Stars Move

Stars, planets, and the Sun and Moon always rise from the eastern horizon and climb up the sky to their highest point located on a line called the *celestial meridian (see diagram on page 4).* They then move down to the western horizon where they set. If you look at the northern sky, you will find that many stars there do not set at all. They dip down closest to the horizon directly north of you, then they begin to climb higher, moving in a circle. The whole sky seems to turn around a point high above the northern horizon, a point that does not move at all. This point is called the *North Celestial Pole.* There is actually nothing for you to see exactly at that spot, but there is a star very close to it —Polaris, or the North Star.

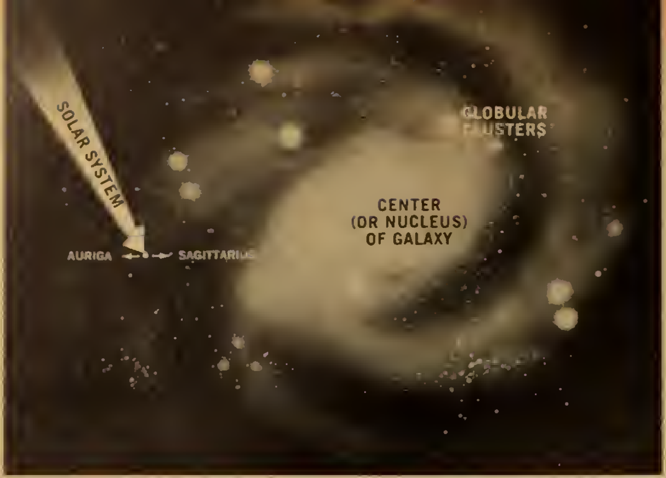
You can find the North Star by following the two stars forming the front edge of the Big Dipper *(see diagram).*

(Continued on the next page)





THE SPRING SKY



Our position in the Galaxy: Whenever you see Sagittarius you are looking toward the center of the Galaxy. Whenever you see Auriga you are looking in the opposite direction. Sagittarius is a summer constellation; Auriga, winter.

Finding Your Way Around the Sky (continued)

This group of stars is always above the northern horizon. But at some times of the year it may be low or high in the sky, or above the northwest or the northeast horizon.

Patterns in the Sky

The stars seem to form patterns that have changed very little ever since men have been watching the sky. Men with imagination have picked out more than 80 groups of stars in which they see the shapes of men and women, whales, snakes, rivers, birds, and even a head of hair. These groups of stars are called *constellations.* But the constellations do not actually look like men, and other animals. It is easier for us to learn the constellations by imagining that their stars are connected by straight lines *(see page 2).*

The sky seems to be different at different seasons of the year. We see constellations rise in the east a little earlier each night, and about two hours earlier each month. The Earth's motion around the Sun, called *revolution,* is responsible for our changing view of the sky. The path the Sun seems to follow across the sky throughout a year is a line called the *ecliptic (see page 8).* The ecliptic runs through a band of 12 constellations known as the *Zodiac.* The planets are always found along the Zodiac.

Venus is always the brightest planet, and when it is visible in the evening sky it usually is the first "star" seen in the deepening twilight. Jupiter, Saturn, and Mars are sometimes very bright, but little Mars can be so far away from us that it can look lost among the stars. Mercury is bright, but it is so close to the Sun that it is never seen in a dark sky. The planets move among the stars, so you can tell them from the stars if you watch them for several weeks.

"Hairy Stars"

As you become more familiar with the sky, you will look at it more often to see your old friends. Sometimes, something new appears, such as a comet. Usually, a comet is too faint to be seen without a good telescope. It may look like a small speck of light inside a hazy cloud from which a tail streaks away. Like the planets, comets follow paths around the Sun, but their orbits are much more stretched out than the orbits of planets. Comets spend most of their time far away from the Sun.

A comet is somewhat like a huge snowball with dust and rocks frozen into it. As it comes closer to the Sun, some of the frozen material in the solid part of the comet is warmed and changes to a cloud of gas, called the *coma.*

In addition to heating the comet, the Sun blows on it with a solar wind. This wind streams away from the Sun at about 600 miles an hour and blows much of the material in the coma out into a long streamer, or tail. Comets never move as fast as the solar wind, so when the comet leaves the Sun the wind blows the tail out in front of the comet.

Our Home in Space

From the Earth we can see a hazy band of light going completely around the sky. Called the Milky Way, it is our view of our home galaxy. Like the billions of other galaxies in space, ours is a huge collection of gas, dust, and stars. Our galaxy, which is shaped like a pancake, is about 100,000 light-years across. (One *light-year* is the distance that light travels in a year. Light travels 186,000 miles per second and takes 100,000 years to cross the Galaxy.)

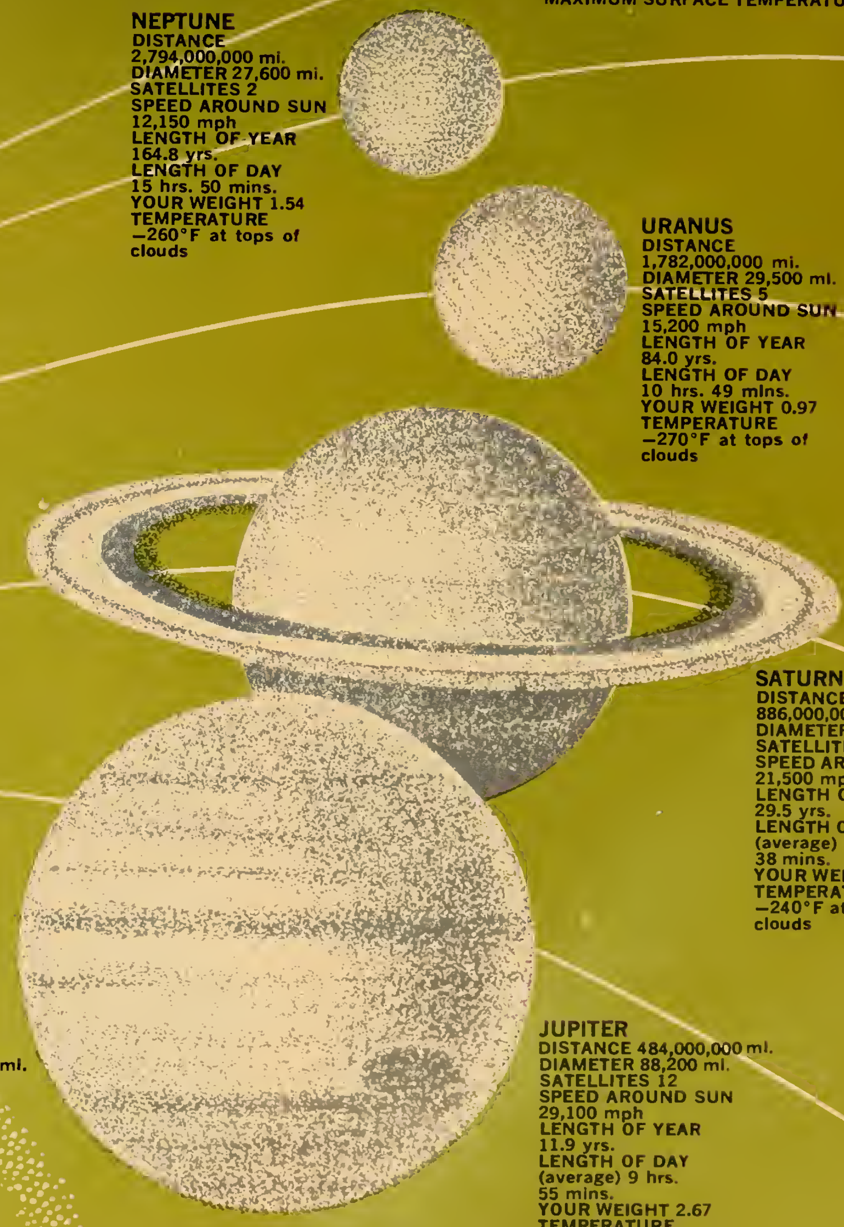
The Sun and planets are located within the flat part of the pancake *(see diagram).* The brightest part of the Milky Way is low in the southeast sky during summer. In that direction you are looking through the constellations Scorpius and Sagittarius toward the center of the Galaxy. The bright center is hidden from view by gas, dust, and stars.

The Sun and its family of planets seem huge to us, stretching off into space for billions of miles. Yet when we think of the small space they take up in the Galaxy, the Sun, Earth, and other planets become dwarfed ■

To find out more about the constellations, stars, Sun, and planets, see the following books: **Worlds in the Sky,** by Carroll L. Fenton, John Day, 1963, New York City; **Fun with Astronomy,** by Mae and Ira Freeman, Random House, 1953, New York City; **Point to the Stars,** by Joseph and Lippincott, McGraw-Hill, 1963, New York City; **Stars: A Guide to the Constellations, Sun, Moon, Planets, and Other Features of the Heavens,** Simon & Schuster, 1956, New York City; **The Sky Observer's Guide,** by Mayall, Wyckoff, Polgreen, Golden Press, 1959, New York City; The following books by Franklyn M. Branley, published by Thomas Y. Crowell Co., New York City: **The Moon: Earth's Natural Satellite** (1963), **Mars: Planet Number Four** (1962), **The Nine Planets** (1958).

THE SUN AND ITS PLANETS

Periods of revolution, the time it takes the planets to circle the Sun, are given in Earth years, or parts of a year. Periods of rotation, the time it takes the planets to spin once around their axis, are given in Earth days or in hours and minutes. The revolution and rotation periods are measured by the stars, so they are *sidereal* (meaning "star") periods. "Speed Around the Sun" is the mean (average) speed of the planets as they travel around the Sun. Diameters and distances from the Sun are mean diameters and mean distances. The entry "Your Weight" means the planet's surface gravity compared with the Earth's surface gravity of 1. To find your weight, multiply it by the figure shown. For example, if you weigh 100 pounds, on Jupiter you would weigh 100 x 2.67 = 267 pounds. (This diagram shows roughly how big each planet is compared to the others.)



SUN
Our local star.
A gaseous sphere mostly of hydrogen and helium.
SURFACE TEMPERATURE 10,000°F
TEMPERATURE AT CENTER about 20 million degrees F
DIAMETER 865,000 mi.
YOUR WEIGHT 28

MERCURY
DISTANCE 36,000,000 mi.
DIAMETER 3,000 mi.
SATELLITES none
SPEED AROUND SUN 107,000 mph
LENGTH OF YEAR 88 days
LENGTH OF DAY 88 days (same side always faces the Sun)
YOUR WEIGHT 0.37
SURFACE TEMPERATURE 640°F

VENUS
DISTANCE 67,200,000 mi.
DIAMETER 7,600 mi.
SATELLITES none
SPEED AROUND SUN 78,000 mph
LENGTH OF YEAR 225 days
LENGTH OF DAY 250 days ("retrograde," or reverse, rotation)
YOUR WEIGHT 0.89
TEMPERATURE −10°F at tops of clouds

EARTH
DISTANCE 92,900,000 mi.
DIAMETER 7,918 mi.
SATELLITES 1
SPEED AROUND SUN 66,500 mph
LENGTH OF YEAR 365.24 days
LENGTH OF DAY 23 hrs. 56 mins.
YOUR WEIGHT 1
MAXIMUM SURFACE TEMPERATURE 140°F

MARS
DISTANCE 142,000,000 mi.
DIAMETER 4,200 mi.
SATELLITES 2
SPEED AROUND SUN 54,000 mph
LENGTH OF YEAR 687 days
LENGTH OF DAY 24 hrs. 37 mins.
YOUR WEIGHT 0.39
MAXIMUM SURFACE TEMPERATURE 86°F

ASTEROIDS
There are thousands of these fragments of rock and metal that move around the Sun between Mars and Jupiter. The orbits of about 1,600 have been worked out. The first four discovered are the largest and have diameters between 100 and 500 miles. DISTANCE between 200 million and 400 million miles. LENGTH OF YEAR between 3.5 and 6.0 yrs.

