nature and science

Volume 5, Numbers 1 - 17

1967 - 1968

nature and science
TEACHER'S EDITION
VOL. 5 NO. 1 / SEPTEMBER 18, 1967 / SECTION 1 OF TWO SECTIONS

Notes about N&S, 1967-68

If you are subscribing to *Nature and Science* for the first time, welcome aboard! If you are one of the thousands of teachers who renew their subscriptions each year, welcome back!

Below and on page 4T of this Teacher's Edition you will find a preview of some of the many new articles, reports, picture stories, investigations, and projects *N&S* has in store for you and your pupils this year.

For your convenience, the suggestions for "Using This Issue of *N&S* in Your Classroom" in the Teacher's Edition will include answers to the Brain-Boosters in the accompanying student edition, together with helpful teaching suggestions by David Webster, the author of Brain-Boosters and a teacher himself. (Answers will also appear in the following students' edition.)

N&S is designed primarily to augment and enrich your science curriculum, though many teachers have found it possible to build an informal yet effective science course around the magazine. However you use *N&S* in your classroom, we suggest that you look through the Teacher's Edition that accompanies each issue for background information, discussion topics, activities, references, and other ideas that will help you and your pupils get the maximum value from the magazine.

IN THIS ISSUE

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

A preview of some of the articles now in progress for the 1967-68 school year

MY YEARS WITH THE EAGLES Is the bald eagle dying out? What must be done to save it from extinction? A young biologist tells of his discoveries after four years of studying eagles in both Canada and the United States.

PIGEONS Some people love these city birds, others call them "flying rats." Whether or not you like them, pigeons seem to be a permanent part of city life. This article tells how a scientist is testing a new method for controlling pigeons, and how your class can observe the little-known behavior of these common birds.

INSECT HOMES MADE TO ORDER Among the most fascinating structures used by insects are plant galls. This Science Workshop tells how to find galls in fields and vacant lots, then keep them to discover what creatures live inside.

LIFE ON A PACIFIC ISLE When naturalist Alan Anderson looked down on tiny Kure Island from the air, he wondered why anyone would bother to study the little sliver of sand and shrubs. In this two-part article he tells how he investigated the surprisingly complex community of plants and animals on Kure.

THE WAYS OF TIGERS What are tigers really like? Until biologist George Schaller went to India, most of what we "knew" about tigers came from hunters' observations along their rifle barrels. After living in tiger country for many months, Schaller reports on the real day-by-day life of these magnificent cats.

TO CONQUER TOOTH DECAY Jerome D. Brent, a dentist himself, recently visited the labs of the National Institute of Dental Research, in Washington, D.C. This is his eye-witness report on the different ways in which scientists are trying to conquer tooth decay.

(Continued on page 4T)

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Around...and Around...

How do you think wheels were invented? You might ask your pupils that question before they look at this WALL CHART. The most common belief is that rolling heavy objects over logs gave early men the idea for wheels. There is no evidence that is true, however. As the chart explains, the earliest wheels found so far were potter's wheels, and the earliest picture we have of wheels being used to move something over the ground was drawn after the potter's wheel had been in use for many years.

Topics for Class Discussion

- *Must a wheel be perfectly round?* Not necessarily. The most important thing about a wheel is that it is free to turn around, or rotate, continuously in the same direction. A potter's wheel could be square, for example, though it would not turn as smoothly as a round one because its weight would not be evenly distributed. (Besides, the corners might rap the potter's hand when he tried to speed up its rotation.) The shape of a windmill or an electric fan is only roughly round, but both are kinds of wheels.

- *Can you think of some modern machines that use wheels in the ways shown in the chart?* The potter's wheel is still used for hand-made ceramic vases, though it is usually turned by a motor. Similar wheels are coated with rouge to polish telescope lenses. How about record-player turntables? Wheeled vehicles are all around us. The wheel and axle is used to lift heavy weights with a crane and in a door knob to pull the door jamb into the lock against the pressure of a spring.

Modern versions of the water wheel are *turbines*—wheels with blades around their rims that are pushed around by steam or by falling water. Turbines provide the rotary motion to turn generators that produce electricity.

The bicycle uses a big gear to make a small gear turn rapidly, but these two gears are connected by a chain that works like the belt connecting the big and small wheels of a spinning wheel. A clock is full of gears that turn each other at different speeds or in different directions.

Activities

- Have your pupils make potter's wheels of wood, cardboard, old phonograph records, and so on, using pencils, stones, and other objects as pivots, and find out what kind can be made to spin longest with a single push. Does lubricating the pivot with oil or petroleum jelly make the wheel spin longer? Why?

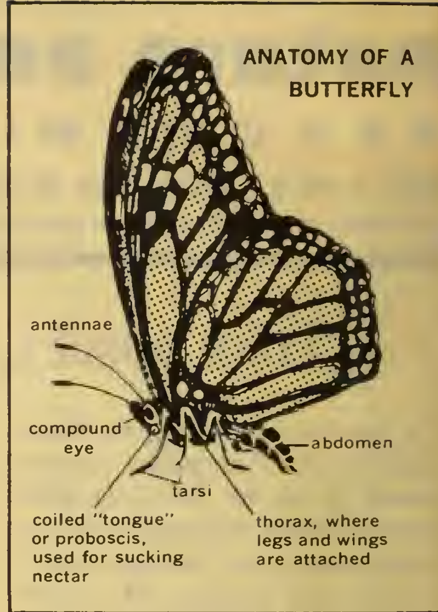
- If you can remove the knob on a closet door with a screwdriver, have your pupils try to open the door by turning the shaft that the knob fits on. Then replace the knob and have them turn it. The knob and shaft form a wheel and axle, and pulling the door jamb back against its spring takes less effort when you turn the wheel and axle than when you turn the axle alone.

Raise Your Own Butterflies

Keeping and raising Monarch butterflies in the classroom can provide teaching opportunities in science, math, art, conservation, geography, and reading. Some of the recent books and magazine articles about Monarchs are listed *(see page 3T)*

In handling the adults, it is important to avoid breaking the "feet" *(tarsi)* when removing the butterfly from the wire of the cage. Also, both adults and larvae must be fed every day, including weekends and holidays. A "good feeding" on Friday will not keep butterflies alive over the weekend. It may be best to have your pupils take the butterflies home at such times.

Adult butterflies have taste receptors in their tarsi. Without revealing this to your class, you might have them see what happens when the tarsi of a Monarch are touched with the honey



solution. The butterfly may extend its "tongue" *(proboscis).*

In addition to making or borrowing a butterfly net, preparing a cage, and gathering milkweed, you should also get some rearing chambers for the butterfly larvae, or caterpillars. A small plastic refrigerator box will do for one or two larvae; a five gallon aquarium tank will hold 50 or more.

If you catch some Monarchs, be sure to put them in a cage with some stalks of milkweed in water or a potted milkweed plant. The mated females will lay eggs on the milkweed leaves and the larvae will hatch in about four days. Then put the caterpillars in rearing chambers and keep them supplied with milkweed leaves on which to feed. The

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

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Why do you need a fun-house mirror to see yourself as others see you?

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WHAT DO YOU SEE IN A MIRROR?

Bringing Up Monkeys

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

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■ How many different places have you seen your own face today? In the bathroom mirror? In a puddle of water? In a glass door, or looking out a window at night? In the darkened screen of a TV set? In the fender of a freshly polished car? Can you think of other places?

The next time you see your face reflected from a shiny surface, look carefully and see if your mirror "twin" is exactly like you. Is the face of your "twin" shorter and fatter or longer and skinnier than yours? Does it bulge in strange places, like a ball of clay that you squeeze in your hand? Is it upside down? Move your head a bit and see if the face you see changes its shape.

How "Honest" Is Your Bathroom Mirror?

Do you think that a flat mirror—the one on your bathroom wall, for example—shows you exactly the way you appear to your friends? The next time you look in it, see if you can find any differences between your "twin" and yourself. If you part your hair on the left, for example, on which side does your "twin" part his or her hair? Do you wear a ring or watch on your left hand? Which hand does your "twin" wear them on? Close your right eye and see which eye your "twin" closes.

To see even more clearly how a mirror changes things, hold the next page up to a mirror. What happens to the words and letters and pictures? See if you can find some letters that the mirror doesn't seem to change. Can you explain why? The explanation may give you a clue about why your mirror "twin" looks so much like you, even though his sides seem to be switched.

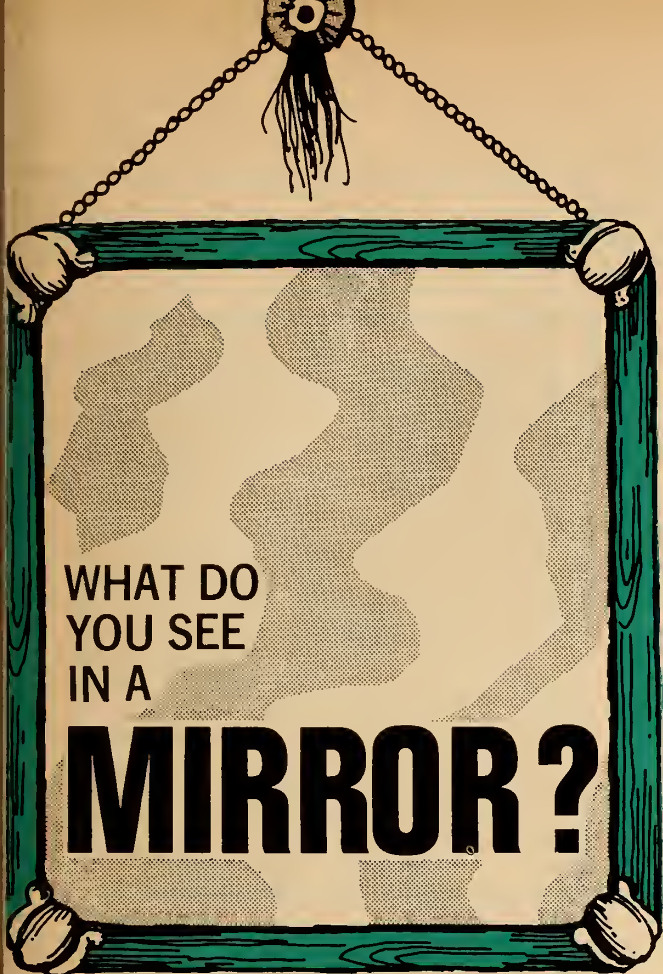
While you are holding page 3 up toward the mirror, look through the paper toward a light and see how the word "MIRROR" appears from the back. Compare this with the reflection you see in the mirror.

Suppose that your head were made of glass with your face painted on the front of it. Would a friend standing behind you see *your* face—or the face of your mirror "twin"?

PROJECT

Stand close to a mirror and look carefully at one eye of your mirror "twin." In the center of it, you should see a tiny reflection of your own face. Do you think that reflection is exactly like your face, or is it reversed like the face of your "twin"? Can you explain your guess?

You can only see an object if some of the light bouncing off the object reaches your eye. Usually the light travels directly from the object to your eye. But when you see the object in a mirror, your eye is receiving light from the

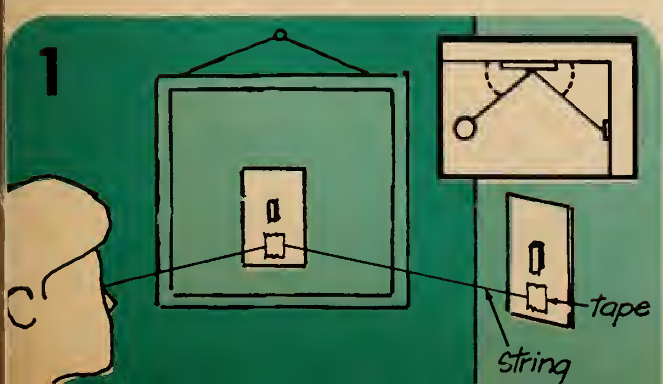


WHAT DO YOU SEE IN A MIRROR?

Here's a way to make a fun-house mirror that stretches, squeezes, or turns you topsy-turvy. It will also show you exactly how you look to your friends. (Will a bathroom mirror do that?)

object that has struck the mirror then bounced to your eye, like a ball bouncing off a wall.

To see how the light travels in a case like this, fasten the end of a piece of string with a piece of sticky tape to a light switch or some other object you can see in the mirror. Stretch the string to the point in the mirror where you see the switch and tape it there. Then run the string directly to your eye *(see Diagram 1)*. You can see that the string (light) from the switch strikes the mirror at an angle and leaves the mirror at an equal angle on its way to your eye.



Since the light from the switch reaches your eye from the mirror, your eye sees the switch as if it were in the mirror.

Make Your Own Fun House Mirror

You can find out what happens when light strikes a curved mirror by making an inexpensive, unbreakable mirror that can be bent in different shapes. You will need one 9-by-12-inch plastic sheet protector—a folded sheet of clear plastic with a sheet of black paper inside. You can buy one for a quarter or so at a stationery store.

Held flat, this serves as an ordinary mirror. (It works best if you face the light and hold the mirror up in front of you.) Begin by holding the top and the bottom of the flexible mirror. When you can see your face clearly in it, gently push your hands toward each other so the middle of the mirror bends outward, away from you *(see Diagram 2)*. Watch what happens to your "twin" as the bend in the

mirror changes. Can you explain how bending the mirror makes this happen? Will bending the middle of the mirror toward you do the same thing? Try it and see.

Now hold the mirror at the sides and gently push the edges so the middle bends outward *(see Diagram 3)*. Stick your tongue out toward the right side of your mouth and watch what happens to it. Does this "twin" look more like you than your flat-mirror "twin" does? Can you explain why?

By bending this mirror in different ways—including several ways at one time—you can change the shape of your "twin" in many ways. You might try this on your friends and see whether they can explain how it works ■

Bringing Up Monkeys

by Judy Redfield

A scientist tells how newborn monkeys are being raised in a laboratory-nursery and tested to find out how their behavior changes as they grow up.

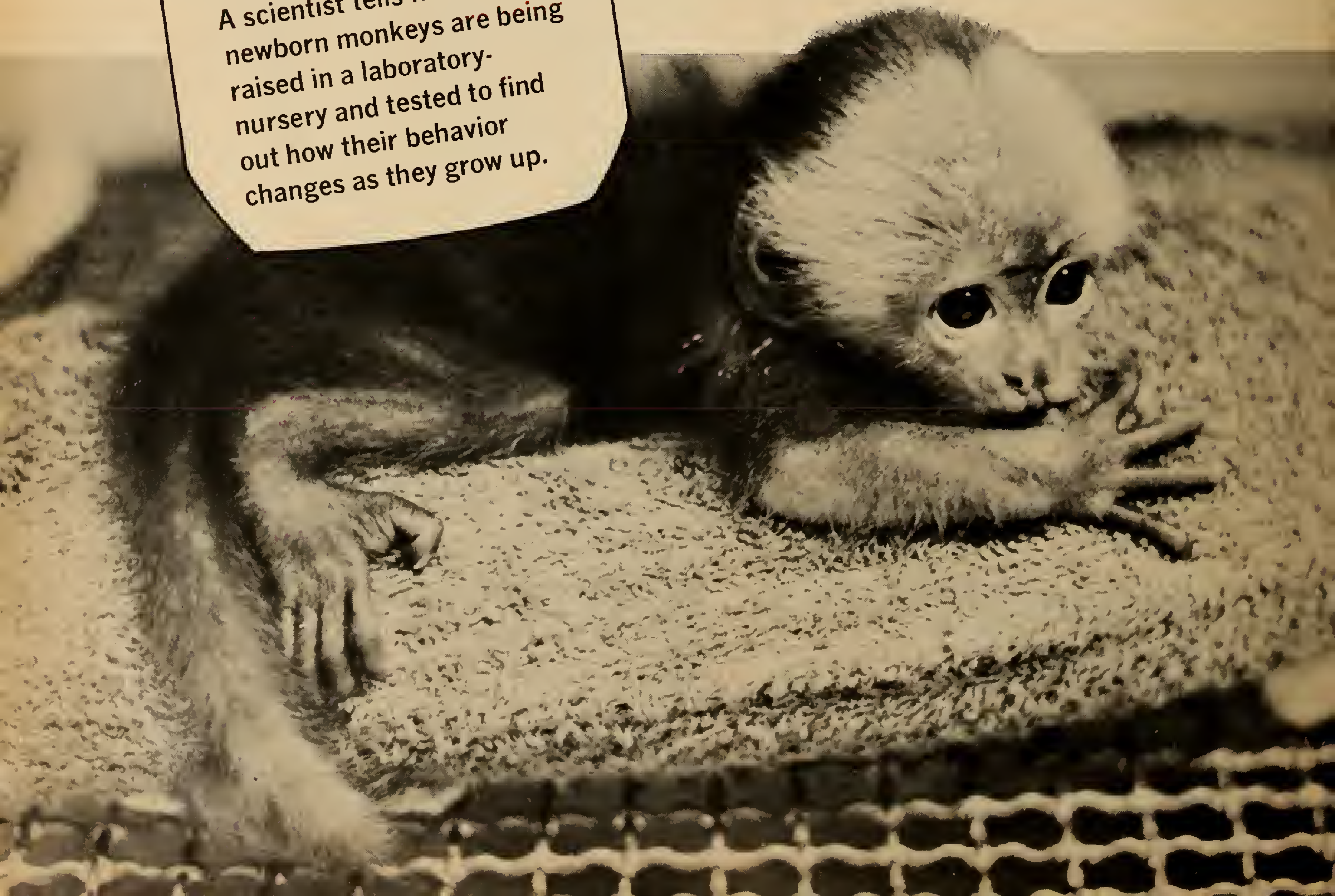
■ "What are you doing these days?" a friend of mine asked.

"As a matter of fact," I replied, "I'm monkey-watching!" My friend looked puzzled, so I explained that I was studying baby Cebus monkeys—trying to find out what they are able to do when they are born and how they learn to do other things as they grow older.

Cebus are one of the many kinds *(species)* of monkeys found in the jungles of Central and South America. The adults of this species weigh about five to eight pounds and are about a foot high when sitting on a branch. They live in the jungle trees in groups of about eight to 18 animals. If you've ever seen an organ grinder with a dressed-up monkey, the monkey was probably a Cebus.

People have known about Cebus monkeys for a long time, but their growth and behavior have not been studied by scientists until recently. Then, about two years ago, scientists in the Department of Nutrition of the Harvard School of Public Health (in Boston, Massachusetts) began trying to breed Cebus monkeys in captivity. Since the experiment began, 10 of the 18 female monkeys have given birth to infants. Eight of these young monkeys are still alive and well.

These Cebus babies were the first of their kind to be bred and raised in captivity, so they were given special care and attention. The infants were separated from their



own mothers and put in a special nursery to help keep them from catching diseases from other monkeys. For a week after each baby was born, it was kept in an incubator to be sure that it did not get chilled. (Newborn monkeys are not able to control their own body temperatures very well.) Until the monkey was two weeks old someone was watching it 24 hours a day, looking for danger signs such as difficult breathing or choking. Every two hours the baby was fed a specially prepared formula out of a doll-sized nursing bottle.

Monkey Friends and Artificial Mothers

When a monkey was one week old, we moved it into a wire cage. The ceiling, three walls, and the floor of each cage were carefully padded to keep out drafts and to keep the baby monkey from hurting itself on the rough metal. Since the baby could not be with its real mother, we gave it a substitute—an artificial "mother" made out of terry cloth. Inside the "mother" was a rolled-up heating pad to keep the baby warm. In the jungle a baby Cebus spends most of its time riding on its mother's back, clutching firmly to her fur. In the same way, the baby monkeys in the cages spent almost all of their time "riding" their artificial mothers.

If a young monkey is to develop normally, it must have some contact with other monkeys in the early part of its life. Studies with Rhesus monkeys have shown that if the baby stays alone for longer than about the first 80 days it will never learn how to act properly with others of its kind.

This may also be true of Cebus monkeys. Cleo, the first baby, was born about two months before our studies began. She was kept alone in her small cage for the first 64 days. At the end of that time, she had not yet learned to walk. She spent most of her time cringing in a back corner of her cage, holding tightly onto her tail.

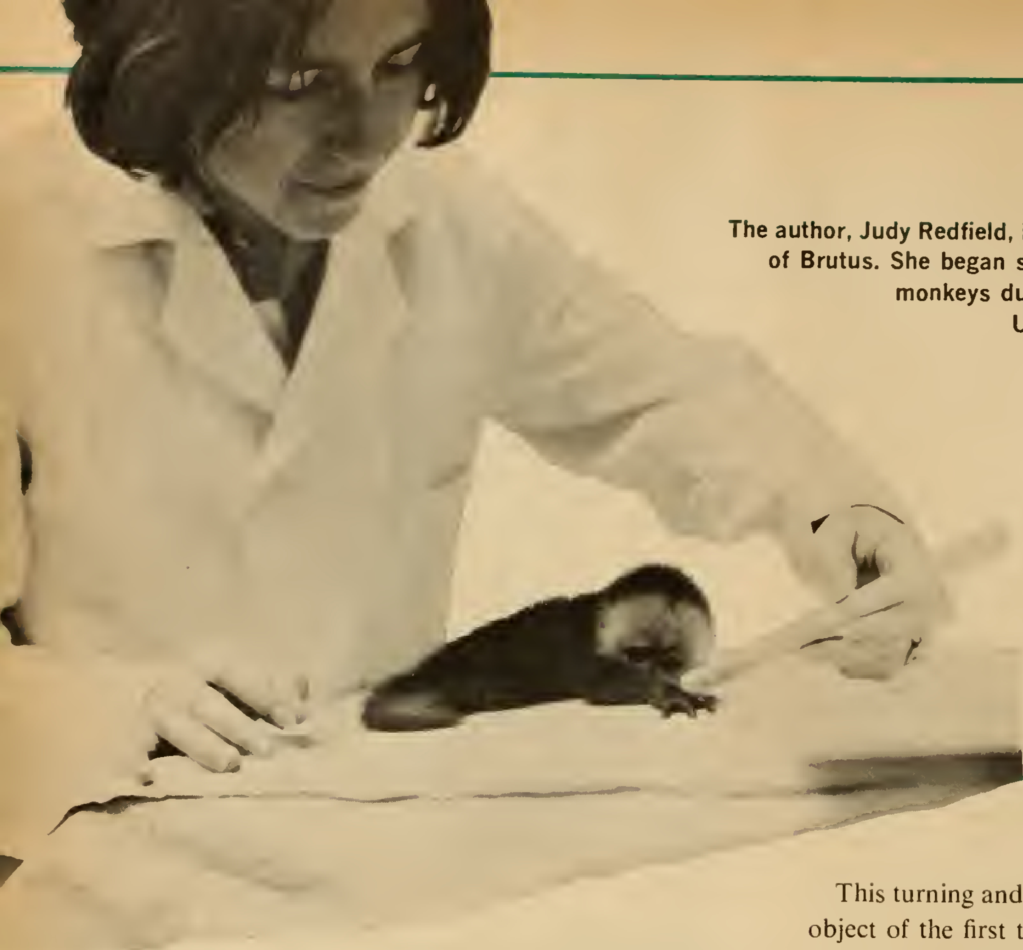
After Cleo was put in a larger cage, with two slightly older monkeys living next door, she slowly became less timid. She learned to walk around and explore. Later, Cleo was allowed to play with some younger monkeys as well. Several months after Cleo had been kept alone, she still showed traces of her unusual behavior. If something new, like a toy rubber ball, was put in her cage, she would kick it and run away from it. The other monkeys would approach the new object and examine it.

After Cleo, the next four babies were close in age. Caesar, Brutus, Thumbalina, and Liz were all born within less than a month. We wanted to keep them from developing Cleo's problems, so when they were two weeks old we put them in pairs in large cages where they could watch other monkeys. Each infant still had its artificial mother for comfort.

At first the baby monkeys together in a cage paid no attention to each other. When one moved around, he might step on the head or foot of his cage mate—as if his companion were only a part of the cage or the artificial mother. After a few squalls of protest, the babies soon learned the difference. *(Continued on the next page)*

'his baby Cebus monkey and the one shown on the cover are ɪoth "riding" their artificial mothers made of heating pads nd terry cloth. The babies often sucked their thumbs.

During their first two weeks of life, the babies had to be fed every two hours. They were fed a formula similar to the kinds that human babies drink. The top photo shows Cleo feeding herself when she was four months old.



The author, Judy Redfield, is shown testing the "grasp reflex" of Brutus. She began studying the behavior of the young monkeys during summer vacation at Harvard University, where she is a graduate student of anthropology.

Bringing Up Monkeys (continued)

From the first, each baby had its own distinct personality. Caesar was a great "actor" and "talker." Brutus was slow and easygoing, and never moved more than he had to. Thumbalina was very serious and precise—always a "perfect lady." Each time she did something, she did it in the same way she had done it before. Liz was a "talker," but also a great explorer. While the others sat quietly on their "mothers," she was off climbing all over the cage.

Comparing Cebus with Rhesus Monkeys

We wondered whether Cebus monkeys develop in the same way as other monkeys—whether, for example, animals of different species can do the same things when they are at the same age. To find out, we tested the baby Cebus monkeys each day, using the same tests that other scientists had used to study the behavior of baby Rhesus monkeys.

Baby monkeys, like human infants, can do certain things automatically as soon as they are born. These automatic actions are called *reflexes*. If a newborn monkey is touched on the cheek, for example, it will turn its head and try to suck. The monkey does this whether its cheek is touched by a stick, a finger, or the nipple of a baby bottle. Later, however, many such actions are not done automatically. After a few days the baby does not turn its head when its cheek is touched unless it knows the bottle is there.

This turning and sucking action is called "rooting." The object of the first test was to see who would stop rooting first. Caesar stopped after seven days. Thumbalina came second, stopping after eight days. Liz and Brutus couldn't seem to make up their minds. During the first week they would root one day and not the next. Like the others, they gave up rooting after about a week. Baby Rhesus monkeys studied by other scientists had also stopped rooting after about a week.

Tests for "Grasping" and "Clasping"

Next we tried testing the "grasp reflex." When a baby was right-side-up on the table, we slipped a wooden rod under one of its hands and quickly raised it. Automatically the monkey's hand grasped the rod and the baby was lifted into the air. The same thing happened when the rod was put under its foot and raised.

We wanted to find out when a monkey could control its grasp. To do this we repeated the test with a sandpaper-covered rod. If a monkey refused to grasp this rough, unpleasant surface, we then knew that the animal could control its grasping. Sometimes, if the baby was squirming around, his hand might accidentally slip off the rod as it was being raised. This happened to Caesar on the very first day. However, we counted a refusal only if the baby did not try to grasp or else moved its hand or foot away.

In this race, Brutus came first, refusing to grasp the rod with his hand on the twenty-second day. This was not surprising, since Brutus disliked moving any more than was necessary. Thumbalina was next at 25 days and Caesar third at 28 days. Liz, always eager to go somewhere, even if it was only up in the air, never refused to grasp with her hand during the test period. None of the Cebus infants refused to grasp with their feet.