JUPITER
DISTANCE 484,000,000 mi.
DIAMETER 88,200 mi.
SATELLITES 12
SPEED AROUND SUN 29,100 mph
LENGTH OF YEAR 11.9 yrs.
LENGTH OF DAY (average) 9 hrs. 55 mins.
YOUR WEIGHT 2.67
TEMPERATURE −220°F at tops of clouds

SATURN
DISTANCE 886,000,000 mi.
DIAMETER 74,900 mi.
SATELLITES 9
SPEED AROUND SUN 21,500 mph
LENGTH OF YEAR 29.5 yrs.
LENGTH OF DAY (average) 10 hrs. 38 mins.
YOUR WEIGHT 1.15
TEMPERATURE −240°F at tops of clouds

URANUS
DISTANCE 1,782,000,000 mi.
DIAMETER 29,500 mi.
SATELLITES 5
SPEED AROUND SUN 15,200 mph
LENGTH OF YEAR 84.0 yrs.
LENGTH OF DAY 10 hrs. 49 mins.
YOUR WEIGHT 0.97
TEMPERATURE −270°F at tops of clouds

NEPTUNE
DISTANCE 2,794,000,000 mi.
DIAMETER 27,600 mi.
SATELLITES 2
SPEED AROUND SUN 12,150 mph
LENGTH OF YEAR 164.8 yrs.
LENGTH OF DAY 15 hrs. 50 mins.
YOUR WEIGHT 1.54
TEMPERATURE −260°F at tops of clouds

PLUTO
DISTANCE 3,671,000,000 mi.
DIAMETER 3,700 mi. (?) SATELLITES (?)
SPEED AROUND SUN 10,500 mph
LENGTH OF YEAR 248.4 yrs.
LENGTH OF DAY 6.4 days(?)
YOUR WEIGHT 4(?)
MAXIMUM SURFACE TEMPERATURE unknown

STARS IN A SHOEBOX

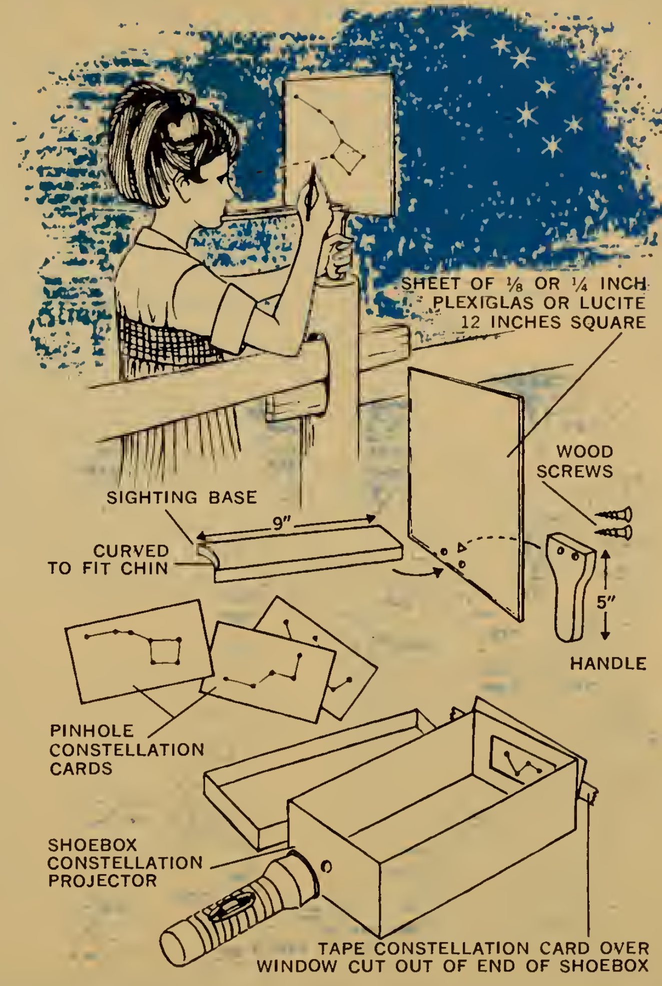
■ With a shoebox and homemade star plotter you can map the constellations. You can also plot the courses of some of the planets among the constellations. (Before you begin this project, it will be helpful if you read the article that begins on page 3.)

Make the star plotter out of two pieces of wood and a sheet of clear plastic *(see diagram)*. When you are ready to use the plotter, rest it on a fence post or against a building or some other firm object. It is important to hold the plotter very steady. Find the constellation that you want to map. Then with a soft grease pencil plot each star of the constellation on the sheet of clear plastic *(see diagram)*.

Next, cut a window in the end of a shoebox *(see diagram)*. Cut several pieces of thin cardboard large enough to cover the window and overlap it by about ¼ inch all the way around. Or, you could use 3x5-inch file cards.

Now you are ready to make your constellation cards. When it is finished, each card will have a pinhole constellation on it. First, using your clear plastic constellation as a guide, draw a smaller version of it on one of the blank cards. Let small pencil dots represent dim stars in the constellation and larger dots represent brighter stars. Draw lines between each dot *(see diagram and star charts)*. After you have drawn the constellation, use a safety pin to punch a hole where each star is—small holes for the dim stars, larger holes for the brighter stars. Write the name of the constellation on the bottom of the card.

Now you are ready to project the constellation.



Punch a hole about a half inch wide in the back end of the shoebox *(see diagram)*. By holding a flashlight against the hole, and with a constellation card taped over the window of the shoebox, you will be able to project the constellation onto a wall or the ceiling of a darkened room. You can also point the shoebox at a lamp and sight through the hole ■

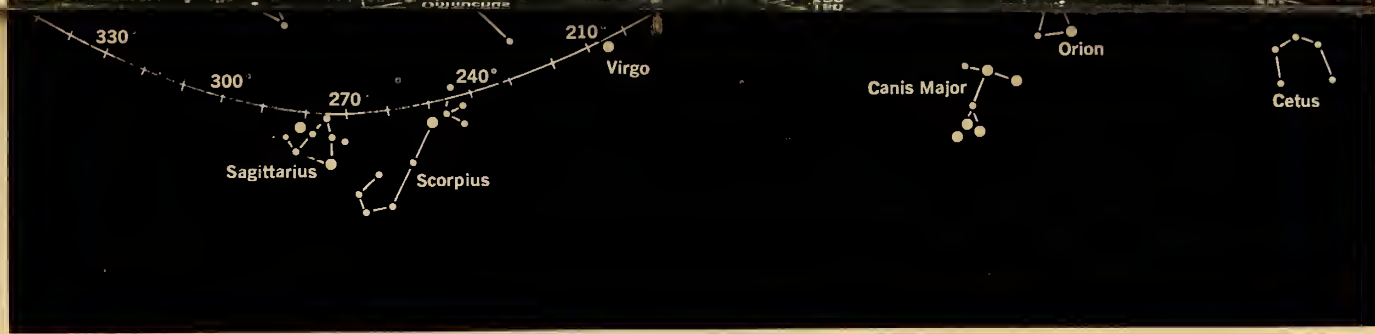
PROJECT

By using the planet finder, locate a planet in or near a constellation. Plot the constellation and the position of the planet on a constellation card.

The following night at about the same time, plot the constellation and planet again. Has the planet changed its position within or near the constellation? Make a plot once every two nights or once every three nights for a month. How does the planet move in relation to the constellation? Does it seem to "back up" sometimes? Does it always move in the same direction?

■ Here are three books that will show you how to plot and where to find the constellations: **Find the Constellations,** and **The Stars,** both books written by H. A. Rey and published by Houghton Mifflin Company, Boston. **The ABC's of Astronomy,** by Roy A. Gallant, published by Doubleday & Company, Inc., New York.

The artwork for the star plotter has been adapted by permission of World Book Encyclopedia.



HOW TO FIND THE PLANETS

■ The star chart (above) and the two tables (right) show you how to find Mercury, Venus, Mars, Jupiter, and Saturn through the rest of this year and all of 1966.

To find the constellations shown on the chart, face south and hold the chart over your head. Once you have practiced finding the constellations, you will be ready to pick out the planets.

Suppose that the date is July 13, 1965, and that you want to find Mars. Look in the 1965 table and read across the July line until you come to the Mars column. You will see a blue number 188. (All blue numbers mean that the planets are visible only in the evening sky. Black numbers mean that they are visible in the morning sky.)

The 188 is Mars' longitude for July 13. To find the planet, look along the white wavy line. This line shows the approximate path of the planets as they move among the stars. Mars will be at the first white cross-line to the left of 180°.

The blank spaces in the tables mean that a planet is too close to the Sun to be seen. Mercury (the hardest to observe) and Venus are visible only for a brief time after sunset and just before dawn. Mercury is always within 6° of the wavy line. This wavy line is the apparent path of the Sun and is called the *ecliptic*. Venus and Mars are always within 7° of the ecliptic, Jupiter within 2°, and Saturn within 3°. —ROY A. GALLANT

The two tables and constellation chart above are based on material appearing in Earth, Moon and Planets, *by Fred L. Whipple, Copyright, 1941, by The President and Fellows of Harvard College, and is used by permission of Harvard University Press.*

PROJECT

Trace the wavy line and longitude figures onto a sheet of paper. Plot the changing position of Saturn from June 1965 through December of 1966 (see *tables*). Plot the positions of the other planets. Do they all move the same way?

PLANET:	MERC.	VEN.	MARS	JUP.	SAT.
DATE: 1965	13	13	13	13	13
JUNE	—	—	173	72	347
JULY	138	136	188	79	347
AUG.	—	173	206	85	345
SEPT.	—	210	226	90	343
OCT.	—	245	247	91	341
NOV.	254	279	270	90	340
DEC.	243	306	293	87	341

PLANET:	MERC.	VEN.	MARS	JUP.	SAT.
DATE: 1966	13	13	13	13	13
JAN.	—	—	317	83	343
FEB.	—	299	342	81	—
MAR.	—	310	4	82	350
APR.	357	337	—	86	354
MAY	—	10	49	92	357
JUNE	—	45	71	—	359
JULY	132	81	91	105	359
AUG.	123	118	113	112	358
SEPT.	—	—	132	118	356
OCT.	221	—	151	122	353
NOV.	—	—	169	124	353
DEC.	—	—	185	124	353

EXPLORING THE SKY

With a pair of binoculars you can see these deep-sky wonders.

■ Exploring the sky with binoculars will open new worlds to you. You will see many stars that you cannot see with your eyes alone. Some stars that appear as single points of light to your unaided eye will appear through binoculars as two stars, or even three.

You can also explore some hazy patches. Some of them will be clusters of stars as dazzling as a diamond-studded jewel box, like the cluster in photo number 6 on the facing page. Others will be clouds of gas and dust, called *nebulae,* like the Orion Nebula (number 5).

When you have practiced using the star charts in this issue, you will be able to pick out many of the constellations with ease. And when you can do that you will be able to locate some of the spectacular objects pictured here. But don't be surprised because they don't look as large and bright as these photographs show them. The photographs were taken with big telescopes hundreds of times more powerful than binoculars. Even though an object appears as a faint hazy patch through binoculars, it is exciting to know what it is (*see captions*).

The star maps in this issue show you when and where to find these deep-sky wonders, and the planet finder on page 9 shows you how to find the planets. As you explore the sky with binoculars, you may see stars and other objects not shown on the star maps. When you do find such objects you can make pin-point records of them on your constellation cards (*see page 8*).

—KENNETH L. FRANKLIN

1 The Great Galaxy in Andromeda is the most distant object we can see without a telescope on a dark, moonless night. The light you see left the galaxy over two million years ago. There may be 100 billion stars in this galaxy.

2 The Globular Cluster in Serpens is about 35,000 light-years away. Tens of thousands of stars, all larger and redder than the Sun, are packed into a ball 150 light-years across. About 100 globular clusters are known.

3 This view of the Milky Way was formed by putting several pictures together. It shows the summer Milky Way from Cygnus on the left to Scorpius on the right. The dark clouds are dust and gas and hide the distant stars from view.

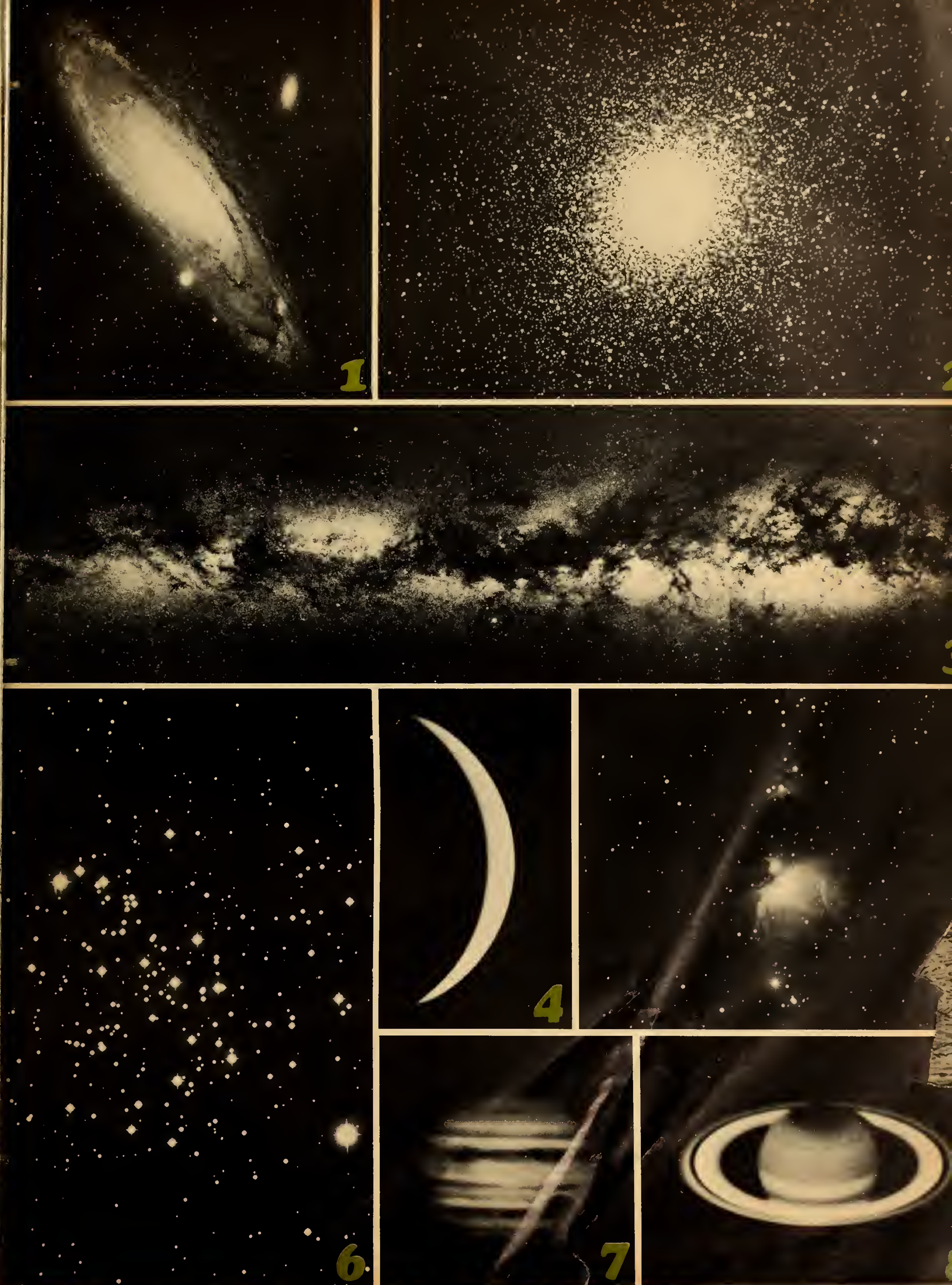
4 The planet Venus will be the "Evening Star" late this summer. You may be surprised to see it look like this photograph when it is very bright in our sky around Christmas. Do you know why this planet is sometimes shaped like a crescent?