Rhesus infants came out far ahead of the Cebus in this test. By about 14 days they were able to control their grasp in both hands and feet. Why were the Cebus slower? It may be that keeping the grasp reflex for a longer time helps the Cebus babies to survive in the jungle. A fall from a high limb could easily be fatal. Since Rhesus monkeys spend a lot of time on the ground, it is less important for Rhesus babies to keep a grasp reflex for a longer time.

Not all the tests that had been tried with Rhesus monkeys could be repeated with the Cebus. Testing the "clasp reflex" turned out to be too rough for the babies. The idea was to roll the infant over on its back and put a wire cylinder against its stomach. The baby would automatically wrap its arms and legs around the cylinder and it could be lifted up in the air. There was no problem with the wire cylinder, but the second half of the test used a sandpaper covered cylinder. The Cebus infants could not hold on to it properly. They got scratched when their arms or legs slipped. Since we didn't want to hurt them, we gave up using the test.

Sometimes the babies seemed to have their own ideas on what the tests were all about. In the test called "releasing and righting," we began by having the baby clasp a wire cylinder. We then set him down, still clasping the cylinder, with his back flat on the table top. From the time he was put down the baby was allowed one minute to let go and turn himself over, that is, "release and right."

At first everything went according to plan. Caesar could "release and right" from the wire cylinder at five days. Thumbalina and Brutus could do it at six days. The Cebus monkeys were ahead of the Rhesus, which do not "release and right" until about nine days. Then a strange thing happened. Instead of continuing to "release and right," the babies decided to climb on top of the cylinder. Liz the explorer climbed first at six days. Thumbalina climbed at eight days and Caesar climbed at 11. Brutus was too lazy to bother until 21 days, and only made the effort once.

Why did they climb? In the wild, mother Cebus monkeys carry their infants on their backs from the time the young are born. The baby's urge to climb may be an attempt to get in the proper position. Baby Rhesus, on the other hand, spend the first three months or so of life clinging to the underside of their mothers. They have no special need for early climbing.

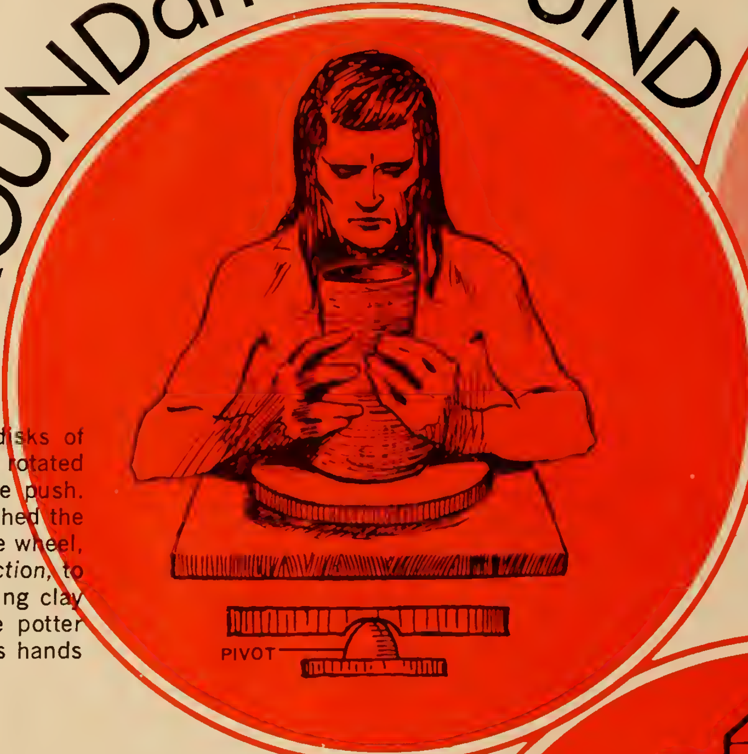
More Tests, and More Monkeys

We are continuing to follow the babies' development. Thumbalina, like Liz, has come to be a great climber and experimenter, scrambling all over the cage, swinging from the bars, and venturing outside when the door is left open to see the world beyond. Caesar and Brutus are much less active. They seldom climb or swing and do not like to go outside the cage at all.

Other babies have been born after these four and we are also studying their development. One is being raised by its own mother for comparison with the others. We hope to follow all these babies from infancy to adulthood, so that we can learn as much as possible about the changes that take place as they grow up ■

In the "releasing and righting" test, a baby Cebus was set down on its back while clasping a wire cylinder. The monkey was allowed a minute to let go and turn over. Brutus, shown here, "passed" the test when six days old.

AROUND and AROUND



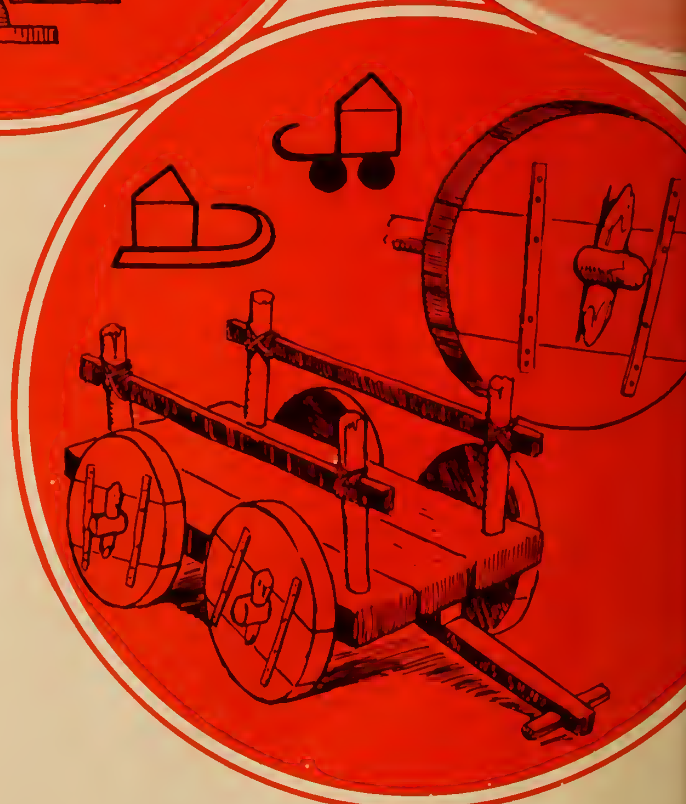
The first potter's wheels were disks of wood or baked clay that could be rotated for several minutes with a single push. Only the center of the wheel touched the knob, or *pivot*, that supported the wheel, so there was little rubbing, or *friction*, to slow the wheel down. The spinning clay tended to push outward, so the potter didn't have to push hard with his hands to shape the pot.

If there's more "roll" than "rock" in modern life, it may be because we use the wheel in so many ways. Almost any machine you can think of has one or more wheels, and wheels help us to move things over land and sea and through the air (except what is carried by animals or boosted by rockets). Bikes, roller skates, hoops, and ferris wheels make the wheel a fun thing.

The wheel is such a simple machine that you might wonder why thousands of years passed before someone invented it. There are many round things in nature, but being round does not make an object a wheel. It must also be able to go around and around, turning continuously in the same direction around its center. About the only things in nature that do that are the stars and planets, but early men did not know that, or realize that they were living on the "rim" of a giant "wheel."

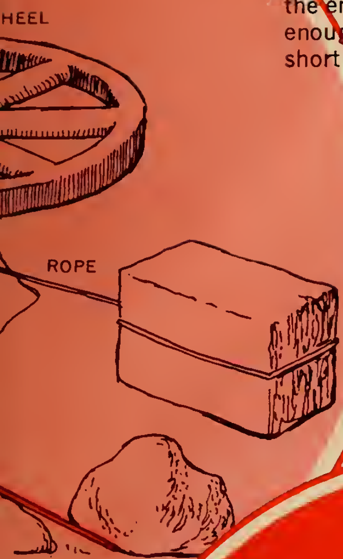
So far as we know, wheels were first used nearly 6,000 years ago by potters in Mesopotamia (now the Middle Eastern country of Iraq). If you have ever made a clay vase, you may remember turning the clay around many times so you could work on all sides of it. Perhaps by accident, some potter found that the round plate his clay rested on could be turned faster by placing the center of the plate over a stone.

Gradually, use of the potter's wheel spread and new uses for the wheel were discovered. This WALL CHART shows some of the ways the wheel has made life easier for people down through the ages. Can you think of some modern machines that use the wheel in each of these ways?

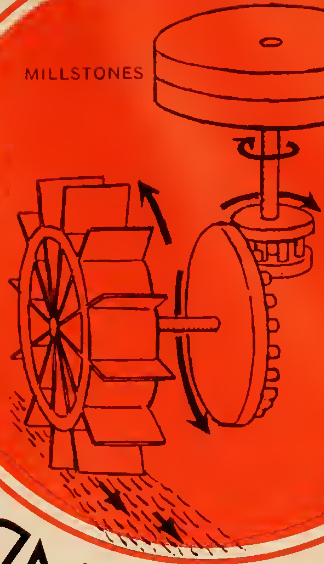


Drawings made about 3500 B.C. *(at top)* show that the Mesopotamians were putting wheels on sleds to make them easier to pull over the ground. At first, the wheels were wooden discs that turned freely around the ends of a pole, or *axle*, on which the sled rested. Only a tiny bit of the wheel rim touches the ground at any one time, producing much less friction than a sled runner rubbing on the ground.

A wheel with an axle attached to its center helped men move objects too heavy to move by muscle power alone. If you think of the wheel as having a single spoke (see *diagram*) you can see that the spoke and axle form a lever with the fulcrum at the center of the axle. Pushing the end of the spoke around turns the axle with enough force to move a heavy weight through a short distance.



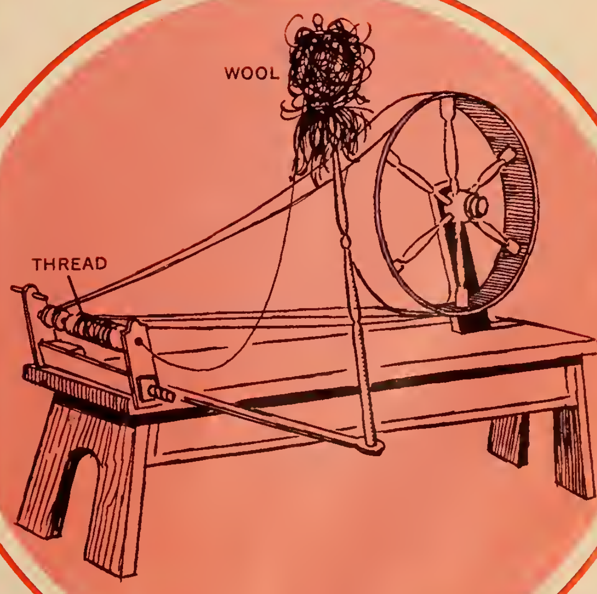
The ancient Greeks used gears—wheels with teeth cut into their edges—to change the direction or the speed of a spinning motion. In this drawing of an early mill, a side-toothed gear turns a rim-toothed gear to make a vertical water wheel turn a horizontal millstone. A large gear turns more slowly than a smaller gear linked with it, so spinning action can be speeded up or slowed down by using gears of different sizes.



...and AROUND...

With the invention of the water wheel, men could use the force of a flowing stream to turn a wheel and axle, instead of their own muscle power. Flowing or falling water pushes against slats or buckets around the wheel's rim and keeps the wheel and axle turning. Can you think of some modern wheels that are turned by the force of steam or water?

...and AROUND



The spinning wheel used an endless cord or belt to make a large wheel turn a small wheel around very fast. The small wheel turned a narrow rod that pulled strands of fiber from a bundle of wool and twisted them into a long thread. Most of the large wheel's weight was around its rim, so a single push made it spin much longer than a solid wheel of the same size.

WHAT'S NEW

The foot-long snout of the giant anteater of South America *(see photo)* suggests that the animal has a keen sense of smell. To find out if this is so, University of Iowa scientists D. W. McAdams and J. S. Way put an anteater through a series of tests.

The anteater was placed in a runway with the choice of turning into a left or right passage. At the end of one passage, the odor of camphor was released. At the end of the other passage, the odor of eucalyptus was released. The two odors are somewhat similar.

The scientists trained the anteater with rewards of food to go into whichever passage the camphor odor was released in. Then they gradually mixed more and more eucalyptus with the camphor. The anteater thus had to smell the difference between the camphor-eucalyptus mixture and pure eucalyptus. Amazingly, it continued to do so until the mixture contained only one part of camphor to 4,000 parts of eucalyptus. The anteater's ability to smell does match the size of its nose!

GIANT ANTEATER

How fast a mosquito eats may determine how long it lives. When a mosquito bites, the victim doesn't feel anything until a few moments later. In that time, a speedy mosquito can suck up a meal of blood and fly away. But a slow eater may get killed while it is still eating.

Professor J. D. Gillett of Brunel University in England compared the eating speeds of wild mosquitoes and mosquitoes that had been bred in a laboratory colony for three years. He found that nearly all of the wild mosquitoes were fast eaters. But nearly half of the insects that had been protected in the laboratory were slow eaters. The biologist suggested that in the wild, many slow-eating mosquitoes are killed before they can reproduce. So more and more of the mosquitoes alive at one time are fast eaters.

Straighten the Leaning Tower of Pisa with electricity. That's the advice of Melvin I. Esrig, who teaches civil engineering at Cornell University in Ithaca, New York. Italy's famous 179-foot tower leans almost 15 feet to one side. Scientists say the tower will fall in 80 to 200 years unless it is straightened.

Professor Esrig suggests that an electric current be sent through the ground below the high side of the tower. The current will break down some of the water in the ground into hydrogen and oxygen. These light gases will escape into the atmosphere, leaving empty spaces, and the ground will then settle into these spaces, lowering the tower's high side. This method was used in Mexico City to straighten tall buildings that were tilted by an earthquake.

Can other animals solve problems by thinking, as humans can? Scientists are trying to find out. At the University of Chicago, four gibbons—small, long-armed apes—have solved problems that *seem* to require thought. In one test, Dr. B. J. Beck tied two strings to some food outside a gibbon's cage. One string ran from the food directly to the cage. The second string ran from the food around a pole, then to the cage, where it was tied to a bar.

Trying to get the food, the gibbon would first pull on the string running between the food and the cage. But the food would not budge because it was held back by the fastened second string. After several tries, the gibbon would give up and do something else. Then, as though he had thought out the problem, the gibbon would suddenly stop what he was doing, grasp the string tied to the bar, and pull the food into the cage.

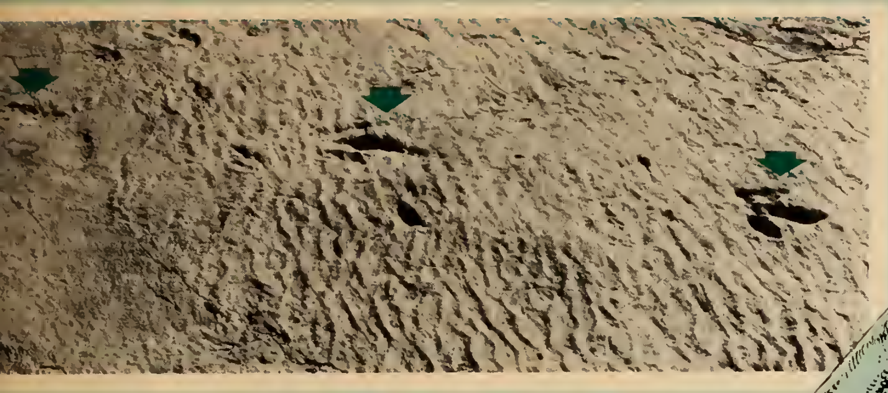
Beetles on a neighbor's car led a Michigan scientist to what may be a useful discovery. The beetles were swarming around newly painted spots on the car. Noticing this, Dr. Orlo K. Jantz tested a dozen auto paints and found two that attract certain beetles to traps where they can be killed with insecticides.

This method has two advantages over killing beetles by spraying plants with insecticide. No useful insects are destroyed. And no poisonous insecticide gets on crops where it can be dangerous to people who eat them.

This photograph showing the sun being eclipsed by the earth was taken from the moon by Surveyor 3 spacecraft. The brightest area of the sun showing is above the earth's North Pole.

Tired? Don't rest. Exercise! That's the word from Dr. W. Laporte of the University of Ghent in Belgium. He tested girls who worked in a Brussels office. Ordinarily they took a short rest in the afternoon when they were most tired. Instead, Dr. Laporte had some girls do light exercises to music, while others just listened to the music and rested. The girls who exercised did better and faster work than those who rested, and ended each day feeling less tired.

"More Dinosaur Tracks?"



The arrows point to footprints left by a dinosaur as it walked from the shore *(left)* into shallow water (shown by ripple marks preserved in the stone). The dinosaur was called *Anchisauripus,* and may have looked like the drawing at right. It lived 180 million years ago.

■ "Hello. This is Tom Jeffreys calling. I'm an engineer with the state Department of Public Works. We've just discovered some dinosaur tracks up at Rocky Hill!"

It was late August 1966. Mr. Jeffreys was calling the Division of Vertebrate Paleontology at the Peabody Museum in New Haven, Connecticut. Surprisingly, no one at the Museum was very excited about Mr. Jeffreys' call. Each year, scientists at the Peabody Museum get dozens of calls about dinosaur tracks. The footprints of dinosaurs preserved in stone are very common in the Connecticut River Valley.

But this time it was different. When scientists visited Rocky Hill the next afternoon, they began to suspect that an unusual discovery had been made. The man who first saw the dinosaur tracks was Ed McCarthy, a bulldozer operator who was digging a basement for a state Highway Department building. He had dug down about 12 feet in an area 120 by 120 feet. Then he noticed the odd-shaped tracks in the rocks at the bottom of the big hole.

Work was halted so that the scientists could investigate the site. They found dozens of footprints and the tracks seemed unusually clear and well-preserved. The scientists urged state officials to let them study the area further. It was decided to halt the plans for building on the site. Instead, the state officials began thinking of a "dinosaur track" state park.

In the weeks that followed, the original cleared area was enlarged to about 300 by 120 feet. Many students from nearby colleges helped clear away the soil, being careful not to damage the dinosaur tracks in the rocky floor they uncovered.

A Glimpse of Long Ago

So far, more than 1,000 dinosaur tracks have been counted in the cleared area. Scientists suspect that as many as 4,000 tracks may eventually be found. The footprints of three different kinds of ancient reptiles have been identified. One of these reptiles, a 12-foot-long dinosaur called Anchisauripus *(see diagram),* left some of the most unusual fossil tracks ever discovered *(see photo).*

The rocks clearly show the shoreline of what was once a body of water. Ripple marks are preserved in the rocks, showing the location of shallow water near shore. One track of Anchisauripus is on the firm surface of the "beach." The next two strides carried the dinosaur into the water, leaving deep prints in the soft mud beyond the shore. Later the mud hardened into stone, preserving the tracks as fossils that give us a glimpse into the life of a dinosaur—180 million years ago.

Scientists from the Peabody Museum have only begun to investigate the many dinosaur tracks at Rocky Hill. Fortunately, they no longer have to worry about the area being destroyed. Last September the Governor of Connecticut announced that the site will become a state park. When the park is opened, people can see one of the largest collections of dinosaur tracks ever found ■

Raise your

■ For the past three years Monarch butterflies have been scarce. Their numbers have been reduced by a virus disease that comes and goes in cycles. Next year and maybe this year, Monarchs will begin to increase again. However, you probably will never see these butterflies in large numbers unless you are lucky enough to find a group during their fall migration, when they fly south as much as 1,800 miles or more.

There is one other way in which you can see large numbers of Monarchs. That is to actually raise them. I've raised thousands of these beautiful butterflies and in this article I'll tell you how to do it.

First you will need butterflies to breed. You can collect them in fields in the late summer and early fall. Go to places where milkweed grows. Monarchs seek out milkweed on which to lay their eggs, and the Monarch caterpillars eat only milkweed.

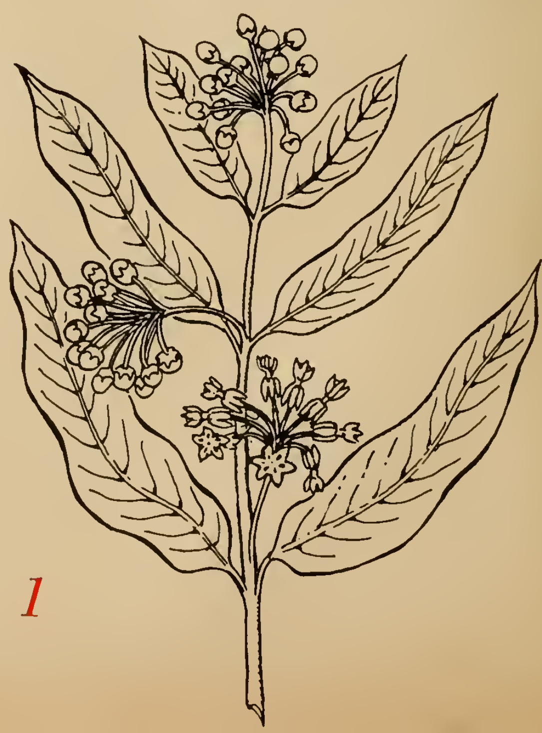
The common milkweed is a familiar sight along roadsides and in fields. You should have no trouble finding it, but avoid plants that resemble milkweed. Dogbane, for example, often grows near milkweed and is sometimes collected and offered to Monarchs. The butterflies will not use it. Diagram 1 will help you identify common milkweed.

To catch Monarchs you will need a long-handled insect net (*see Diagram 2*), plus some patience and persistence. Diagram 3 shows how to identify a Monarch and how to tell it from a Viceroy butterfly, which is very similar. Before trying to catch any Monarchs, you should build a cage like the one shown in Diagram 4.

Robert W. Stegner, is an Associate Professor of Biology and Education at the University of Delaware, in Newark, Delaware.

Once you have caught some butterflies, they must be fed. Mix one part of honey with five parts of water. The Monarchs will drink this "nectar" from such things as a sponge, cheesecloth, or such materials as "Chore Boys" (scouring pads). Whatever you use for feeding, be sure that it is easy to clean and to refill.

To feed the butterflies, first wash the feeding device under the water tap. Then put it in the cage with some water remaining in the meshes or holes. If a butterfly does not move to drink, pick it up gently by the middle of its body (not by the wings), loosen its "feet" carefully from the wire, and place it on the feeding device. It will usually drink readily (*see photo*). When it has had a drink of



1

own Butterflies

by Robert W. Stegner

PART 1

Here is how you can catch and keep alive some beautiful Monarch butterflies. Then you can get ready for Part 2 of this article, which tells how to mate Monarchs and raise the young.

3

water, add some drops of the honey solution to the feeding device so the butterfly can be nourished.

You may find it necessary to "train" some of the butterflies to use your feeding device by first gently unrolling the butterfly's coiled "tongue" with the point of an eye dropper and giving the insect a small drop of honey solution. Usually it will begin to feed. Then you can put the butterfly quickly on the feeding device where it will probably continue to feed by itself. You cannot always depend on caged butterflies to feed themselves, so watch to see that all the Monarchs are eating. Feed the butterflies at least twice a day. The honey solution should be mixed fresh daily.

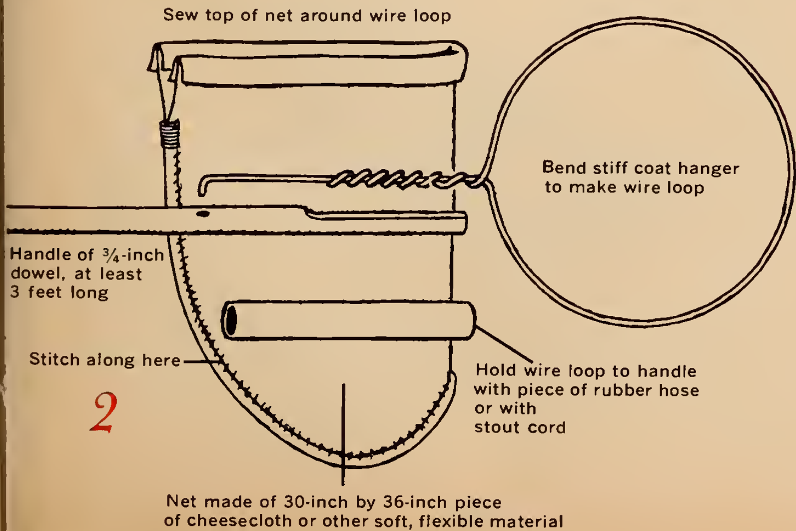
Milkweed Is a Must

If you want to start your own colony of Monarchs from eggs, you will need a supply of milkweed plants. Depending on the climate in your area, you may be able to collect milkweed from fields well into the fall. Keep the stalks in water so that they do not dry out. If you want to keep raising Monarchs through the winter months, you will have to put the milkweed stalks in plastic bags and freeze them. It is important to freeze them as quickly as possible after cutting. Try to collect the youngest plants, which have tender green leaves. Coarse, tough milkweed leaves are not suitable food for Monarch caterpillars.

If you catch a Monarch, put it in a cage with some stalks of milkweed. Female Monarchs will lay eggs on the leaves if they have mated with a male before you caught them. In the next issue of *Nature and Science* I will tell you how to mate Monarchs and raise your own adult butterflies. Meanwhile you can prepare a cage or cages, make a butterfly net, and gather some milkweed ■

INVESTIGATIONS

- Are adult Monarchs attracted to light? How do different colored lights affect them?
- Are the butterflies attracted to fresh flowers? Do they prefer certain colors? What happens when you put plastic flowers in their cage?



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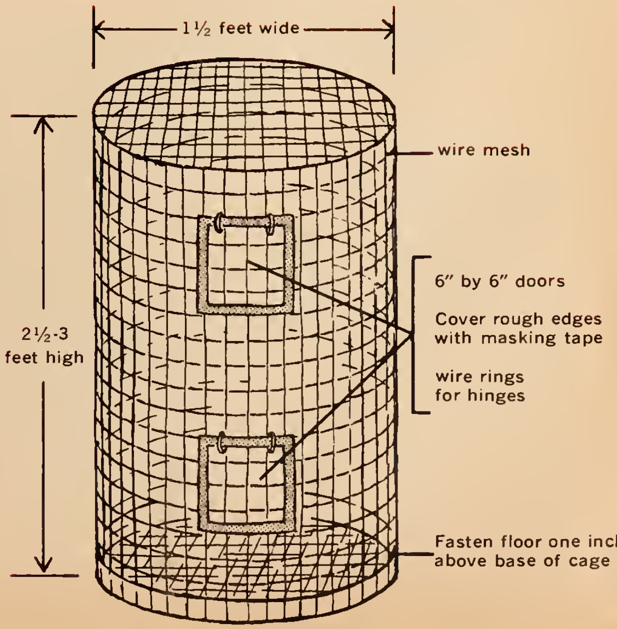


4

Small WORLDS under glass

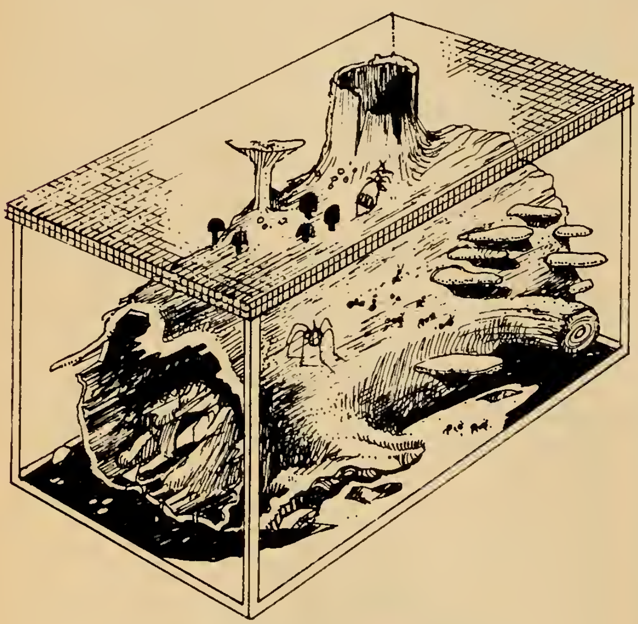
by MARLENE ROBINSON

Here is how you can set up a miniature forest, desert, or field in a glass container and have a bit of green outdoors in your home all winter long.