5 The Great Nebula in Orion is in that part of the constellation we call Orion's sword. This cloud is about 10 light-years across and 1,500 light-years away. Some of its stars are "new," less than a million years old.

6 This cluster in Cancer, the Crab, is about 13 light-years across and 2,700 light-years away. A cluster like this is made up of stars all about the same age. This group of 80 stars is one of the oldest known. It may be 10 billion years old.

7 Jupiter is the giant of the planets. A large spot can be seen every 10 hours in its southern hemisphere. With binoculars you can see four of its 12 satellites. Make a drawing every few hours to find out how they move.

8 From July to November, Saturn may be seen moving westward in Aquarius. If you have a telescope, you should be able to see the rings. In 1966 they will be harder to see because we will be viewing them edge-on. This happens every 15 years.


1
4
6
7

MAKING STAR TRAILS WITH YOUR CAMERA

■ Did you know that you can make your own photographic records of the stars moving across the night sky? You do not need a telescope or any other expensive equipment. Any inexpensive camera will do the job, so long as it has a time exposure setting.

Here is how to make photographs like those shown on this page. First, wait for a dark, clear night. There must not be any clouds, and it must be after the Moon has set, or a moonless night. Most calendars show when the Moon is not visible (called a "new moon").

If you have a tripod, fix your camera to it and aim the camera directly at the North Star. (To find the North Star, see page 5.) When you aim your camera, get the North Star right in the middle of the view finder. If you do not have a tripod, you can prop the camera in position on a card table or bench by placing books around it. You may have to wiggle around in some awkward positions to aim it, but it can be done. Be sure the support does not jiggle.

The film you use should be the "fastest" film you can buy. If your camera has *f*-stops, adjust the lens opening to the widest opening. When you have set the camera to time exposure and have opened the shutter, you can go away and leave it. You will want a time exposure of an hour or longer. On the same night, or on other clear nights when there is a new moon, you can try longer time exposures. You can also aim your camera at different parts of the sky.

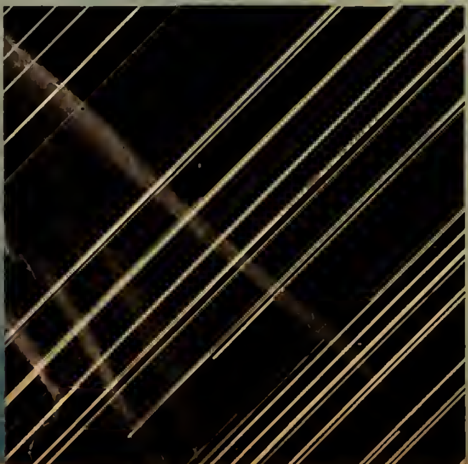
During the time exposure each star leaves a trail of light as the star moves around the sky. In the north polar photograph shown here the North Star is near the very center of the arcs that appear as circles. Each streak of light was traced out by one star. The other photograph shows the "motion" of stars when the camera was pointed straight up from the Equator. If you pointed your camera halfway between the southern horizon and a point straight above you, what kind of a pattern do you think you would get? Try it.

The longer you leave the shutter open, the longer the star trails will be. As you know, the stars do not actually move across the sky each night. It is the Earth's motion—its spinning on its axis like a top—that makes the stars *appear* to move as they do. This motion is called *apparent motion.*

Each hour you leave the lens of your camera open, the stars trace an arc which is about 1/24th part of a complete circle. If you left the lens open for two hours the stars would trace 1/12th of a circle. If it stayed dark for the full 24 hours a day, each star would trace out a full circle.

—ROY A. GALLANT

■ To find out more about the stars, how they move, and things to do in astronomy, see the following books: **Experiments in Skywatching,** by Franklyn M. Branley, Crowell, 1959, New York City; **The Stars by Clock and Fist,** by Henry M. Neely, Viking, 1956, New York City. **A Beginner's Guide to the Skies,** by Robert and Margaret Mayall, Putnam, 1960, New York City; **Exploring the Universe,** by Roy A. Gallant, Garden City Books, 1956, Garden City, New York.



You can make circular star trails by pointing your camera at the North Star and making a long time exposure.

By pointing your camera at different parts of the sky you will get star trails of different patterns. At what part of the sky do you have to point your camera to get these star trails?

MAPPING THE MOON

Hundreds of craters, some with rays, are visible in these photographs of the Moon at first quarter (left) and at third quarter. The great, dark "seas" are not water, but may be plains of lava, which does not reflect much sunlight.

■ Astronomers used to make maps of the Moon by looking at it through a telescope and then drawing what they saw. Today maps of the Moon are made from clear, sharp photographs like those you see on this page. But the older method is good to learn. It is still useful, for example, in making a map of Mars. The changing atmospheric conditions on Earth prevent us from seeing surface details except in fleeting glimpses.

You might think that the best time to observe the Moon is when it is full. Actually, this is a poor time to see details. When the Moon is full, light from the Sun falls on it in such a way that we cannot see any shadows.

The best time to see details of the mountains, the craters, and the "seas" of the Moon is when the Moon is a crescent, at the quarters (as in the photos), or *gibbous*. (A "gibbous" Moon is one that is between full and quarter.) At these times sunlight strikes the Moon in such a way that the Moon's mountains and craters cast long shadows. These shadows can then be seen against the bright background. The shadows show up best at the *terminator*. This is the line that separates the lighted part of the Moon from the dark part.

When the Moon is in its third quarter, you should be able to see the craters Copernicus and Kepler. Both of these craters appear in one of the photographs on this page.

Check a calendar or almanac to find out when the Moon will next be gibbous. For your first drawing attempt, observe the Moon with your eyes alone. As you observe, work with a flashlight and drawing pad. You can begin by drawing a circle about eight inches in diameter. Next draw the terminator, then fill in the larger features you see. Write the date on your drawing.

Compare Your Map with a Friend's Map

Ask a friend to make a drawing at the same time that you make yours, then compare the two. Some people see features sharply, but others do not.

When you have finished your drawing, make another one. But this time use your binoculars. Night glasses, which are 7 x 50 binoculars, will give you the best results. When you use the binoculars, rest them against a firm object so that your view of the moon will be steady. You will be surprised by the amount of detail you can see. The lunar "seas," which are not really seas but waterless plains, and certain large craters stand out quite sharply. When you finish the drawing, compare it with the photos on this page to find out how accurate you have been ■

PROJECT

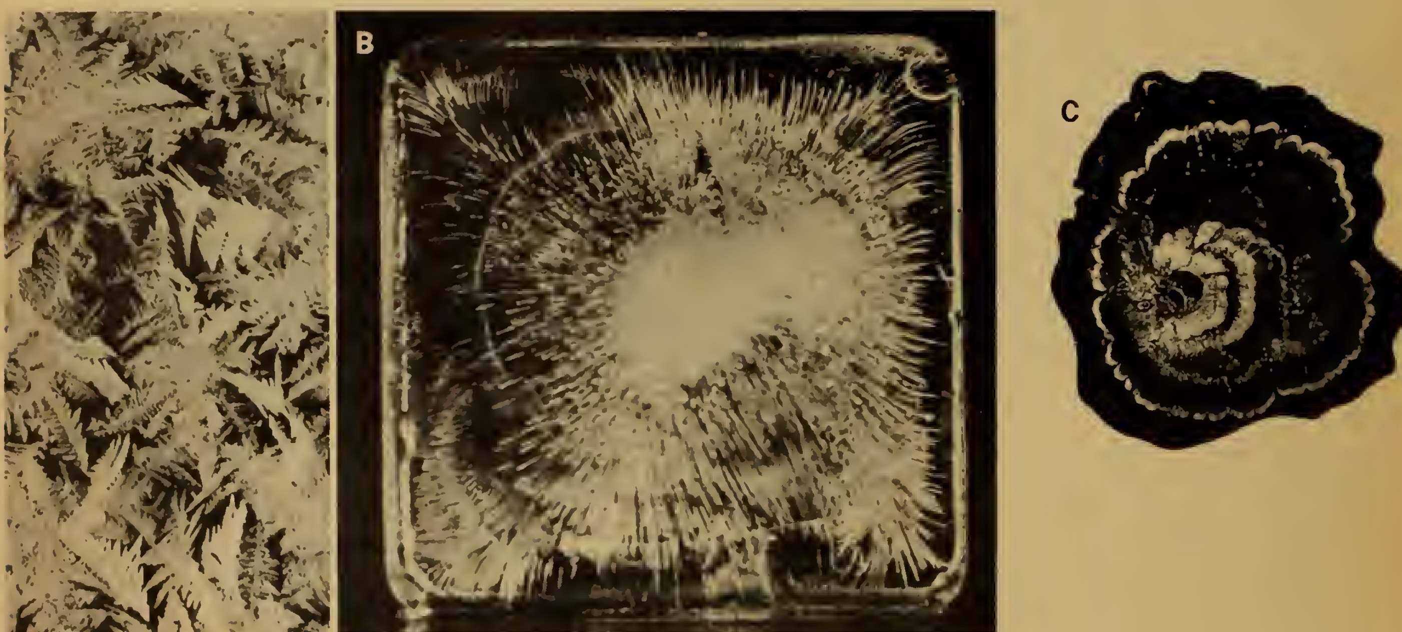
If you look through binoculars, how many of the features shown in these two photos can you see? Draw a new map of the Moon each night for several nights and save each drawing. How does the position of the terminator change?

BRAIN BOOSTERS

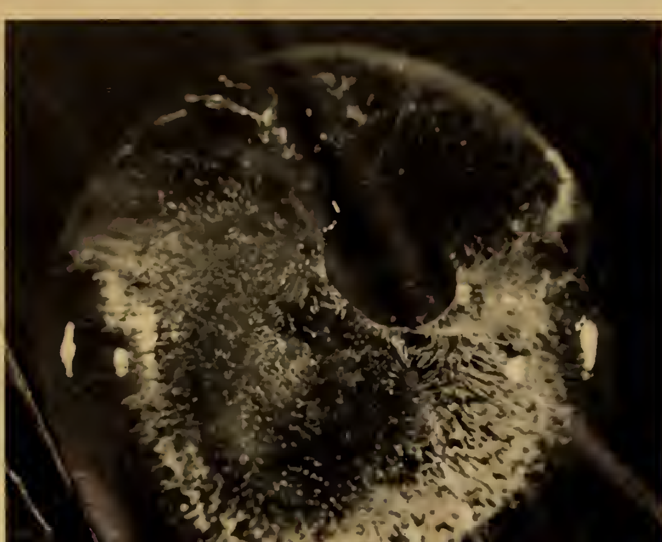
prepared by *David Webster*

FUN WITH ICE

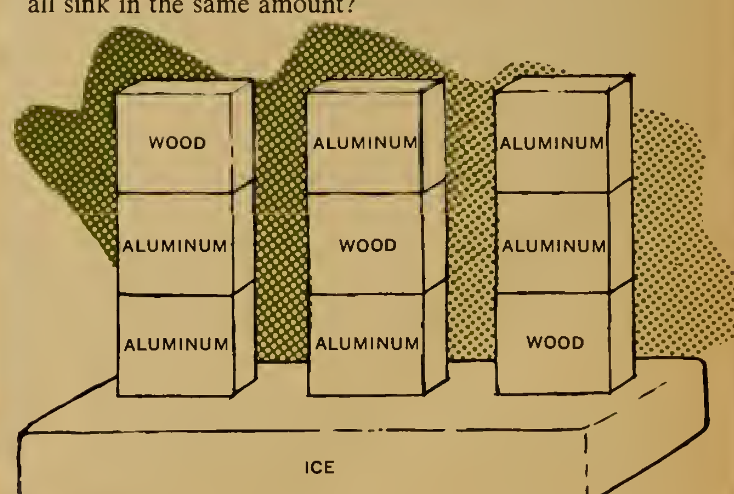
1. The Mystery Photographs are all pictures of ice. Can you identify them?



2. Here is an ice ball that is hollow inside. Can you make a piece of ice like this?



3. Have you ever noticed how some things sink into ice by melting some of it? The sketch shows blocks of aluminum and wood in different positions on a flat piece of ice. Which pile of blocks would sink in most? Or would they all sink in the same amount?



WHAT DO YOU KNOW ABOUT THE MOON?

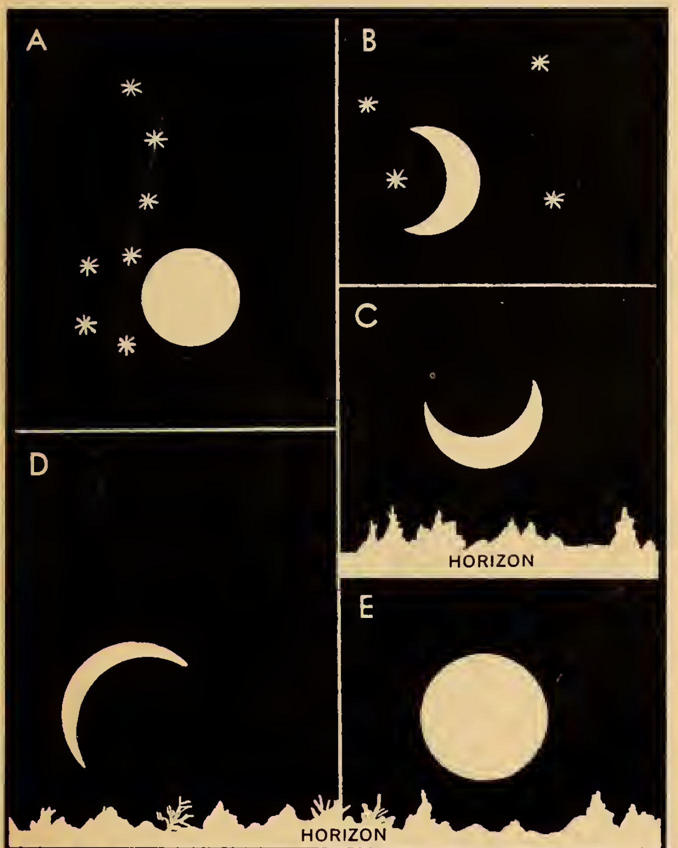
1. Can you ever see the Moon in the daytime?