■ To many people, the word "terrarium" means a miniature garden of wild plants. But a terrarium can be much more than that. It can be a small sample of a particular *habitat* (living place) where certain plants and animals are found. It can be a woodland, a meadow, a desert—any place a particular community of plants and animals lives.

You don't need much equipment to set up a terrarium. The ideal containers are those that you can see into–glass aquarium tanks, clear plastic boxes, gallon-size pickle or mayonnaise jars. For a top you will need a piece of glass, or plastic, or screening. And no matter what kind of habitat you have in your terrarium, it should have an inch-deep base of gravel so that water can drain through the soil. On top of this put two or three inches of soil. Don't leave it all level. Make a hill in one corner, or have the soil slope from back to front. Be sure you get the soil from the same place you collect the plants. Soil is a part of the habitat too.

If you plan to dig up plants from someone's land, first get the owner's permission. Since the plants you will need for the terrarium will be small ones, you can easily dig them up with a trowel or big spoon. Be sure to get a lump of soil along with the roots. To protect the plants and to keep their roots from drying out, wrap them in damp newspaper or put them in plastic bags when you dig them up. Put the plants in the terrarium as soon as possible.



ROTTING LOG COMMUNITY

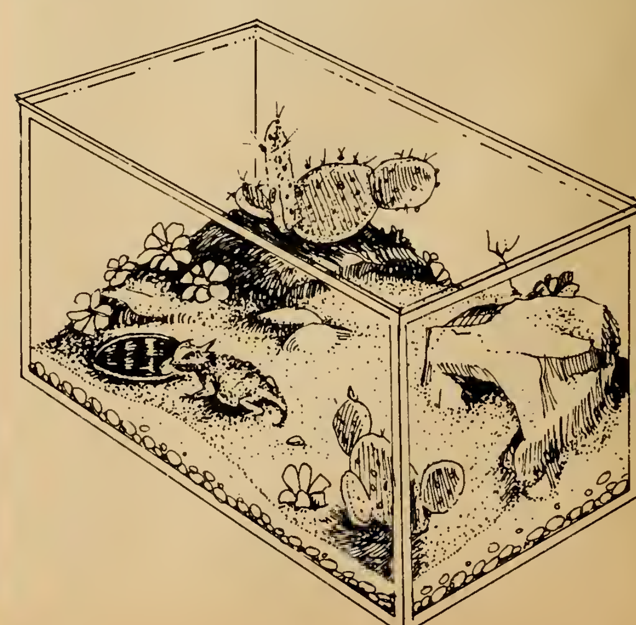
Break open a rotting log with a trowel, put two or three chunks into a plastic bag, and take them back to put in your terrarium. No soil is needed. If the log was in a damp spot, you should add water to the terrarium from time to time.

Many creatures may live in the log, including ants, termites, spiders, and horned beetles (sometimes called "bess" beetles because they make a squeaky hiss). If your log contains some ants, provide a few crumbs and some sugar water on a piece of sponge for them. To keep the ants from crawling out of the terrarium, spread a layer of Vaseline along the upper edge. Watch to see what kinds of insects and other animals come from the log. Some may be in the form of eggs when you collect the log and may develop into adults while in the terrarium.

DESERT COMMUNITY

If you don't live near a desert, you'll have to get material for your desert community from places near at hand. You can get sand from a beach or garden supply store. Some kinds of desert animals, including horned lizards, can be found in pet shops. The lizards will eat small insects such as ants and mealworms (also available from pet shops).

You can buy small cacti from florist shops or variety stores. Also get some succulents, which are plants that hold water in their fleshy leaves. Besides the plants, put some rocks in the terrarium, making cliffs or overhangs near the edges. Put a small dish of water in one corner. Leave an open area of sand in the center, especially if you have a horned lizard. (You will discover why.) The temperature of the desert terrarium should be kept between 70 and 80 degrees F.



Your terrarium will be especially fascinating if you have some animals in it. But too many animals or animals of the wrong kind or size will destroy the plants. Adult turtles, toads, and frogs will crawl over and uproot plants. However, young turtles, small species of frogs, and most small lizards and salamanders do well in terrariums. Of course, a terrarium requires more care if it contains animals, since you will have to feed them.

Each living thing, whether plant or animal, must have certain conditions in order to live a healthy life. Keep this in mind when you set out to gather plants and animals for your terrarium. Mark off a four-foot by four-foot area in whatever habitat you choose—forest, meadow, or the like. Get down on your hands and knees and look for animals and the plants they live near. Look below ground, too.

Ask yourself the following questions. The answers will give you some guidelines for setting up a terrarium of the particular kind of habitat you want.

1. *What is the temperature where the animals and plants live?* Take thermometer readings in several different places on your plot of ground. If possible, do this on several different days, and at different times of the day. Take an average of all the readings. Then, once your terrarium is set up, try to keep it near the same temperature. Unless you want desert conditions, your terrarium should not sit on a radiator or in direct sunlight.

2. *How moist is the habitat?* To answer this question dig into the soil to see how wet it is and also look at the skins of any animals you might find. Are they dry and scaly like a lizard's or wet like a salamander's?

You can control the amount of moisture in your terrarium in two ways. One way is to regulate the amount of water you put in. The other way is by the kind of top you choose for the terrarium. A screened top (or no top at all) allows water vapor to escape from the terrarium. A top of plastic or glass traps water vapor inside. By leaving such a top partly open, you can get conditions somewhere between very dry and very wet.

Below are drawings and tips for setting up four different kinds of terrariums. You may think of others to try. Start planning now if you want to have a "small world under glass" in your room this winter ■

MEADOW COMMUNITY

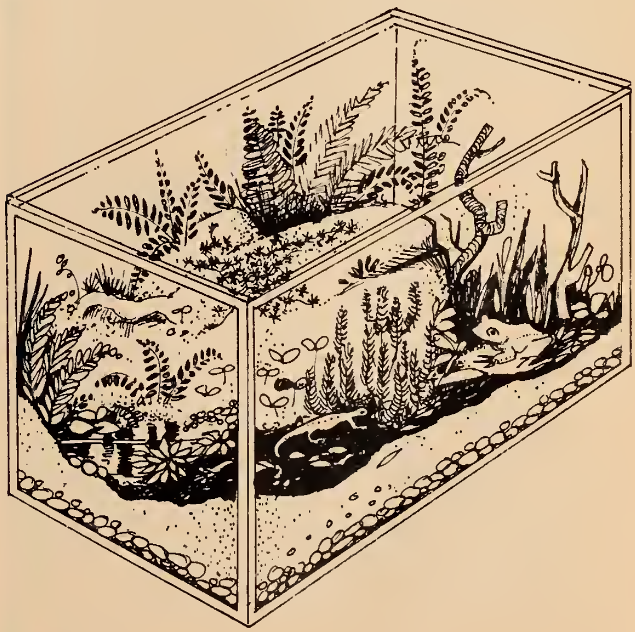
The problem here is limiting yourself to a few of the many grasses, weeds, seedling trees, and other plants that grow in meadows. There are also many animals to choose from, including spiders that spin beautiful orb webs. (These spiders need lots of room, such as a 10-gallon aquarium tank, in which to make their webs.)

You may find plants with insect eggs or cocoons on them; watch to see what hatches from them. If you want to have one larger animal in the terrarium, try to find a small garter snake. It will eat earthworms and large insects. Be sure to keep the terrarium fairly dry, since snakes often get skin diseases if kept in damp surroundings.

FOREST FLOOR COMMUNITY

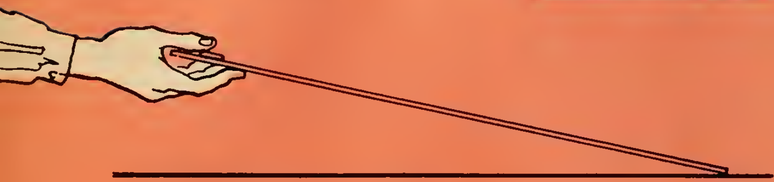
This is the kind of habitat people most often have in a terrarium. For plants, get small ferns, tree seedlings, wildflowers, and especially evergreen plants such as partridgeberry or wintergreen. After a few of these plants are put into the soil, the rest of the surface can be covered with mosses, attractive stones, and perhaps a small limb.

For animals, look for small toads, frogs such as cricket frogs or tree frogs, and red efts (which are small salamanders). These animals and the plants of the forest floor all need moisture, so keep the terrarium well-watered and make a small woodland pool in one corner.



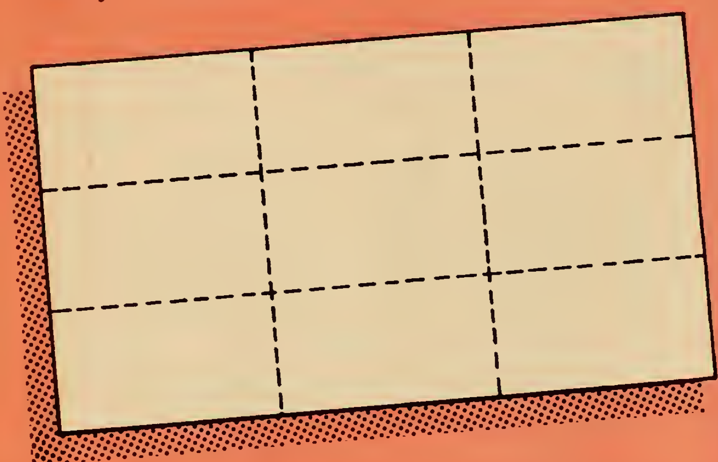
BRAIN BOOSTERS

prepared by **DAVID WEBSTER**



WHAT WILL HAPPEN IF?

Place a coin on the end of a yardstick and lift the end about a foot high. What happens to the coin when you let go of the yardstick? Does it stay on the yardstick or fall more slowly?



FUN WITH NUMBERS AND SHAPES

Tear a piece of paper into nine pieces as shown and mix them up. How can you tell which piece came from the center of the paper?

Submitted by David Augustine, Crown Point, Indiana

MYSTERY PHOTO

Notice how crooked the lines in the street are. Did the painter make a mistake?

FOR SCIENCE EXPERTS ONLY

If hot air rises, why is it colder on top of mountains?

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

HAVE YOU AN IDEA FOR A BRAIN-BOOSTER?
Send it with the solution to David Webster, R.F.D. #2, Lincoln, Massachusetts. If we print it, we will pay you $5. Be sure to send your name and 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.

CAN YOU DO IT?

Hold two straws in your mouth, but put only one of them into a glass of water. Can you drink any water?

Using This Issue...
(continued from page 2T)

rearing chambers must be covered to keep the leaves from drying out and to keep the larvae from escaping. The larval stage lasts about two weeks. Part 2 of this article will give further details about rearing larvae and about mating unmated female Monarchs.

Topic for Class Discussion

- *Why do the Monarch and Viceroy butterflies look so much alike?* The Monarch tastes "bad" and is avoided by predators such as birds. Over many thousands of years the Viceroy has evolved a resemblance to the Monarch. Now, even though it doesn't have the Monarch taste, it too is shunned by predators. This phenomenon of natural selection is called *mimicry*.

Activity

- Have your pupils investigate the migration of Monarchs, by reading *(see References)*, looking for identity tags on captured Monarchs, and perhaps by participating in a tagging program themselves. Tags for Monarchs and instructions for using them can be obtained from the scientist who has studied Monarch migration for years: Professor Fred A. Urquhart, Scarborough College, West Hill, Ontario, Canada.

References

- "The Care and Breeding of Monarch Butterflies," is a booklet available from the author of this article, Dr. Robert W. Stegner (University of Delaware, Newark, Delaware 19711). Dr. Stegner has offered to answer questions about raising Monarchs and would like to have reports from teachers who try this project.
- "A Treeful of Butterflies," *N&S*, September 20, 1965.
- "Mystery of the Monarch Butterfly," by Paul Zahl, *National Geographic*, April 1963.
- *Monarch Butterflies*, by Alice L. Hopf, Thomas Y. Crowell Co., New York, 1965, $3.75.
- *The Travels of Monarch X*, by Ross Hutchins, Rand McNally & Co., Chicago, 1966, $2.95.

Small Worlds Under Glass

If you want a neat, attractive terrarium that will last all school year, you should keep animals out. But if you want to attract children's attention to this miniature habitat and don't mind a slightly messy terrarium, then by all means include an animal or two.

Horned lizards (mistakenly called horned toads) are difficult to keep in captivity unless you can feed them ants. Have a sure supply of ants before trying to keep these animals.

Besides trying the kinds of terrariums described in the article, you might set up a stream bank habitat, or terrariums based on the forest floor of different kinds of forest.