2. Is the Moon ever directly overhead?

3. Why is there an eclipse of the Moon only when there is a full Moon?

4. Galileo was the first to explain why some areas of the Moon are bright and other parts are dark. He decided that this was because different areas were rough or smooth. Are the bright spots rough or smooth?

5. Below are some sketches of the Moon in the sky. Which of these positions of the Moon could never occur?



PROBLEMS FROM READERS

1. Can you arrange four shapes like the one below to form a square? Can you make two squares with the four shapes?

Submitted by Andrew Davidson, Somerville, New Jersey

2. Two painters were working in a room. One was painting the ceiling and the other was painting the floor. One painter complained that the room was too hot and opened the window. The other painter complained that the room was too cool and shut the window. Which painter was working on the ceiling?

Submitted by Marc Cultice, Edmonds, Washington

3. Can you hum a tune with your mouth closed and your nose blocked? Try it. Can you explain what happens?

Submitted by Cynthia Anthony, Lexington, Massachusetts

Solutions to Brain-Boosters in this issue

F... ...th Ice

1. Photo A is frost on a window. The bubbles which often form inside an ice cube are shown in Photo B. Photo C shows the layers of ice in a hailstone that has been cut in half.

2. To make a hollow, ball-shaped ice cube, fill a balloon with water. Put it in your freezer until the ice is about a half inch thick. Then cut off the balloon, chip a little hole in the ice, and pour out the water inside. Can you make a hollow ice cube with a smaller ice cube inside of it?

3. The pile of blocks with the two aluminum blocks on the bottom would sink in most. What do you think would happen if you did this outdoors when the temperature was below freezing? Which pile would sink in least?

What Do You Know about the Moon?

1. It is often possible to see the Moon in the daytime about a week before and a week after the new moon. Why is the Moon out in the daytime only during these phases?

2. When seen from the United States, the Moon is never directly overhead. Near the Equator, however, it would sometimes be exactly overhead.

3. For an eclipse to occur, the Earth must come between the Moon and Sun (*see diagram*). When this happens, the half of the Moon that is facing toward the Earth is lighted.

4. The bright spots of the Moon are rough. Galileo reasoned correctly that a rough surface scatters the light, making it possible to see some light from any angle. Unless you are at one special place, a smooth surface appears dark when held in a light. You can demonstrate this, as Galileo did, with a piece of paper (rough surface), a mirror (smooth surface), and a light.

5. It is never possible to see the Moon as pictured in sketches a, b, and d. Can you explain why?

Problems from Readers

1. Here is how to arrange the four shapes to form one and two squares.

2. The painter who complained that the room was too hot was working on the ceiling. Warm air rises, so the ceiling would be hotter.

3. You cannot hum much of a tune with your mouth closed and your nose blocked. You may be able to produce a series of squeaks, but not much else. To make musical sounds, you must pass air across your vocal cords in your throat.

METEOR HUNTING

■ During July and August the night sky promises to put on two of its spectacular meteor showers (*see table below*). A meteor shower is always an exciting thing to watch.

Every day millions of pieces of metal and stone rain down on the Earth from space. When these objects survive the hot journey through the atmosphere and strike the ground, we call them *meteorites*.

A *meteor* is the fleeting streak of light caused by frictional heat as the stone or metal fragment speeds through the atmosphere. Most of the objects burn up and do not survive the journey to the ground. They often enter the atmosphere at speeds of 90,000 miles an hour or more and flare up about 75 miles above the Earth. They are visible for a second or so, then disappear from view at a height of about 50 miles. Their remains fall to Earth as fine dust.

Before a meteor streaks into view, it is called a *meteoroid*. Great swarms of millions of meteoroids travel around the Sun, as the planets do. When the Earth crosses the path of a swarm we have a meteor shower. Shower meteroids are the remains of old comets and are about as soft as cigar ash.

The meteorites you see in museums are the rock-metal type. Unlike shower meteoroids, the rock-metal types travel alone through space and are called *sporadic* meteoroids.

In the past, many large meteoroids have plunged into the Earth, leaving great scars (*see photo*). The largest meteorite on display is the Ahnighito meteorite. It weighs 34 tons and is on exhibit atThe American Museum-Hayden Planetarium in New York City. —ROY A. GALLANT

This giant crater in Ontario, Canada, has been partly filled in since it was formed by a meteorite—perhaps an asteroid —450 million years ago. Other such craters are known.

PROJECT

Meteor showers are named after the constellations out of which the meteor swarm seems to flow, or *radiate*. The Leonid Shower, for example, is named after the constellation Leo. When you observe a shower, make a map of the sky and draw in several of the major constellations. Be sure to include the constellation from which the shower radiates. Look all around the sky as you observe.

Each time you see a meteor, trace its path backwards to find out where it may have come from before it became bright. Draw this path on your map. After you have drawn in several paths, study them. Do they form a pattern?

It is possible to see about seven sporadic meteors an hour on any night. Does your map show you which are sporadic and which are shower meteors?

Meteor trails like this one are caused by stony or metal objects plunging into the atmosphere and heating up. About seven meteors per h[illegible] be seen on most nights.

WHEN TO WATCH FOR METEOR SHOWERS IN 1965-66

NAME OF SHOWER	DATE SHOWER IS STRONGEST	NUMBER OF METEORS PER HOUR
Delta Aquarids	July 29	20
Perseids	Aug. 12	50
Orionids	Oct. 20	25
Taurids	Nov. 5	15
Leonids	Nov. 16	25
Geminids	Dec. 13	50
Ursids	Dec. 22	15

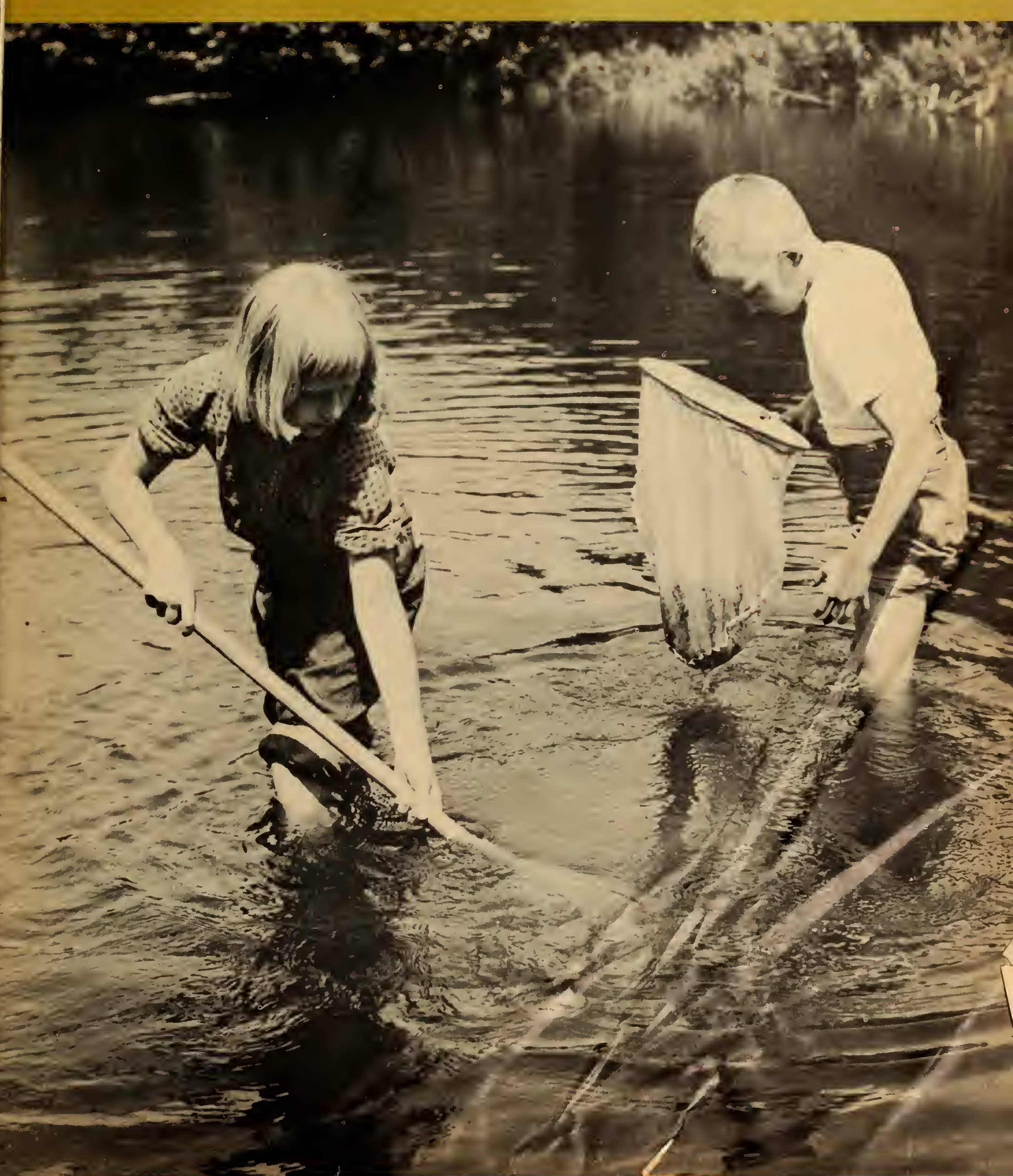
Some showers are best seen in the morning hours, others in the evening hours. Some showers can be seen only on the date shown, but others, such as the Perseids, may last nearly two weeks.

nature and science

VOLUME 2 NUMBER 18

SPECIAL ISSUE

EXPLORING THE EDGE OF A POND



LIFE AROUND A POND

Conk-kar-ree—a Red-winged Blackbird sings from its perch on a cattail stem... *Splash*—a turtle slides from a log into the water... *Jug-o-rum, Jug-o-rum*—a Bullfrog calls from his hideout in the reeds.

These are the sounds and sights of a swamp, or pond, or marsh. Scientists who study wildlife call these places "wetlands," and wetlands are valuable because of plants and animals that live in them.

As you use this issue of *Nature and Science* to help you explore wetlands, keep in mind that a pond is a community of living things. Many of the animals that live in a pond depend upon other pond animals for life. Some other animals need pond plants for food.

Many pond plants live in a particular place in a pond and can live nowhere else. If a pond is filled in or drained, a whole community of living things is wiped out. No wonder that state conservation departments try to save as many wetlands as possible. Find out what is being done to save ponds, marshes, and swamps in your area.

This issue was prepared with the advice of scientists at The American Museum of Natural History and the New York Botanical Garden. Editor of the issue was Laurence P. Pringle.

nature and science

VOL. 2 NO. 18 / JULY 1965

PUBLISHED FOR
THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
A DIVISION OF DOUBLEDAY & COMPANY, INC.

MANAGING EDITOR Franklyn K. Lauden; SENIOR EDITOR Laurence P. Pringle; ASSOCIATE EDITOR David Whieldon; EDITORIAL ASSISTANT Linda Britton; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Don Cailliez;

CONSULTING EDITOR Roy A. Gallant; CONTRIBUTING EDITOR James K. Page, Jr.

PUBLISHER Richard K. Winslow; CIRCULATION DIRECTOR J. D. Broderick; SUBSCRIPTION SERVICE Charles Moore

Contents

CREDITS: Cover, photo by Gordon Hicks; pp. 2, 4, 5, 6, 7, 11, 12, 13, 15, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, photo by Harry L. Beede; pp. 8, 9, drawings by R. G. Bryant; p. 11, photo by Paul Villiard; p. 13, photos, top from the Philadelphia Academy of Sciences, lower left by Hal. H. Harrison, lower right by Hugh Spencer, both from National Audubon Society; p. 14, photo, left by Hugh Spencer from National Audubon Society, others by Donald Zeiller; p. 16, hailstone photo from AFCRL Tech. Photo Branch, butter photo from Educational Services Incorporated.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through November and January through May; monthly, September, December, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office.

Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

SUBSCRIPTION PRICES in U.S.A. and Canada: 80 cents per semester per pupil, $1.40 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $4 per school year. Single copy 20 cents. Single subscription per calendar year (18 issues) $3, two years $5.50. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, New York 11531.

HOW TO EXPLORE A POND

by Laurence Pringle

Wear old clothes and boots or sneakers, then set out to investigate the many plants and animals that thrive in ponds and other wet places.

■ People have always been attracted to ponds, bogs, swamps, and marshes. No wonder—these quiet waters are the home of a wonderful variety of plants and animals. There are fish to catch, birds to watch, tadpoles and turtles to collect and raise.