If droplets of water form on the inside of the glass, the terrarium is either too hot or too wet. Check the temperature. If the terrarium is too wet, open its cover part-way for a day or two. Then replace it and see if the terrarium has dried out enough. It is better to tolerate some water condensing on the glass than to dry the terrarium too much.

Brain-Boosters

Mystery Photo. Ask your pupils if they can think of a way that parts of the lines or parts of the street might have been moved. The lines were originally painted straight, but the road tar softened in the summer sun and was gradually moved by the heavy traffic.

What will happen if? After a few trials, your pupils will probably conclude that the end of the yardstick falls away from the coin, so it must be traveling faster. If your pupils have learned that objects fall through the same distance in the same length of time whatever their weight (except when air slows down one more than the other), they may wonder why the end of the stick falls faster than the coin.

Have them drop the yardstick with the coin at different places on it and watch closely. At the 18-inch mark, the coin will fall at the same speed as the stick. The earth's gravity pulls on an object as if its weight were all in one place—the object's *center of gravity*. This is why the coin and the center of the yardstick fall at the same speed. But the stick's end falls farther than its center in the same length of time, so the end must be traveling faster than the center—and the coin.

Can you do it? Only by holding a finger over the end of the straw that is not in the liquid can your pupils get liquid through the other straw. Have them try to explain why. To get liquid through a straw, you have to draw all of the air out of it so the air in the atmosphere can push the liquid up through the straw. But as long as you are drawing in air from the atmosphere through one straw, you can't draw air out of the straw that is in the liquid. It is as if you were trying to suck air out of the straw in the liquid with your mouth wide open (have your pupils try that).

Fun with numbers and shapes. When a sheet of paper is ripped into nine pieces, the middle piece is the only one with all four edges ripped. If your pupils do not realize this, have each one tear up a piece of paper into nine pieces. Probably some will then notice the difference in the number of ripped edges on different pieces.

For science experts only. Almost everyone knows that hot air "rises" and that the tops of mountains are cold. Yet these two facts appear to be contradictory. After allowing the children to puzzle over the answer, you could give them this explanation:

The air, rather than being heated directly by the sun, is heated by being in contact with the warm earth. Heat makes the molecules of gases that make up the air spread apart, so there is less air in a given amount of space. This makes the heated air lighter than the air around it, so it is pushed upward by the colder, heavier air around it. The air continues to expand as it is pushed upward, because the higher it goes the less air there is pressing down on it. When a gas expands it becomes colder (a refrigerator is cooled by utilizing the same principle). *(See "How Cold Can It Get?"* N&S, *Nov. 15, 1965.)* The cooling that results from the expansion of the air causes the reduced temperatures on mountains.

THE BATS OF CARLSBAD CAVERNS Among the wonders of these famous caves are the thousands of bats that fly out of the caverns each evening in quest of insects. Paul Spangle, a park naturalist at the caverns, tells what men have learned about the bats, and what mysteries remain to be solved.

THE GRANDEST CANYON OF ALL A WALL CHART and accompanying article show why the Grand Canyon of the Colorado is a living textbook in the study of the history of the earth and its life.

THE GERBILS AT HOME A teacher tells how to care for and study these rodents, which are growing in popularity as classroom animals. This is just one of several upcoming articles designed to help you exploit the learning possibilities in common plants and animals of the classroom.

SLEEPY SEEDS Some seeds don't sprout. Why? This SCIENCE WORKSHOP explores the powerful effects of light on seeds, using common lettuce seeds, and is one of several *N&S* botanical investigations that your pupils can work on individually or as a class.

MYSTERY OF THE MAYAS Over a thousand years ago, Maya Indians built great cities in the jungles of Central America. Suddenly, the Mayas vanished. Archeologists are searching the ruins of their cities for clues to their mysterious disappearance.

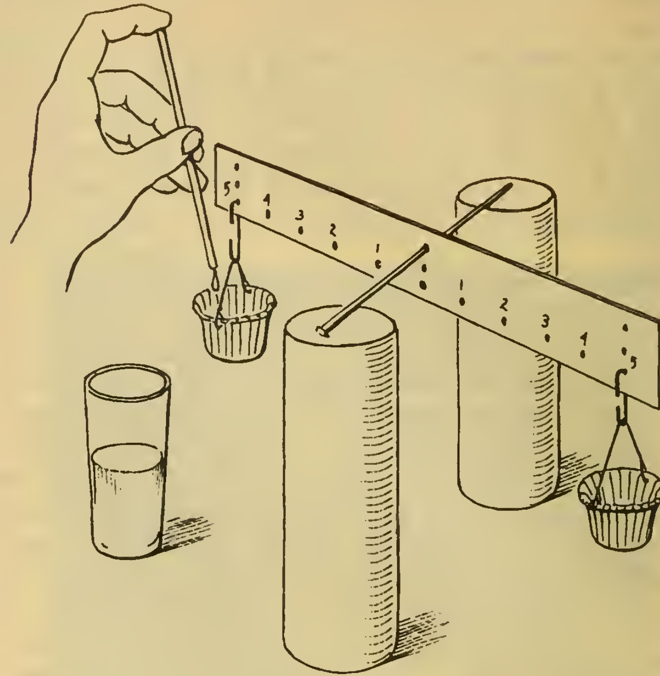
DISCOVERING AN INVISIBLE GAS How do you find out that an invisible substance is really a mixture of a number of invisible substances? The story of how oxygen was discovered gives your pupils a fascinating and instructive view of how scientists probe the unknown.

THE FLASHING CODES OF FIREFLIES How do these beetles (not really flies) produce light? Why do different species have different signal flashes? This article answers these questions and suggests ways for your pupils to study fireflies.

HOW TO BE A METEOR WATCHER An astronomer at The American Museum-Hayden Planetarium tells your pupils how to observe the aerial "fireworks" caused by objects from space that shower into the earth's atmosphere at certain times each year.

PEANUTS AND PENNIES By graphing the lengths of peanuts grown in fertilized soil and unfertilized soil, scientists can tell whether the fertilizer probably helps produce bigger peanuts. Flipping pennies and graphing their results will help your pupils understand the concept of probability.

WHAT'S IN A BALANCE? By making a simple balance and changing it in various ways, your pupils can find out why some balances are better than others for weighing certain things.



IMPROVING NATURE'S ENGINEERING Scientists have not been able to make a substitute for wood that has all of its useful qualities. But they are finding ways to make wood even more useful.

ELECTRICITY ON THE MOVE Homemade electroscopes, batteries, and circuits will help your pupils think of electric current as a flow of electrically charged particles. Electricity and magnetism are related in an account of the work of Faraday and Maxwell, and the electromagnetic spectrum is presented in a pictorial WALL CHART.

UNIDENTIFIED FLYING OBJECTS There is no evidence that the strange "objects" or "lights" people have reported seeing in the sky come from other worlds. But scientists believe these reports need to be investigated more carefully and more thoroughly than they have been.

SPECIAL TOPIC ISSUES

DESERTS What may seem to be a forbidding, desolate land becomes an inviting, lively one as this issue explores "life in Death Valley," takes you on a famous desert expedition, and describes the ways in which animals and plants are adapted to survive in the desert environment.

SPACE-SHIP EARTH As the earth spins through space, the expanding human population is using and abusing the limited resources that are aboard. This timely special issue will describe such problems as waste disposal and water and air pollution, then tell how scientists and engineers are trying to solve these problems.

COMMUNICATIONS For an animal species to survive its members must be able to exchange "information" with each other. This special issue examines some of the ways in which animals communicate (including ways invented by men), and describes an attempt to teach chimps to talk. Your pupils can test themselves to find out whether they always "get the message"—and if not, find out why.

nature and science
TEACHER'S EDITION
VOL. 5 NO. 2 / OCTOBER 2, 1967 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Mating Monarchs

Breeding Monarch butterflies will take patience and persistence. The successfully mated female will probably be ready to lay eggs as soon as she is released by the male. Keep milkweed in cages with the mated females; it stimulates egg-laying. The smaller the cage the more contact the females will have with the milkweed.

Remember to plan this project so that the dramatic events take place when school is in session, not on weekends. The eggs hatch about four days after laying and the larval and pupal stages last about two weeks each.

Problems that may arise include: crushing of small caterpillars during transfers; escape of caterpillars from containers; death from disease or rough handling; breaking of tarsi when picking up adults; tattering and loss of beauty of the adults from rough handling.

Nevertheless, the opportunity for your class to "raise their own butterflies" will spark a continuing interest in the project, and the educational opportunities are many. It might be a pleasant finale to release the adults before they become tattered and crippled.

Remind your pupils that butterflies have *complete metamorphosis*. This is the term for the development of butterflies, moths, beetles, flies, and many other kinds of insects whose young don't look anything like their parents. Some other insects have *incomplete metamorphosis*, with the middle (nymph) stage resembling the adult *(see diagram)*.

Regarding the investigations suggested at the end of the article: Monarch larvae can be stimulated to feed on lettuce and cabbage leaves but they usually do not thrive on this diet. Caterpillars on a "reducing diet" will form small chrysalids and small adults. There is a direct relationship between temperature and growth, with the life cycle proceeding more rapidly in a warm temperature.

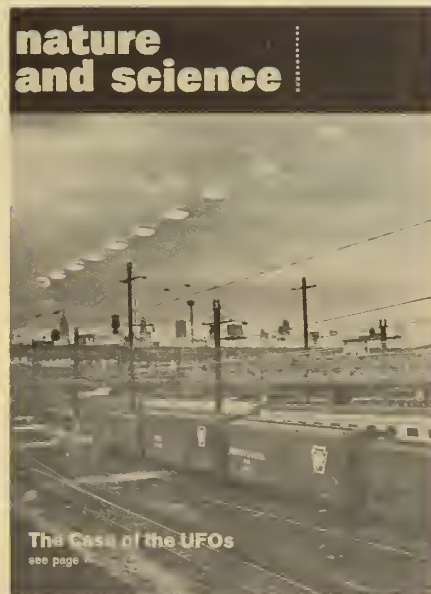
The author of "Raise Your Own Butterflies" invites teachers to address questions and reports on this project to him. Write to: Dr. Robert W. Stegner, Dept. of Biological Sciences, University of Delaware, Newark, Delaware 19711.

Brain-Boosters

Mystery Photo. It is the lighted filament of a light bulb. Get some clear (non-frosted) bulbs of different sizes

(Continued on the next page)

INCOMPLETE METAMORPHOSIS
PRAYING MANTIS



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 1T-4T.)

IN THE NEXT ISSUE

The ways of tigers . . . How gears work . . . A SCIENCE WORKSHOP suggests ways in which your pupils can investigate "sleepy seeds" . . . Brain-Booster Contest . . . Textures and patterns found in nature.

Using This Issue . . .
(continued from page 1T)

and allow the students to inspect their filaments.

What would happen if? You can help the children find which track is fastest by experimenting with rolling marbles. Use heavy paper to make ramps in the shape of the four that are illustrated. They need not be narrow and grooved; a piece of paper held at the proper angle will suffice. Some students can hold the paper ramps in place while others race marbles down them. You should find that Track "D" is the fastest.

Can you do it? Challenge your pupils to blow up a balloon so that it partly fills the inside of a bottle. Give everyone a medium size balloon so they can experiment at home and report their results the next day. A balloon can be partially inflated inside a bottle by first heating the air inside the bottle with hot water. The balloon should then be quickly inserted. As the air cools, the balloon will slowly increase in size. It can be inflated even more by placing the bottle in a freezer.

Fun with numbers and shapes. When you have a few extra minutes, let the students work on this problem in class. Here are two solutions:

$$56 + 8 + 4 + 3 = 71, \quad 71 + 29 = 100$$

$$95\tfrac{1}{2} + 4\tfrac{38}{76} = 100$$

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SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

For science experts only. When wood burns, the moisture and air inside expands. After the pressure builds up, the gas ruptures the wood fibers with loud snaps. Popcorn "pops" for the same reason. You could talk with your class about the relationship between the temperature and volume of a gas. Most materials expand when heated and contract when cooled. Perhaps the children can apply this principle to the problem of blowing up the balloon inside the bottle.

Just for fun. At the same time you give out balloons for the "Can you do it?" question, you could also supply Alka-Seltzer tablets. The children could then collect a balloon full of the carbon dioxide gas that is given off when water is added to Alka-Seltzer, mixed with air from the bottle *(see "Speeding Up Your Reactions," N&S, May 8, 1967, and Teacher's Edition).*

The Animal Movers

This article illustrates the concept that *organisms are adapted to their environment.* For perhaps 70 million years, New Zealand has been separated from other land masses by a barrier of ocean water. Communities of plants and animals evolved, adapting to each other and to their environment.

Because of New Zealand's isolation, there were no ground-dwelling mammals, such as rats or weasels, which might be found on other large land masses. In the absence of mammalian predators, many of New Zealand's birds nested on the ground. There they were defenseless when man introduced mammalian predators. Many species of birds, lizards, and other native animals have been wiped out.

The history of imported animals is full of failure, for most species simply do not survive when taken to a new environment, even when that environment resembles their own. Even the most "successful" importations often failed at first. Starlings, for example, were brought to North America several times before they survived, reproduced, and began to spread.

In North America, some successful importations that have become nuisances include the starling, English sparrow, pigeon, and gypsy moth. The ring-necked pheasant and brown trout are two introduced species which are now valuable game animals.

Reference

- *The Alien Animals,* by George Laycock, The Natural History Press, Garden City, N.Y., 1966, $4.95.

Keeping Things Under Control

Education is mainly a process of learning how to control oneself and one's environment. Since feedback is a necessary part of any control system, understanding how feedback works will help your pupils cope more effectively with themselves and the world around them.

From the examples of feedback at work shown in this WALL CHART, and with your assistance, your pupils should be able to grasp this concept: *In order to control something, you have to know what is happening as the result of your actions so that you can plan what to do next.* Feedback makes the *effect* of an action *act back* on the *cause* of that action, letting it know what happened as a result of its previous action and permitting it to determine future action.

For example, when you have explained something to your pupils, they feed back questions or comments that tell you that you have made your point—or that you will have to explain it further. If your explanation appears to bore your pupils, or to interest them, this feedback also helps you decide what to do next to maintain control of the class.

Suggestions for Classroom Use

- Ask your pupils if they have heard the word "feedback" used before, and if so, what they think it means. They may have heard it used in a TV show or movie about businessmen.

A company that makes washing machines, for example, gets feedback reports that show how many people are buying its product. If the reports lead the company to make *more* of the same machines, the feedback is called

(Continued on page 3T)

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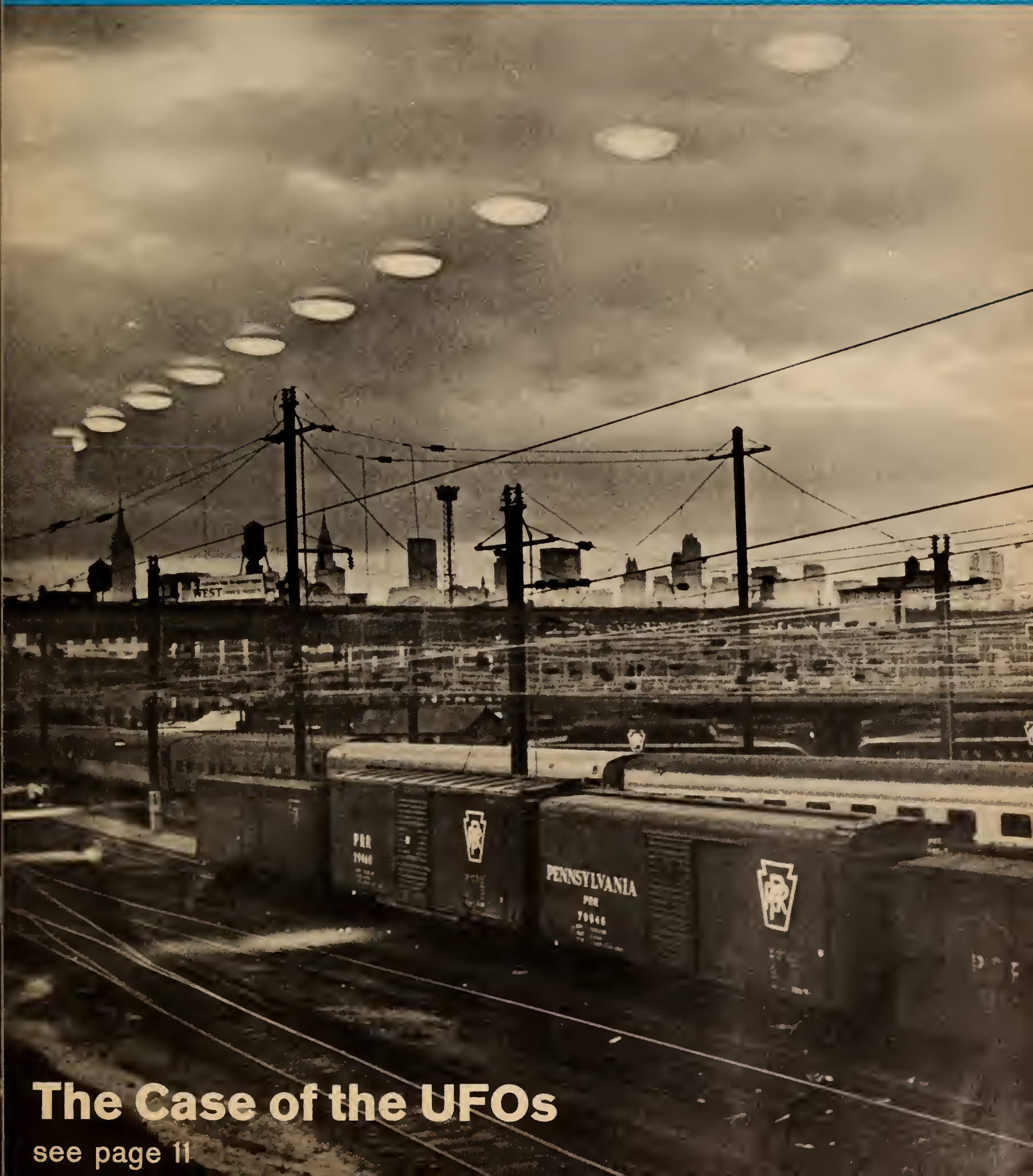
What happens when man tries to "improve" a country by importing animals from a different part of the world? To find out, see . . .

THE ANIMAL MOVERS

page 6



The Case of the UFOs

see page 11

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PICTURE CREDITS: Cover, Donald Rice; pp. 2-3, Robert W. Stegner; p. 4, left photo by Harry Brevoort, middle and right photos by Hal H. Harrison, from National Audubon Society; pp.4-5, 13-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, photo by Joan Hamblin; pp. 6-7, Joseph Sedacca; pp. 8-9, R. G. Bryant; pp. 10-13, United Press International.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; EXECUTIVE EDITOR Laurence P. Pringle; ASSOCIATE EDITORS Robert J. Lefkowitz, Steven W. Morris; EDITORIAL ASSISTANT Roma H. Gans; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Donald B. Clausen • CONSULTING EDITOR Roy A. Gallant

PUBLISHER James K. Page, Jr.; CIRCULATION DIRECTOR J. D. Broderick; PROMOTION DIRECTOR Elizabeth Connor; SUBSCRIPTION SERVICE Alfred Thiem

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, December through April; monthly September, November, May, and July (July special issue). Second Class postage paid at Garden City, N.Y. and at additional office.

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Raise Your Own Butterflies, Part 2

Mating Monarchs

by Robert W. Stegner

There is still time to catch some Monarch butterflies, keep them alive, and then raise some beautiful butterflies of your own.

A male Monarch (top photo) has a small, black scent gland on the middle vein of the hind wing (see black arrows). A female Monarch (bottom photo) lacks this scent gland.

■ In Part 1 of this article, I told you how to find and catch Monarch butterflies, feed them, and get ready to raise some Monarchs from eggs. Female Monarchs that are already mated will lay eggs on the milkweed leaves in their cage. If you don't see them doing this, they should be mated. Photo 1 shows how to do it. (The photos on page 2 show how to tell a male and female Monarch apart.)

Once the butterflies are joined together in their mating position, you can pick them up and put them in a cage. The butterflies may stay together for several hours (*see Photo 2*). When they separate, the female will probably begin to lay eggs on the underside of milkweed leaves.

A female will lay eggs even when held by the wings. She may lay several eggs quickly and then pause. Let her fly around the cage for a couple of minutes or hold her gently by one wing so that she can flap the other. In a cage, a female Monarch may lay dozens of eggs on one milkweed plant, but in nature the eggs are widely scattered.

It seems that the motions of the butterfly's wings help it to get ready to lay another egg. In the wild, this helps insure that the eggs are widely scattered. Then, when the eggs hatch, the caterpillars aren't likely to compete with each other for food.

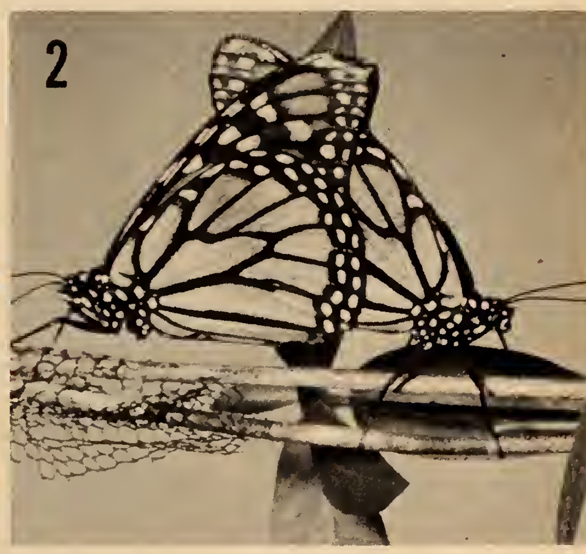
Care of Caterpillars

The eggs will hatch in about four days. They darken just before hatching. When the little caterpillars hatch from the eggs, move them to *rearing chambers*. These can be almost any washable container with a close-fitting top to keep the caterpillars from escaping. (The top also helps keep the food plants inside from drying out.) A small plastic refrigerator box can be used as a rearing chamber for one or two caterpillars. A five-gallon aquarium will hold 50 or more, but disease is more likely to strike when you keep the caterpillars in large groups.

Move the newly hatched caterpillars (*larvae*) to a rearing chamber by cutting off the leaves they are on and putting the leaves in the chamber. Do not move the leaves if there are unhatched eggs on them. Instead pick up the caterpillars with a camel's hair brush. The larvae will attach themselves to the brush by a fine thread of silk. Be careful not to lose the larvae as you move the brush back and forth.

The caterpillars have big appetites. Six or eight large ones may completely strip the leaves from a large stalk of milkweed overnight. Keep food available at all times.

To mate Monarchs, put the abdomens of a male and female together like this. The male has claspers on the end of its abdomen that grip the female. Once the butterflies are joined together, you can put them in a cage.



The butterflies may stay in this mating position for several hours. Then the female will begin to lay eggs on milkweed leaves.

Put a wire frame on the bottom of the rearing chamber (*see diagram on next page*). Then you can stick the leaves upright in the wire so that the larvae can feed easily. This also keeps the leaves from matting together, and keeps them from being soiled by wastes from the larvae. To keep the rearing chamber clean, put a paper towel on the bottom and replace it daily. You should dampen the paper towel so that the air inside the chamber is moist. Don't let the air get so humid that water drops form on the inside walls of the chamber.

The larval stage lasts about two weeks. It ends when the larvae form beautiful *chrysalids* (*see Photo 4*). When this is about to happen the caterpillars will hang from a

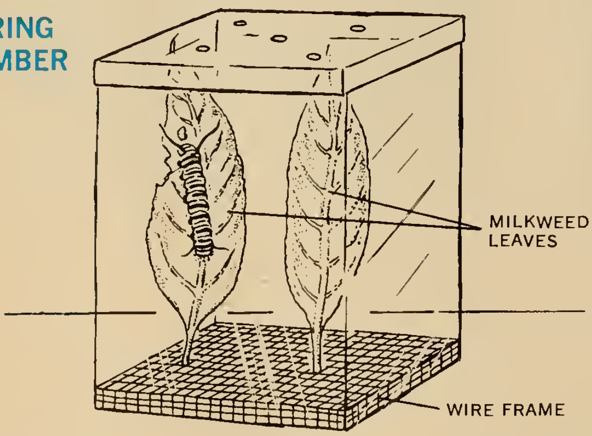
(Continued on the next page)

A Monarch caterpillar (Photo 3) can eat an amazing amount of milkweed leaves during its two weeks of growth. Then the caterpillar forms a chrysalid (Photo 4). The chrysalid turns dark when the butterfly is ready to emerge. You will be able to see the adult inside (Photo 4). Then the chrysalid splits open and the adult comes out (Photo 5).

Mating Monarchs (continued)

silk "button" for about 12 hours. Just before the larval skin breaks open, the caterpillar will hang more limply than before. Watch for this. When the skin of a larva breaks open, you will be able to see the green chrysalid inside. (The chrysalid is also called the *pupa.*)

REARING CHAMBER



Now you have a little rest. The butterflies stay in the chrysalid form for about two weeks. The chrysalids will turn a darker color when the adult butterflies are nearly ready to come out. The adults often emerge during the morning. It is a fascinating show as the flame-colored adults emerge from the jewel-like chrysalids. How different they are, the larva, pupa, and adult (*see Photos 3-5*). Yet all are stages of the same life cycle.

The newly emerged adults hang from the chrysalid case while body fluids pump into their wings, spreading them to full size. Then the wings dry. (The container should be at least four inches high and four inches wide to allow this to happen without the wings touching the sides or bottom.) As soon as their wings are dry, move the adults to a cage and offer them some water and food. (*For feeding directions, see Part 1 of this article, in the September 18, 1967 issue of* N&S.) In about four to six days they will be ready for mating. They may mate in the cage but you will probably have to start them (*see Photo 1*).

By following these directions, you may be able to keep a population of Monarchs throughout the fall and early winter. If your colony does not develop disease, you can raise Monarchs through the entire winter. And while you are working with Monarchs, there are many questions about their lives you can investigate. There is still much to learn about these beautiful insects ■

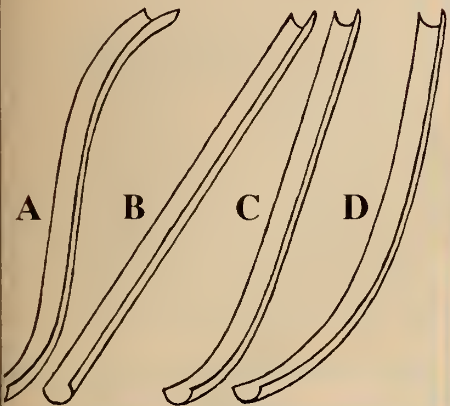
INVESTIGATIONS

- Will Monarch larvae eat plants other than milkweed? Maybe you can get them to eat lettuce or cabbage by soaking these leaves in juice from mashed milkweed leaves.
- How much food does it take to raise one caterpillar? What happens if a caterpillar gets less food than normal?
- Does temperature affect the growth of the larvae? Will they change to the chrysalid stage more quickly in a warm room or in a cool room?