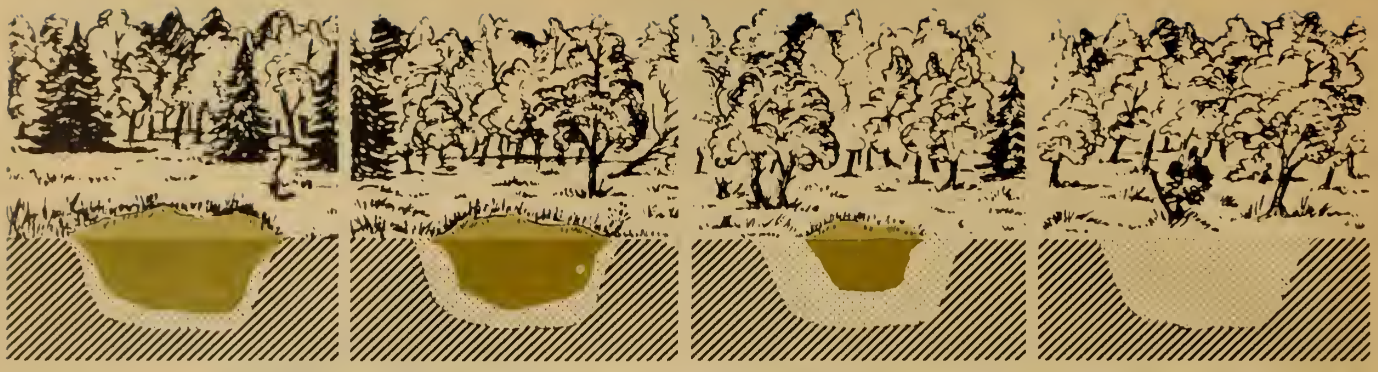
The chances are there's a pond nearby that you can explore this summer. If there are no natural ponds, there are probably some man-made ones. As you explore the edge of a pond (or marsh, or swamp, or lake), remember that the many living things there make up a sort of community. You can try to discover how the different kinds of plants and animals fit into this community *(see pages 8 and 9)*. You'll also find that these communities vary from pond to pond, and in different parts of the country.

Imagine that you are standing on a hill overlooking a pond. You are surrounded by trees—oaks, maples, beeches.

As you walk down the slope, mosquitos may start to annoy you—they began their life in the pond. As you leave the trees behind and work your way among young willows and alder shrubs, your feet may sink into the mud. Ahead are sedges (marsh grasses) and cattails. Frogs sit on rocks or driftwood among the reeds . . . dragonflies dart about . . . a water snake glides through the mud.

In wading boots, you can push through the cattails to see the open water. Here and there it is dotted with water lilies. This is a good spot to stop and look around.

(Continued on the next page)



Ponds gradually disappear as they are filled in with soil and the remains of dead plants and animals. As the water gets shallower, the plants at the pond edge creep inward. After thousands of years, the pond is completely filled in.

How To Explore a Pond (continued)

Birth and Death of a Pond

A pond forms when water is trapped in a pocket of land and cannot drain away. Some ponds were formed thousands of years ago, when glaciers gouged out valleys across much of the northern United States. Other ponds begin when a river cuts a new course and leaves part of its old channel behind. Sometimes people make ponds by damming small streams or by digging out basins with a bulldozer.

No matter how a pond is made, it immediately starts to disappear. Scientists who study the history of the Earth (called *geologists)* consider ponds to be temporary things—lasting just a few thousand years. That may seem long to us, but it is a short time compared with the age of the Earth—perhaps 4½ billion years.

As soon as a pond forms, it begins to vanish. Soil washed in from the surrounding land begins to fill it. The dead bodies of tiny plants and animals settle on the bottom. Plants begin to grow along the shore. When some of these plants die, their remains also settle to the bottom.

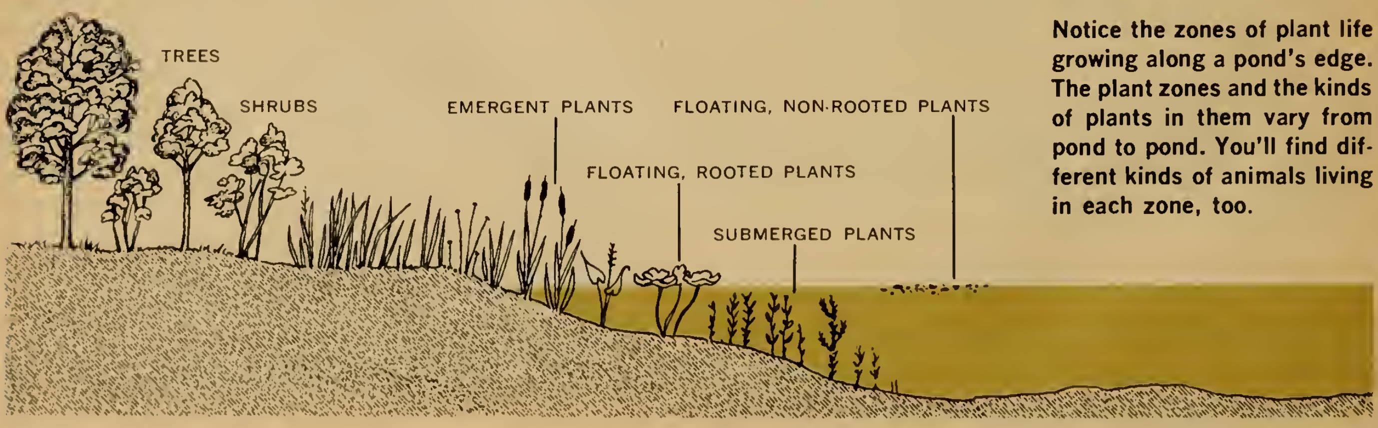
As the remains of plants and animals pile up on the bottom, the water becomes shallower and the shore plants grow out further toward the center of the pond. Year by year the plants creep inward *(see diagrams).* Eventually, the pond is completely filled in. In much of the United States, the filled-in pond is covered by a forest if the area is undisturbed by humans. In the prairie states of the central United States, the pond becomes a grassland.

Case of the Disappearing Pond

As you explore a pond, look for clues that hint at its future disappearance. Is the pond bottom bare or is it covered with leaves and other parts of dead plants? Look for different "zones" of plants. You'll probably find at least four or five zones *(see diagram).* One is made up of *floating* plants that have no contact with the bottom. There may also be *submerged* plants that grow on the bottom but do not reach the surface.

Closer to shore, you'll find *emergent* plants, rooted in the soil at the bottom of the pond but sticking out of the water. Emergent plants include cattails, bulrushes, and arrowheads. Next is a zone of plants that grow in the wet muck at the pond's edge. Beyond that, on drier ground, are shrubs and trees or grasses.

You may find one pond that has all of these zones of plant life and another pond with practically no plants along



Notice the zones of plant life growing along a pond's edge. The plant zones and the kinds of plants in them vary from pond to pond. You'll find different kinds of animals living in each zone, too.

TRACKS OF SOME POND MAMMALS

EQUIPMENT FOR STUDYING POND ANIMALS

its shore. Which is younger? Do you think you could tell a natural pond from a man-made one by looking at the plants in and around it?

As you explore the edge of a pond, make a sketch of the plant zones you find. Your sketch might look like the diagram on page 4. Then, as you visit the pond from time to time, make notes on where you find certain animals or their signs. Some animals, like Muskrats, spend most of their time in the water. Spotted Sandpipers may use only the zone right along the edge of the water. What about an animal like the Raccoon? Where might it be found around a pond? Try to figure out why certain animals use particular areas and not others. Carry a notebook and keep a record of what you see.

Things To Watch For

Some of the other articles in this issue tell about the snails, turtles, and insects that live in ponds. But these are just a few of the animals you can find and study.

The *mammals* that live around ponds are active mostly at night. They include Muskrats, Mink, and Raccoons, as well as the more rare River Otters and Beavers. You may find their tracks in the mud *(see diagrams)*. The shape of their feet offers some clues about the kind of life these animals lead. Is there webbing between the toes? How might this help an animal? Look for signs of the animals' feeding. Would you say that a Raccoon is a meat-eater, a plant-eater, or both?

Muskrats are sometimes active during the day. You may see one swimming out in the pond or feeding on the shore. Try to find out how the animal's long, hairless tail is used for swimming. Also look for the animal's den. It may be a hut made of reeds and cattails, or a tunnel dug into the bank.

Ponds and other wet areas attract many birds. They range from tiny marsh wrens, building their nests among cattail stems, to four-foot-high Great Blue Herons, prowling through the water for food. Watch to see what different kinds of birds eat, where they nest, and what parts of the pond they use.

Beside a pencil and notebook (and insect repellent), you may want to take some other equipment on your pond exploration trips. If you're particularly interested in birds, carry binoculars and a field guide *(see the book list below)*. The diagrams on this page show equipment you can use to collect water insects, tadpoles, salamanders, and other small water animals for study at home.

Visit a pond as often as you can. There's always something going on. Sit quietly and watch. You may see a kingfisher plunge into the water after a minnow, a frog snap up an insect with its long tongue, or a Muskrat building its house for the winter. In any season, life around a pond is full of exciting events to see and mysteries to solve ■

Look in your library or bookstore for these books on ponds and other wet areas, and the life in them: **Field Book of Ponds and Streams,** by Ann Haven Morgan, G. P. Putnam's Sons, New York, 1930, $5; **In Ponds and Streams,** by Margaret Waring Buck, Abingdon Press, Nashville, Tennessee, 1955, $1.75 (paper); **Birth of a Forest,** by Millicent Selsam, Harper and Row, New York, 1964, $2.95; **Audubon Water Bird Guide,** by Richard Pough, Doubleday and Co., Inc., New York, 1951, $4.50; **Field Book of Nature Activities and Conservation,** by William Hillcourt, G. P. Putnam's Sons, New York, 1950, $4.95.

HUNTING POND INSECTS

You'll find insects over, on, and in the water of ponds. With equipment from your home, you can catch and study them.

by Alice Gray

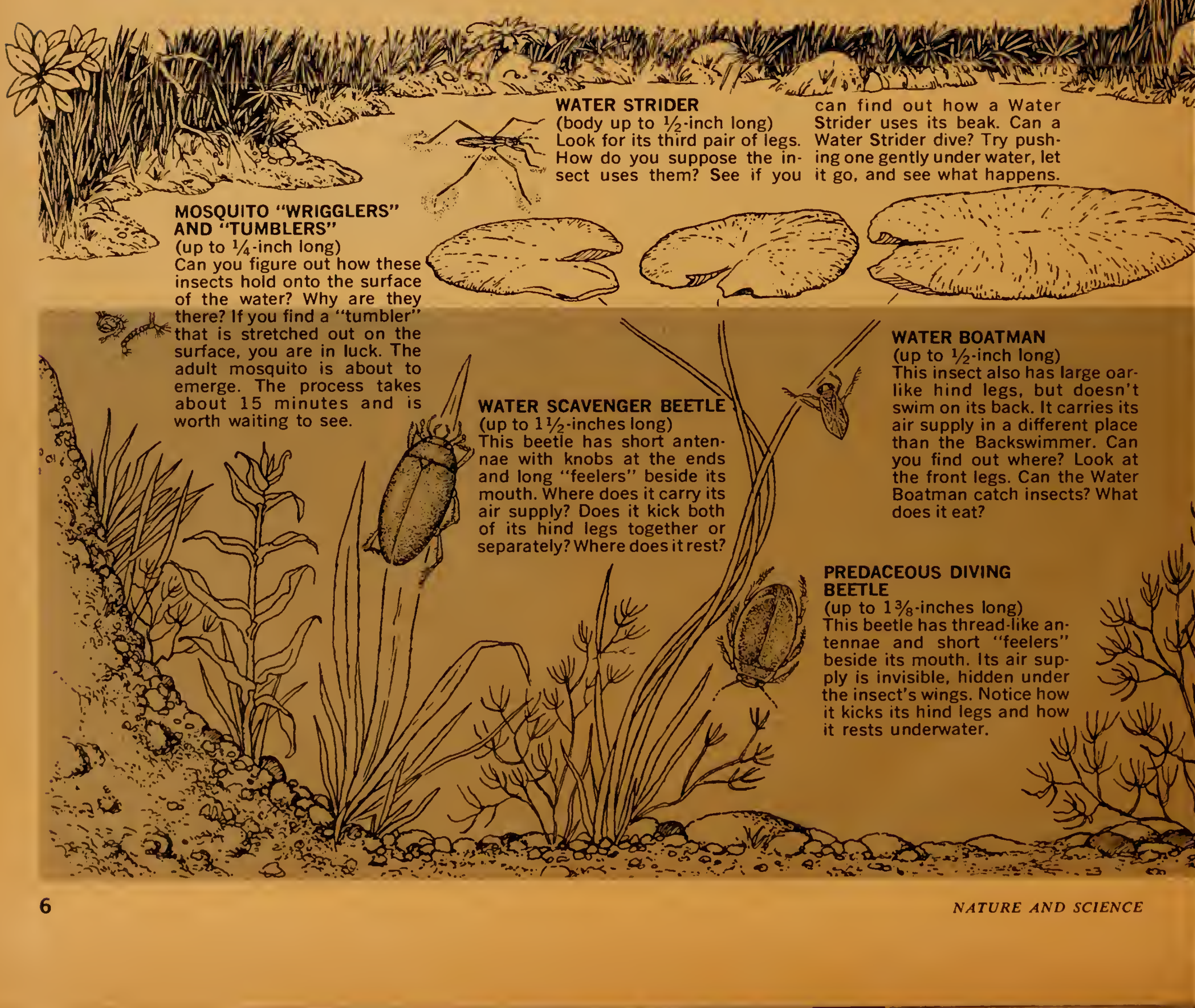
■ It's lots of fun to hunt for pond insects and to try to find out how each is fitted for its particular way of living. You will often see insects "skating" over the surface of the water. Some spend most of their time just below the surface. Some climb among the water plants. Others swim in open water, sprawl on the bottom, or lie buried in the mud.

To catch and study these insects, you will need a sieve tied to a long stick; a wide-mouth quart jar of clear glass; a shallow pan of a light color, about as big as a pie pan; a spoon; and a medicine dropper *(see page 5)*. A small pair of tweezers would be handy (not the eyebrow kind—they are too stiff). Take a magnifying glass, and a notebook so that you can keep a record of the things that you discover.

When you get to the pond, fill your jar about two-thirds full of water. Put a little water into your pan, too. Now you are ready for any insect you may catch.

Catching Insects in Different Places

Probably the first kind you see will be shiny black oval ones about half an inch long, swimming rapidly in circles on the surface of the water. These are Whirligig Beetles. Dip one out with your sieve and put it into your jar. Some things to look for and find out about this insect are listed with the drawing of a Whirligig on this page. When you



have studied one kind of insect, let it go and look for another kind.

Now skim the surface of the water quickly with your sieve. Rinse the sieve in your pan to wash out anything you have caught. Are there any very small insects that thrash about briefly, then float to the surface? These are probably the immature stages of mosquitos *(see diagrams)*. The long ones are *larvae*, or "wrigglers." The round ones are *pupae*, or "tumblers." Take up one of each with your medicine dropper or spoon, and put it in the jar, where you can look at it from the side with your magnifying glass.

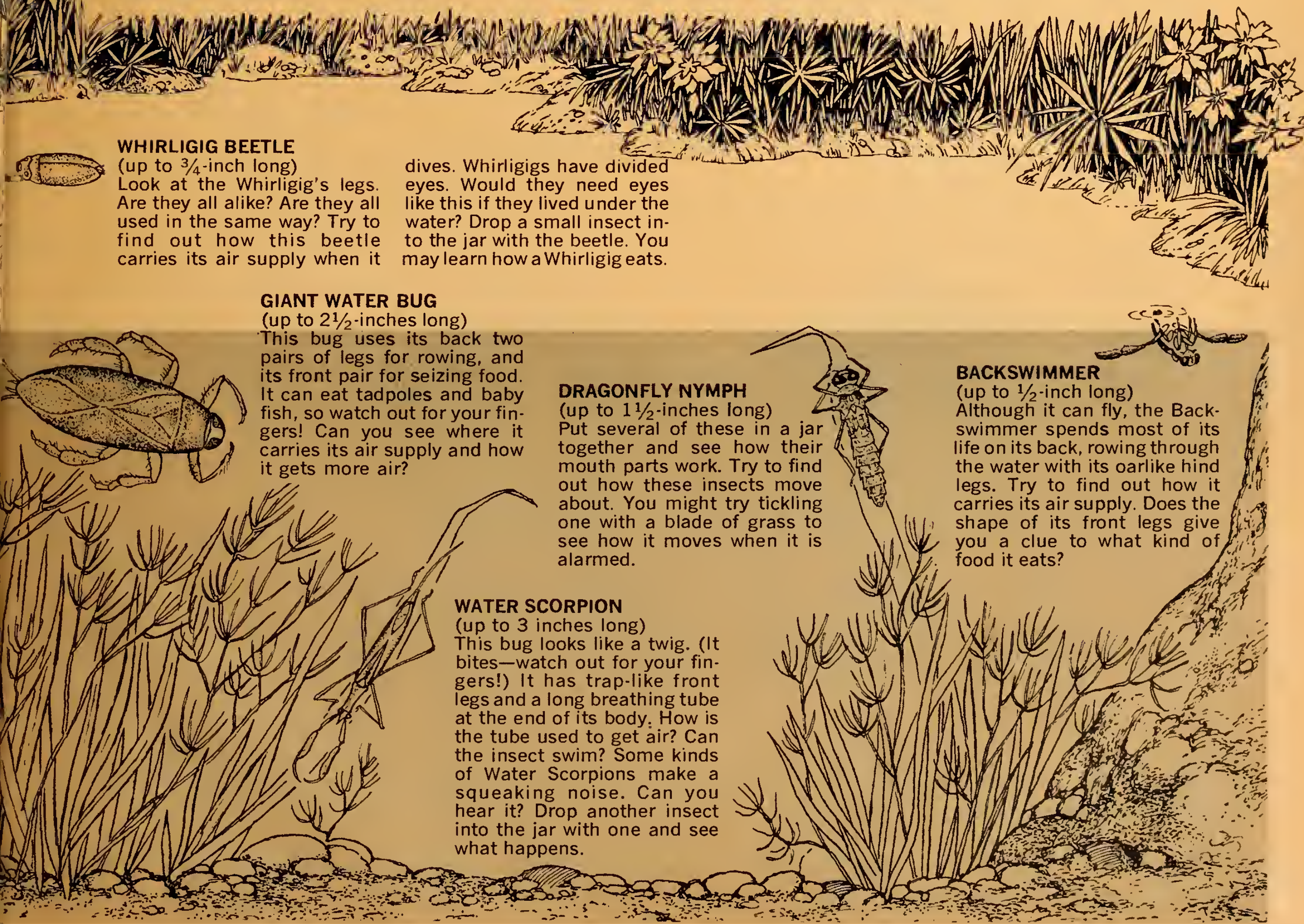
In a spot where you look straight down into the water, you may see something swimming. Perhaps it is a Water Boatman or a Backswimmer, a Water Scavenger or a Predaceous Diving Beetle *(see diagrams)*. You can put any one of these into your jar to study it. *Be careful*—most of these big insects can bite. Also, they can escape by flying.

Some insects rest among the stems and leaves of water plants nearly all the time. Pull up a handful of water plants, put them in your pan, and see what you can find. Put a piece of plant into your jar, too, so that you can see how the insects climb.

To find insects that live in the pond bottom, scoop up a cupful of mud in your sieve and swish it back and forth in the water until most of the mud has washed through the screen. Dump what is left into your pan and watch closely until things start to move. (You might hurry up the process by draining off all the water.) Pick up the insects you want to see with tweezers or your dropper, and put them into the jar so you can look at them.

Many water insects are active at night. Try sealing a lighted flashlight and some stones for ballast into a big glass jar and sinking it in shallow water. The light will attract water insects as a porch light attracts moths.

You may be tempted to take home some big water insects and try to keep them in an aquarium. But most of them are cannibals. You can't keep more than one in a tank for very long, and it will need a steady supply of live insects for food. You can probably find out much more about water insects by watching them in the pond ■



WHIRLIGIG BEETLE
(up to 3/4-inch long)
Look at the Whirligig's legs. Are they all alike? Are they all used in the same way? Try to find out how this beetle carries its air supply when it dives. Whirligigs have divided eyes. Would they need eyes like this if they lived under the water? Drop a small insect into the jar with the beetle. You may learn how a Whirligig eats.

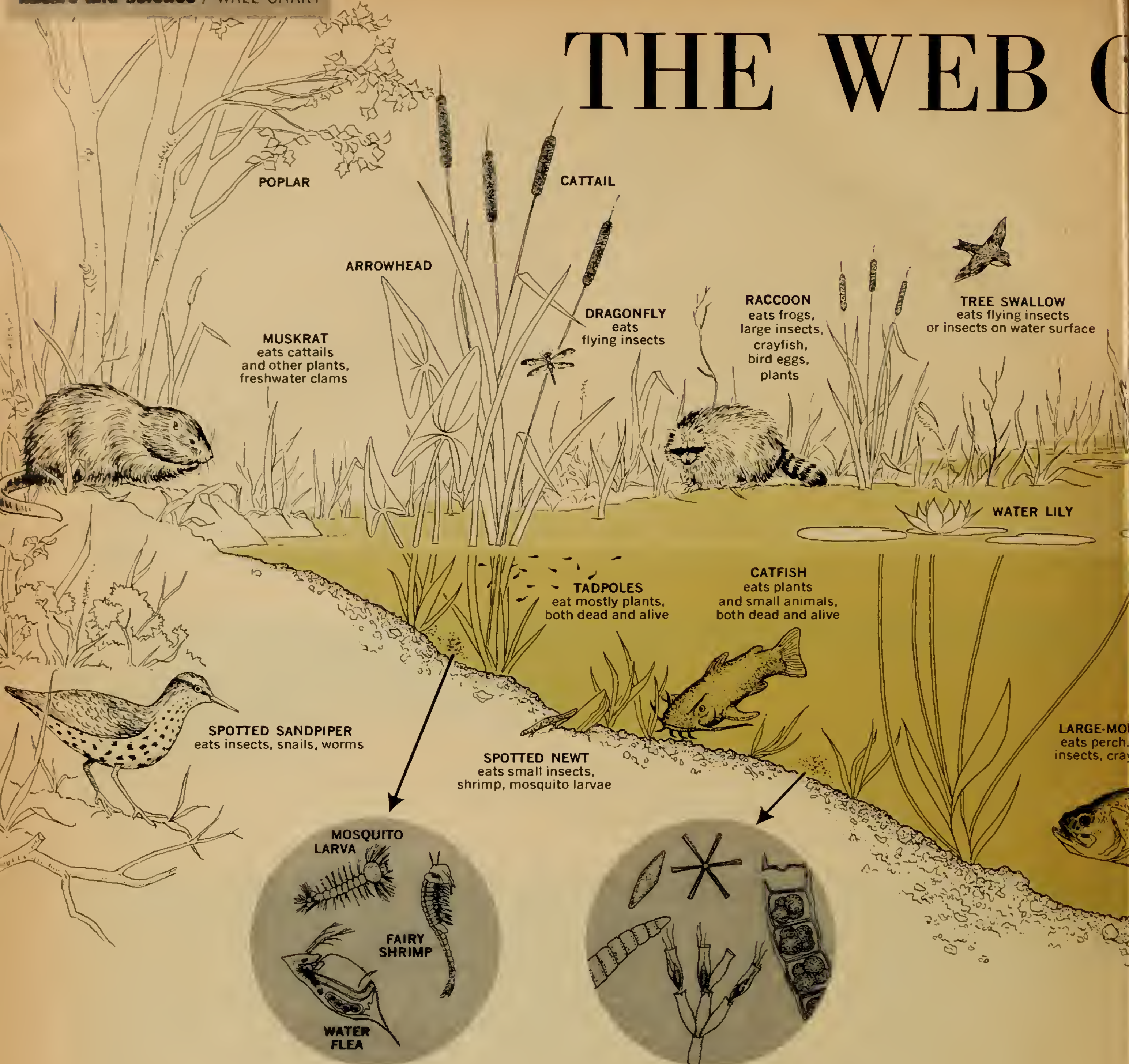
GIANT WATER BUG
(up to 2½-inches long)
This bug uses its back two pairs of legs for rowing, and its front pair for seizing food. It can eat tadpoles and baby fish, so watch out for your fingers! Can you see where it carries its air supply and how it gets more air?

DRAGONFLY NYMPH
(up to 1½-inches long)
Put several of these in a jar together and see how their mouth parts work. Try to find out how these insects move about. You might try tickling one with a blade of grass to see how it moves when it is alarmed.

BACKSWIMMER
(up to ½-inch long)
Although it can fly, the Backswimmer spends most of its life on its back, rowing through the water with its oarlike hind legs. Try to find out how it carries its air supply. Does the shape of its front legs give you a clue to what kind of food it eats?

WATER SCORPION
(up to 3 inches long)
This bug looks like a twig. (It bites—watch out for your fingers!) It has trap-like front legs and a long breathing tube at the end of its body. How is the tube used to get air? Can the insect swim? Some kinds of Water Scorpions make a squeaking noise. Can you hear it? Drop another insect into the jar with one and see what happens.

THE WEB (



Enlarged view of small insects, shrimp, and other animals that eat microscopic plants and animals. These animals are then eaten by big insects, fish, and other meat-eaters.

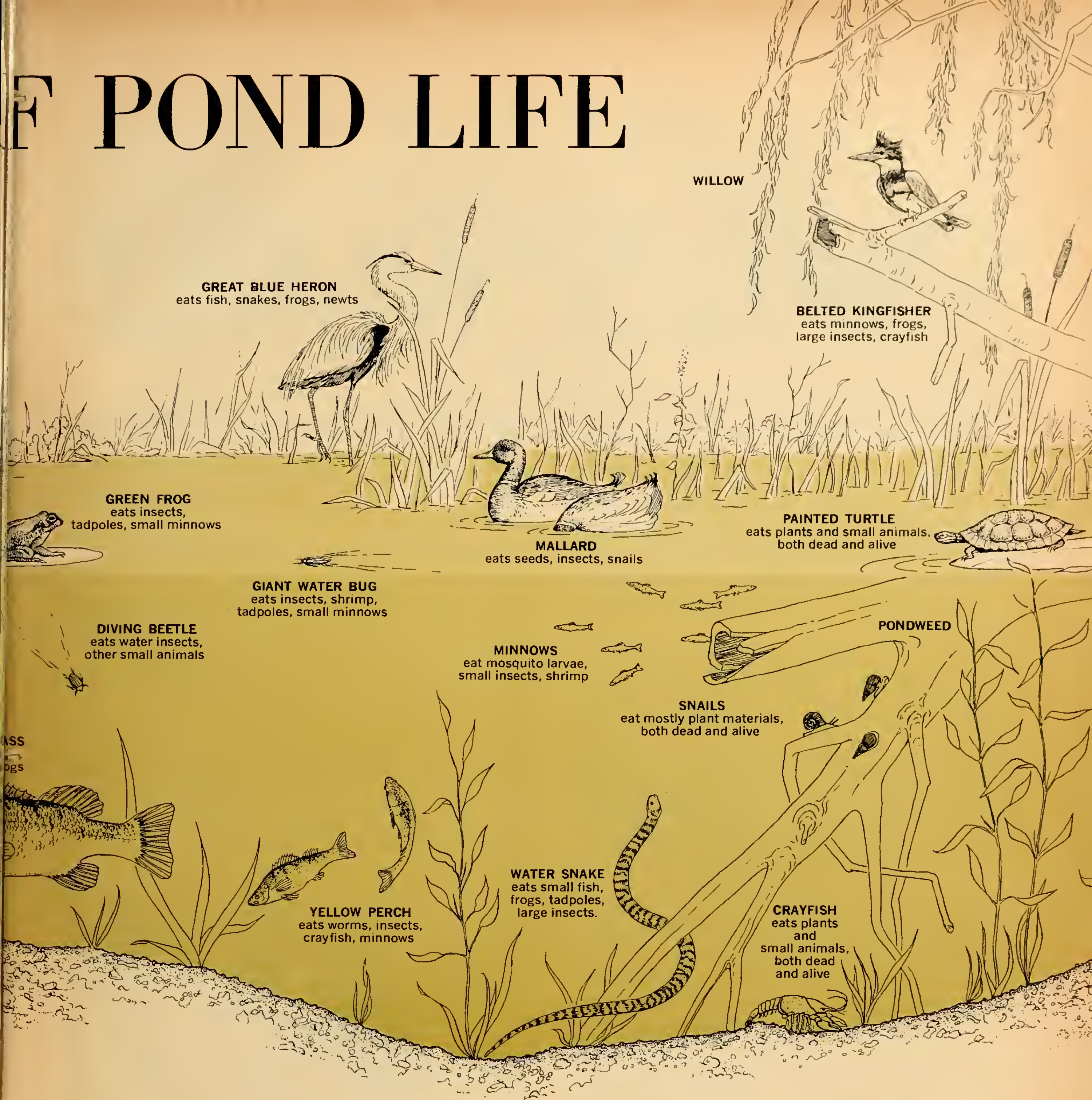
Enlarged view of microscopic plants and animals. The tiny plants, called phytoplankton, use Sun energy to make food and are the main source of energy in a pond's web of life.

The drawings on these pages will help you identify some of the plants and animals that live in and near ponds, lakes, marshes, or other areas of quiet water. As you explore life around a pond, try to figure out the "job" of the different kinds of plants and animals you see in the pond community.

■ Think of all the different people v
city or town. Some are milkmen, te
or grocers. Others are students, hou
tists. Each has a job in the communi

The same is true of the different
and animals that live in a pond. Th
community too, and each has a j
plants, for example. They are *food-p*
combine energy from the Sun with

F POND LIFE



live in your
s, lawyers,
es, or den-

s of plants
e part of a
Take green
cers. They
r and min-

erals from the soil and store this energy in the form of fats, sugars, and other foods. The stored energy in green plants is then passed on to *plant-eating animals*. Some plant-eaters are so small that you can see them only with a microscope. Others may be large, like Muskrats and Beavers.

Some animals are *meat-eaters*. They feed mostly on the plant-eaters. They, in turn, are eaten by other meat-eaters, and energy is passed from one to another.

When a plant or animal dies, some of its stored energy may be passed on to an animal that eats dead plants and animals. Or the dead plant or animal may slowly decay. Its energy is taken in by bacteria and molds as they break down the material in the dead organism into simpler substances. Some of the dead organism also becomes part of the soil, and later may be taken into the roots of a plant. Then the cycle of energy starts all over again ■

INTO A SNAIL'S WORLD

by Paul Villiard

You can get these animals from a pond or pet shop, then raise them and study their lives.

■ One of the most fascinating kinds of animals that live in ponds can also live in your home. Snails are common animals in fresh-water ponds, and you can collect some by looking for them on the leaves and stems of water plants. Or you can buy some snails from an aquarium supply store. Then you can watch them grow, mate, lay eggs, and raise their young.

Some snails are good animals to have in aquariums because they eat the simple green plants, called *algae,* that grow on the sides of aquariums. Other snails are a problem because they eat the larger green plants that give an aquarium a natural look.

People who keep fishes in aquariums hunted for a long time to find a snail that would eat algae and left-over food, but would not eat other plants. They tested four kinds (species) of snails called *Ampullaria.* Three of them are terrific plant eaters. The last kind eats only dead leaves, algae, and left-over fish foods. Its full name is *Ampullaria cuprina.* You will find these snails for sale in stores where tropical fish are sold. They cost a few cents, for small ones, to a quarter or more for large ones.

A Home for Snails

Whether you buy or catch your snails, first you must get a home ready to keep them in. You can keep them in large, wide-mouth jars or in aquariums. A five-gallon aquarium is a practical size. It should be planted with some living plants put in washed sand or fine gravel. The best plants for your snail's home are *Vallisneria* and *Sagittaria.* You can also try plants collected from a pond.

Put in not less than a dozen *Vallisneria* and one or two *Sagittaria* plants for a five-gallon tank. Double this number for a ten-gallon tank. To keep the plants healthy and growing they must have some kind of food, and the best way to get it is from fish body wastes (droppings). Put three or four *Zebra danios* in your tank. These fishes are available all year around, every pet store has them, and they cost only few pennies each. They will not bother the snails as many other fishes do. They are hardy and eat anything, and they live two years or even longer.

After planting your tank and filling it with cool water from the tap, allow it to stand for two or three days. Put a glass cover on top to keep out dust and cut down evaporation. Then get your fishes and put them in. Float the fish container with the water and fishes in it inside the tank for a couple of hours, to let the water in the container come to the same temperature as the water in the tank. Then gently tip out the fishes.

A day or so after you have put in the fishes you may add two *Ampullaria cuprina* or other snails. Feed the fishes—and the snails too—with the best fish food you can buy. The food should be rich in animal matter—ground shrimp, liver, beef, fish and fish eggs, and a little cereal. You can buy small cans of food like this in pet stores. Do not feed more than will be eaten in about five minutes, then feed again, repeating until the fish leave some of the food. The snails will clean up all the leavings, but do not feed any more for that day or you will foul the water.

Keep your tank where it will get some light for a few hours each day, but not in direct sunlight.

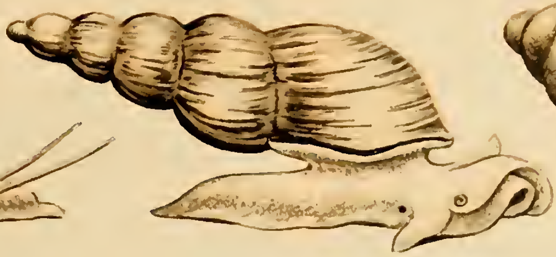
Watching Your Snails

Now start to observe your snails. First of all, see if you can see the motion of a snail's foot muscles. Watch closely as a snail walks up the glass. You will be able to see the rippling movement of the muscles in its foot.

Watch the snails as they walk up leaves, eating the algae that form on the plants. At times the snail will travel to the top without making the leaf move. At other times the leaf will curve downward and gently let the snail drop to the bottom of the tank. Can you figure out why?

Your snails will frequently crawl up to the top of the tank and push their breathing tubes, or *siphons,* up out of the water. They stand with the siphon extended, pumping

LARGE WHEEL SNAIL



GREAT POND SNAIL

TADPOLE SNAIL

their bodies just as though they were filling up with air. See if they bend the plant leaves more before they pump themselves up or afterward. Watch the way they let go their hold on the glass and drop to the bottom of the tank. Do they fall faster after pumping up, or slower? Can you figure out why?

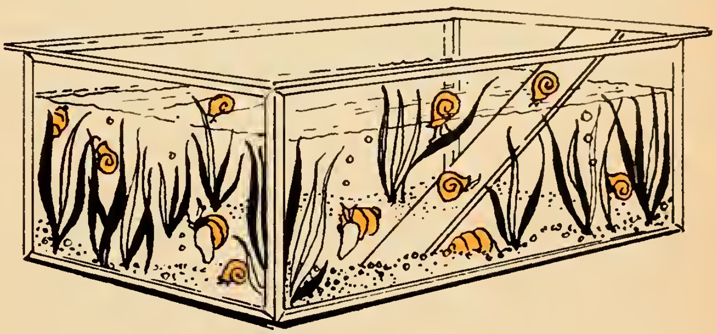
After the tank has been set up for a few weeks you may see a green film growing on the glass at the place where the most light hits it. This film is algae, and *Ampullaria cuprina* likes to eat it. The snail eats by scraping the algae off the glass with its tongue (called a *radula*). The radula is like a ribbon set with rows of tiny teeth. The snail can rotate these teeth to scrape algae from the glass. The teeth of these snails are snowy white, and you can plainly see them and their rotating action *(see photo)*.

Notice how fast the algae grow on the glass and how fast the snails eat them. Move the tank closer to or farther away from the light to adjust the rate of growth. If you are careful enough and have patience enough, you can adjust the growth of the algae to match the feeding rate of the snails, and they will keep the tank almost completely clean of algae.

This snail was photographed through the glass wall of its aquarium. You can see the tiny teeth on its tongue that are used to scrape algae from the glass.

Raising Young Snails

After the snails grow to be about 1½ inches in diameter, they will mate and have young. They lay their eggs out of the water on a surface from which the young snails can drop into the water as they hatch. A good breeding place



for your snails is a strip of sanded or ground glass about two inches wide. It should be long enough to stand slanting out of the water in the tank *(see diagram)*. Some sort of cover should be kept over the tank to keep the air moist above the water, to keep out dust, and to keep the animals from crawling out of the tank.

The strip of ground glass should stick out of the water several inches. It should lean against the side of the tank with its ground surface facing up. The snails will crawl up near the top of the strip and lay their eggs in a large cluster, cementing them firmly to the glass. The eggs are round and pink, and very soft and sticky. After a short time they dry off and the shells harden. In a couple of weeks the eggs hatch and the tiny snails drop into the water.

If you keep the young snails well fed and warm (about 75°F) they will be ready to breed about eight months after hatching. If you get a large surplus of healthy snails you can trade them with your friends, or sell or trade them to your pet shop owner ■

PLANTS THAT EAT ANIMALS

Look for them around a swamp or bog, or grow them at home from seeds. You can find out what kinds of food they catch and digest.

by Richard M. Klein and Pamela C. Edsall

■ Many years ago, the few people who traveled to distant lands usually wrote books on their adventures so that stay-at-homes could share their experiences. In more than one of the books written about Australia and the island of Madagascar, a chapter was given to a story about "man-eating plants."

According to these books, the plants had long *tentacles,* or "feelers," that wrapped around a man just like the tcntacles of an octopus. The screaming victim was carried into the mouth-like flower, swallowed, and digested. All that was left was a grinning skeleton. None of the travelers actually saw the plants, but they all said that they had been told about them by friends.

Today, we know that there are no man-eating plants. Thcre are, however, plants that can eat insects such as mosquitos and beetles, and other small animals. These are called *insectivorous* ("insect-eating"), or *carnivorous* ("mcat-eating") plants. You can sometimes find these plants growing in swamps, bogs, and other wet areas.

Probably the best known of the insect-eating plants is the Venus Flytrap. It grows in swamps in the Carolinas and a few other places. At the end of each of its leaves is a real trap, made of two flattened parts edged with curved teeth (*see photos*). If you look closely at the flat part, you will see that each surface has three thin hairs. The plant also has cells which make a chcmical that attracts flying insects. When a fly lands on the trap, it touches the hairs. In some way that is not understood, the touching of the trigger hairs causes the trap to spring shut. Once the insect is trapped, its struggles causc the cells of the trap to produce a liquid. This liquid is made of chemicals called *enzymes,* which begin to digest the insect. The enzymcs change the insect's body into liquids that the plant can soak up.

When most of thc insect's body is digested (in a few days), the trap slowly opens. The insect's remains blow away in the breeze, and the trap is ready for its next victim.

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden. Miss Edsall is his Research Assistant.

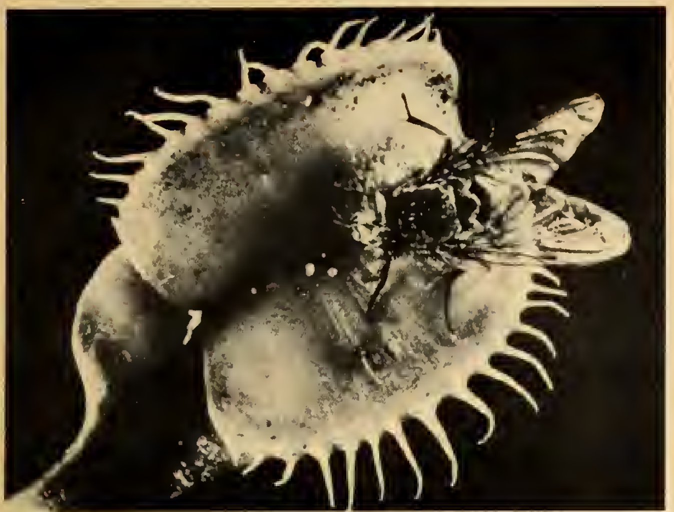
Come into My Pitcher...

Another group of insect-eating plants is the *pitcher plants.* They are common in the northern United States and in Canada. Instead of trapping inscets, pitcher plants let insects trap themselves. Thc pitcher-shaped lcaves produce sugar nectars and odors that attract insects. When an insect lands on the rim of the pitcher and tries to reach the nectar, it slips on the wax coating of the rim and falls into the water-filled pit. Guard hairs, pointing downward, keep the insect from crawling out. It drowns. Then its body is slowly digested and the food is taken into the plant. If you cut open the leaf of a pitcher plant, you can find the skeletons of flies, beetles, and other insects (*see photo and diagram*).

Of all the insectivorous plants, the ones that are most interesting from a scientific and engineering point of view are the *bladderworts.* These plants live under the water. You can recognize them by their thin leaves and by the

RAISE YOUR OWN INSECT-EATERS

There are five types of insectivorous plants in the United States. All of them live in swamps or bogs, and most of them can be easily recognized. Many states have laws against collecting these rare plants. However, you can buy seeds of several kinds, particularly the Venus Flytrap, from large seed companies. Biological supply companies, such as Turtox (8200 South Hoyne Ave., Chicago, Illinois 60620) or the Carolina Biological Supply Co. (Burlington, North Carolina) sell young plants or seeds of several different kinds of insectivorous plants. You can grow them in moist soil or in wet sphagnum moss. If the plants dry too rapidly, cover the pots with plastic bags, or grow them in a terrarium.



This housefly has landed on the lobed trap of a Venus Fly-trap. When it touches the trigger hairs of the trap, the two lobes snap together, enclosing the fly. After a few days the fly's body is mostly digested and the trap opens.

small traps which grow on the side branches close to the main stem (*see photo*). The trap, or bladder, is shaped differently in different kinds of bladderworts. Usually, however, it is like a small sac, or bag, with a "mouth" or "door" at one side. Many hairs surround the mouth. Some of these hairs act as guides, bringing the insects close to the mouth. Others are "trigger hairs" (*see diagram*).

The trap is set when the mouth is closed and the sides of the sac are pushed in. The water pressure is less inside than outside. When an insect brushes a trigger hair, the mouth opens, and some water and the insect are sucked into the sac. As the insect is digested, some water passes out through the walls of the sac. This lowers the water pressure inside the sac, resetting the trap for its next capture.

The *sundews* are another group of common insect-eating plants. Their small leaves are flat at the tip and covered with small tentacles (*see photo on next page).* These tentacles give out a sticky fluid. When insects land on a leaf, they stick to the fluid. The tentacles fold over the insect, and enzymes in the fluid begin to change the insect's body into food for the plant.

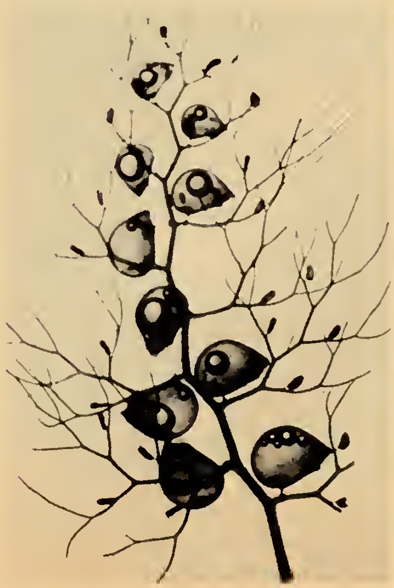
Some Unanswered Questions

As scientists learn more about these insectivorous plants, certain questions about them become more and more puz-

(Continued on the next page)

Insects that are lured into the pitcher-shaped leaves of pitcher plants drown inside and are slowly digested.

The traps of bladderworts catch insects and other small water animals that pass too close to the trap's mouth.



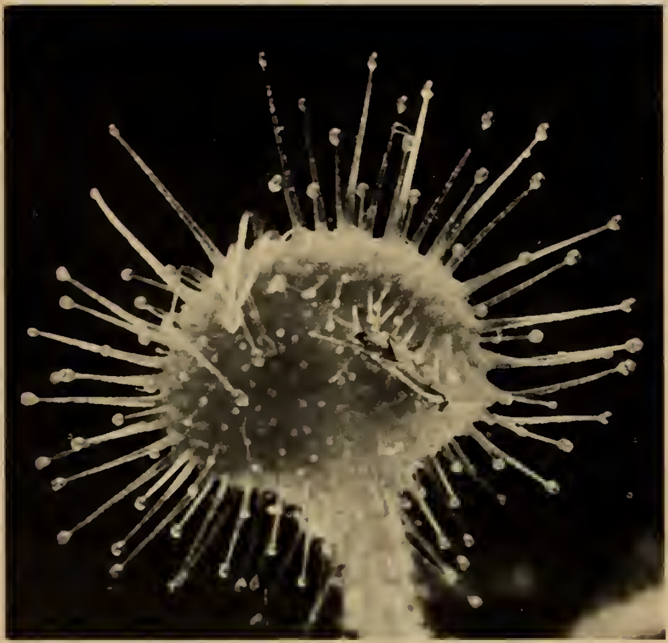
INVESTIGATION

The trap of a Venus Flytrap will not spring unless the insect touches two of the hairs, or touches one of the hairs twice quickly. You might try touching a single hair twice to spring the trap. Use a watch with a second hand and find out how quickly you must touch the trigger hair the second time to spring the trap.

You can feed small bits of meat, the white of a hard-boiled egg, or other food to a Venus Flytrap. Will it digest paper, or wood, or string?

zling. We know, for example, that these plants are found in many parts of the world, and that they did not all develop from a single kind of plant. But we do not know when and where the different kinds of these plants first grew.

An even harder question to answer is this: How did these plants develop into insect-eaters? They all grow in swamps or bogs, where the soil has few minerals that plants can use. Also, none of these plants have roots that are very good for taking minerals from the soil. Plants need minerals, especially those that contain *nitrogen,* in order to grow. Scientists have found that these plants will grow, flower, and form seeds without ever "tasting" an insect. But they grow better if they get nitrogen from the bodies of insects or if they are given the same amount of nitrogen in the form of fertilizer. This may explain *why* these plants developed into traps for insects. But exactly *how* this came about is a mystery that may never be solved ■



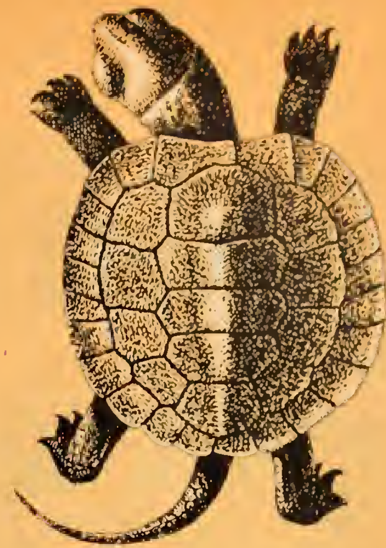
This closeup view shows an insect trapped on the sticky "hairs" of a sundew. Parts of the insect's body will slowly be changed into food that the plant can soak up.

By the time she was five years old (left), Vivian Zeiller had several pet turtles. Now 18, she is studying art at Mount Ida Junior College in Boston.

Young turtles hatch from eggs in the early fall and feed for a few weeks. Then they must dig underground to survive the cold of winter.

This photo compares a newly-hatched Box Turtle with an adult. If well-fed, a young turtle will double its size each year for several years.

TRAPPED BY A TURTLE



When Vivian Zeiller was caught by a turtle in 1950, she began an investigation that could go on for 100 years or more. You can find out a good bit about turtles, though, by keeping them for just a few weeks or months.

■ It all began in 1950, when Vivian Zeiller was just three years old. She was playing in the backyard of her home (in Tenafly, New Jersey) when a Box Turtle walked past. She tried to pick it up, the turtle snapped its lower shell shut, and Vivian's finger was caught.

Carrying the turtle, she ran to her father for help. He pried her finger loose. Vivian was free of the turtle, but her interest in turtles was just beginning. Her father built a cage for the turtle and Vivian began studying her new pet. But this was just the start.

Today the Zeiller turtle pen measures about 35 feet square. Inside are 30 Box and Wood Turtles. Through the years, Vivian has marked each new turtle by filing V-shaped marks on the edge of its upper shell, or *carapace*. For example, Esmerelda, a female Box Turtle bought from a pet shop in 1963, has two file marks on the fifth plate from the rear on her left side (*see diagram*). Her code number is $L\text{-}5^2$ (left side, fifth plate, two marks).

By keeping records like these, Vivian and her family hope to learn more about how long turtles live. Many turtles live at least 15 or 20 years, but there is one record of a Box Turtle that lived 129 years. The Zeillers have already learned a lot about the lives of the turtles in their pen. Although Box and Wood Turtles seldom go into the water, the pattern of their lives is like that of turtles you may find in ponds, marshes, and other wet areas.

Turtles Through the Seasons

In the fall, the turtles burrow into the leaves and soil, digging a hole that will be their winter home. (Pond turtles usually spend the winter in the mud at the pond bottom.) They reappear on warm days in late March or early April, and mate soon after leaving their winter dens.

In late June, the female digs a hole in the soft earth of a sunny area and lays her eggs, then covers them. The young hatch and crawl to the surface in the early fall, just a few weeks before they go underground for the winter.

If you want to catch some turtles to study, first check to find out what kinds are protected in your state. (To find out, call or write to the nearest office of your state conservation or fish and game department.) You can catch young pond turtles with a long-handled scoop net. Don't take more than you can easily care for.

Whether you keep your turtles in an outdoor pen or in an aquarium, they should have both land and water. In a pen, dig a hole in the ground, then set in a pan of water with its rim at ground level. In an aquarium, put in rocks which the turtles can crawl onto.

Many pet turtles die from lack of food, so be sure to feed yours well. The Zeillers feed each turtle a teaspoonful of canned dog food every three days. The turtles also eat melon rinds, peaches, other fruit, and tomatoes.

Weigh and measure your turtles from time to time. File a mark on a different part of each turtle's shell edge to tell them apart. (Never mark a turtle with paint—it may kill the animal.) Keep a record of the identity marks and measurements in a notebook.

See what you can find out about the lives of your turtles. How much time do different kinds of turtles spend in the water? How does a turtle swim? How are its feet used? Can it swim backward? Do your turtles seem to prefer certain kinds or colors of food?

Unless you plan to feed and care for your turtles indoors all winter long, you should let them go at the end of the summer. Release them in a woods or pond like the one where you found them. Someday you may return to that spot, catch a turtle, and recognize your mark on him. Then you can check your notebook and see how your old friend has grown through the years ■

To identify turtles, see the Golden Nature Guide, **Reptiles and Amphibians,** by Herbert Zim and Hobart Smith, Golden Press, New York, 1953, $1; a useful pamphlet on turtles and their care is **The Care of Pet Turtles,** by H. G. Dowling and S. Spencook, New York Zoological Society, New York, 1960, 25 cents.

brain boosters

prepared by **DAVID WEBSTER**

MYSTERY PHOTOS

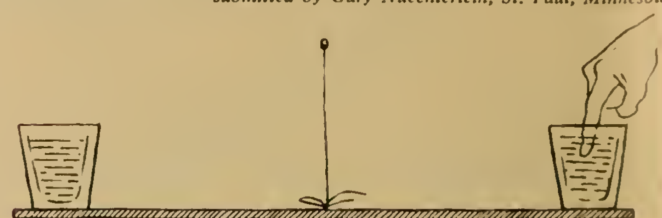
1. What is it?

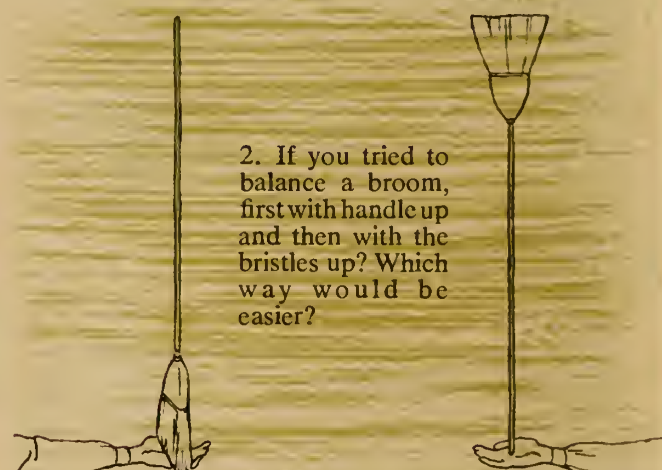
2. What is it?

WHAT DO YOU THINK WOULD HAPPEN . . .

1. If you balanced two glasses of water as shown, and stuck your finger into one glass of water? Would that side go up, go down, or stay the same?

submitted by Gary Nuechterlein, St. Paul, Minnesota





2. If you tried to balance a broom, first with handle up and then with the bristles up? Which way would be easier?

CAN YOU DO IT?

1. Is your fist bigger or smaller than your best friend's fist? Can you figure out a way to measure the size of your fist?
2. Can you use a piece of string and some salt to take an ice cube out of a glass of water without touching the ice with your hands?

submitted by Ira Haber, Kensington, Maryland

FOR SCIENCE EXPERTS ONLY

1. How much do you weigh while you are in the air after jumping from a diving board? Imagine a bathroom scale strapped to your feet. Would it register any weight?
2. The tiny water plants called *algae* cannot live at temperatures of 212°F. Yet many algae grow in the boiling water of the Mammoth Hot Springs. (These springs are high in the mountains in Yellowstone Park, Wyoming.) How do the algae survive the boiling water?

ANSWERS TO BRAIN-BOOSTERS ON THIS PAGE

Mystery Photos: 1. A large hailstone. 2. A dish of melting butter. **Can You Do It?** 1. One way to measure your fist size is to use a large jar partly filled with water. Put your fist into the water and see how much the water rises. The bigger the fist, the higher the water will go. 2. To get the ice cube out of the glass of water, place one end of the string on the ice cube. Leave the other end of the string hanging over the edge of the glass. Then sprinkle some salt on the string which is on the ice cube. After a few seconds the string will be frozen to the ice, and the ice cube can be lifted from the water with the string. **What Do You Think Would Happen?** 1. The glass of water into which you stuck your finger would be heavier. What would happen if you put two fingers into one glass and one finger into the other glass? 2. You should find it easier to balance the broom with the bristles up. Do you know why? **For Science Experts Only:** 1. While you are in the air after a dive, you weigh nothing. If a scale were strapped on your feet, it would show about 0 pounds. 2. Since Mammoth Hot Springs are thousands of feet above sea level, the water in them boils at about 180°F. instead of 212°F. For this reason algae are able to live in the boiling water.