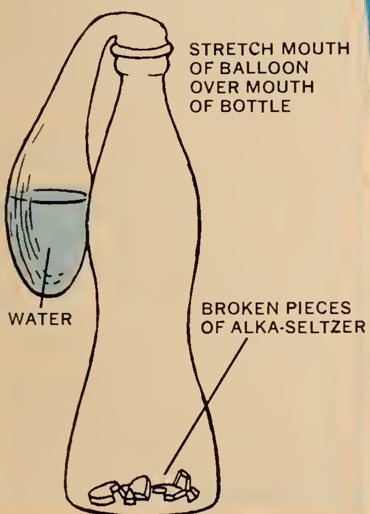
Brain Boosters

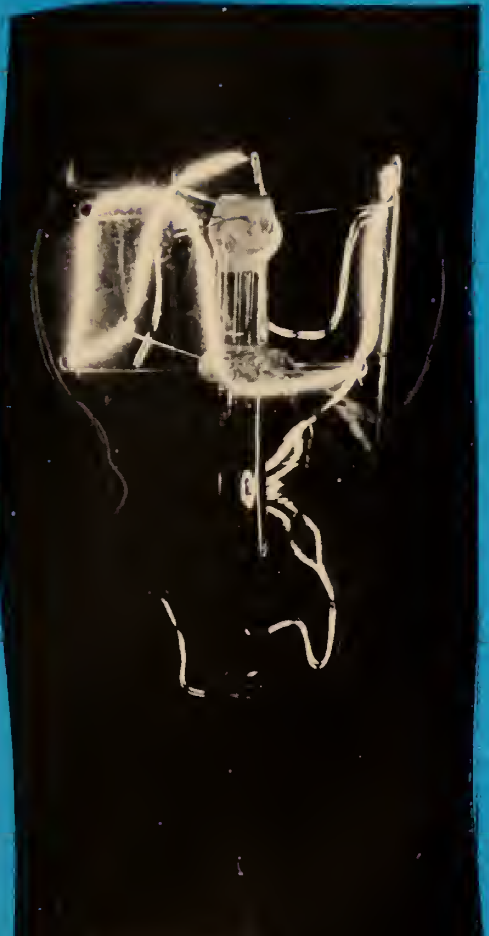
prepared by **DAVID WEBSTER**

What would happen if?
Here are four tracks for rolling a marble downhill. Which one would make a marble go fastest? Or would there be no difference?



Just for fun
You can blow up a balloon with some Alka-Seltzer tablets. To do this, arrange a balloon and bottle as shown in the sketch. Then dump the water onto the tablets and watch what happens. What gas fills the balloon?

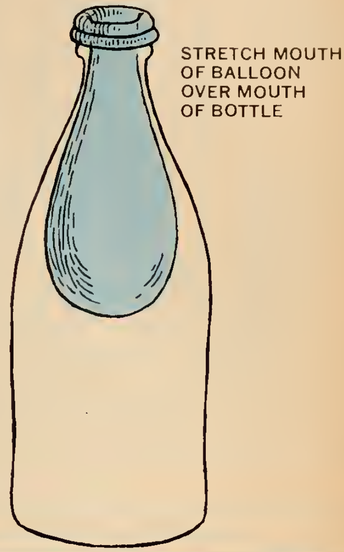




Mystery Photo
What is it?

Idea submitted by Gordon Rosenberg, West Lafayette, Indiana

Can you do it?
Can you blow up a balloon inside of a bottle?



For science experts only
Why does firewood crackle when it burns?

Fun with numbers and shapes
Here are the digits from 1 to 9 arranged so they equal 100. Can you find another way to do this?

$$\begin{array}{r} 15 \\ 36 \\ +\,47 \\ \hline 98 \\ +\,2 \\ \hline 100 \end{array}$$

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The crooked lines on the street were originally painted straight. The road tar was softened by the summer sun, however, and was gradually moved by the traffic.

What will happen if? When the end of the yardstick is released, it falls faster than the coin. The middle of the yardstick does fall at the same rate as the coin, but the raised end of it drops faster.

For science experts only: Mountain tops are colder because the air is heated mainly by being in contact with the warm earth. As the warm air near the ground begins to rise, it expands, because the air pressure is less at higher altitudes. When a gas expands it becomes cooler.

Fun with numbers and shapes: If you rip up a sheet of paper into nine pieces, the middle piece will be the only one with all four edges ripped.

Can you do it? The problem was to drink with two straws, one of which was not in the water. One way to do this is to block off the open straw with a finger. Can you explain why?

THE ANIMAL MOVERS

Men sometimes try to "improve" a country by importing animals from another area. The result is often a disaster.

■ Somewhere in a New Zealand forest, a hunter raises his rifle, takes careful aim—and brings a red deer to the ground. Many hunters in Europe and North America might envy this man, for he can shoot as many deer as he wishes, at any time of year. What's more, his government has given him ammunition for the hunt. He might even be one of about 120 hunters whom the government *pays* to hunt deer.

As you may have guessed, New Zealand has far too many deer. Yet only a little more than a hundred years ago, New Zealand didn't have a single one! The story of the red deer gives just one good example of what can happen when men move animals from one place to another.

When men first set foot on New Zealand about 600 years ago, the islands were covered with lush vegetation. But in the groves of giant tree ferns, dense rain forests, open fields, and rocky mountain slopes there were no mammals at all, except two species of bats. The only four-footed animals on the islands were reptiles and amphibians. The woodlands and fields of New Zealand had never known grazing mammals. There were no deer, swine, wild sheep, goats, bears, cattle, or other large creatures. There were a few fish in the streams, a wide variety of insects, and many birds.

Man, the Animal Mover

The Maori people who first visited New Zealand from islands to the north brought only some half-wild dogs, some rats, and two kinds of fleas. None of these seemed to have much effect on the new territory. But in 1773, Captain Cook brought three small pigs to the South Island.

The pigs ate plants and the eggs and young of ground nesting birds. They are believed to have started the populations of wild hogs that live on the island today. With each later visit, Captain Cook brought seeds and animals that he thought would help make the islands more suitable for humans. Other ocean travelers who followed him probably brought still more rats, mice, pigs, and goats.

This was just a beginning. In 1840, when Europeans began to settle in New Zealand, animals became a major concern, first for food, later for sport. Some animals were imported simply because they reminded the people of their former countries.

Creatures were brought to New Zealand from around the world. From North America came the elk, whitetail deer, mule deer, moose, Canada goose, California quail, and the bobwhite. From Europe came the small brown owl and chamois. From Asia came the axis deer, sambar deer, Japanese deer, Chukar partridge, laceneck dove, Indian myna, and peafowl.

Animals from England included rabbits, hares, red deer, hedgehogs, ferrets, skylarks, starlings, house sparrows, and many others. From Australia came opossums, wallabies, black swans, Cape Barren geese, brown quail, magpies, white cockatoos, the eastern rosella, and the laughing kookaburra.

Many of these animals didn't survive. A few became a valuable part of the New Zealand wildlife. Today, however, New Zealand considers at least 29 of its imported creatures to be "problem animals."

Too Many Deer

The story of the red deer shows how a valuable animal can become a "problem." You could hardly blame the

This article is adapted in part from the book, The Alien Animals, *by George Laycock, published by The Natural History Press, Garden City, N.Y. Copyright © 1966 by George Laycock.*

original importers for thinking this animal would make a valuable addition to the New Zealand countryside. Here was a land of plentiful vegetation and favorable climate, with no large *predators* (meat-eating animals) except man.

The first deer was brought to New Zealand in 1851. A pair had begun the trip across the ocean, but the female died. Eleven years later three more deer were brought. The settlers continued to import them.

Not until 1925 or 1926, when deer were already reaching alarming numbers in some areas, was the transplanting stopped. By then, people noticed that the deer were causing great damage to crops and forests. Soil washed away from slopes where the deer had eaten away most of the plant life. Today the red deer are still called "a serious menace."

Some animals were brought to New Zealand in order to help control the animals that were imported earlier. The imported rabbits, for example, became so plentiful that they were destroying crops and other plant life. To control the rabbits, the government imported thousands of weasels, stoats, and ferrets (all members of the weasel family). Ferrets are now scattered from one end of New Zealand to the other, but they don't seem to have any real effect on the rabbit populations.

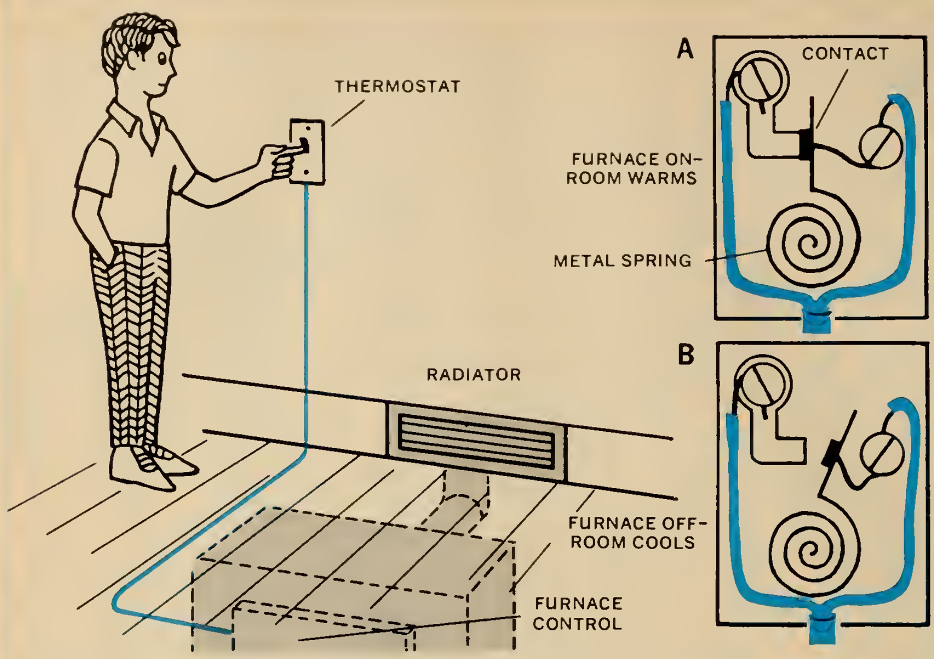
The rabbits were competing with sheep for food, so the sheep farmers bought cats and let them go to fend for themselves. The cats ate rats and no doubt fed on some young rabbits. But they also helped themselves to the quail and pheasants that people were trying to raise. And they killed small birds and helped wipe out the native lizards.

No one in New Zealand—or anywhere else, for that matter—could have known for sure which animals would "work out" well and which would not. No one can safely predict what effect an animal will have in a new living place. As one biologist explains, "There is no reason to expect an imported animal to fit in. It enters a world where the different kinds of plants and animals have lived together for many thousands of years. This is reason enough for it to either die out or become a nuisance. It would be unusual for an imported animal *not* to cause trouble."

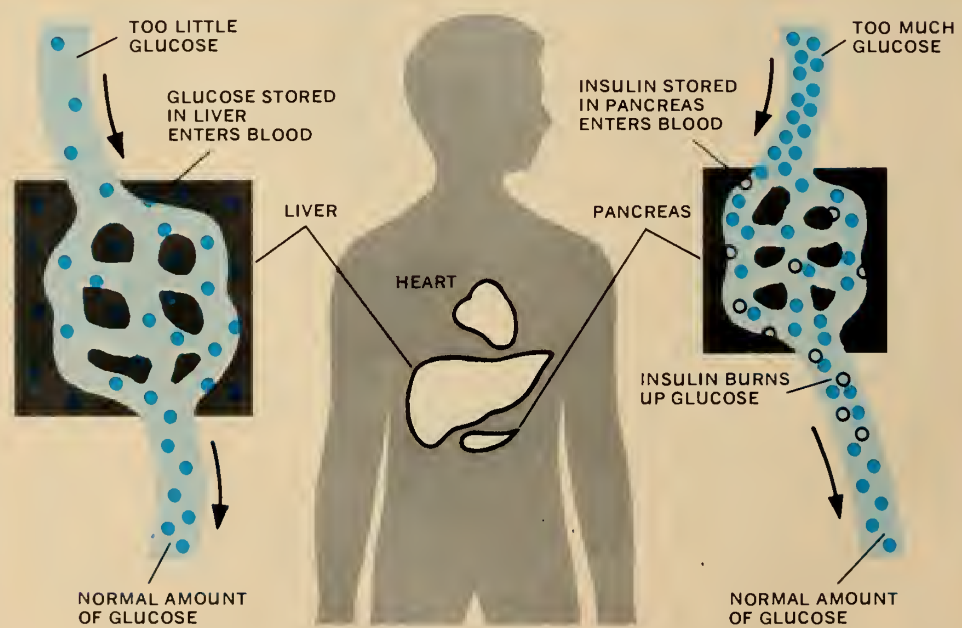
With the example of New Zealand as a guide, man has learned that "animal moving" is a dangerous game ■

EXAMPLES CLOSE TO HOME

Strict laws now control the importation of plants and animals into the United States. Before these laws were passed, however, many kinds of plants and animals reached North America from other continents. Can you name some of them? Are they helpful to man or are they a harmful nuisance?



A *thermostat* feeds information about the temperature of the air in a room back to the furnace control box. When the air is too cool, the end of a coiled metal spring in the thermostat is pushed against an electrical contact, signaling the control box to turn on the furnace *(Diagram A)*. As the air warms up, the spring *expands*, or stretches, and pulls its end away from the contact when the air is about the desired temperature *(Diagram B)*. This signals the control box to turn the furnace off.



Your blood carries *glucose*, a sugar made from the food you eat, to your body cells to give them energy. Your *liver* stores glucose, and your *pancreas* makes a substance called *insulin* that "burns up" glucose. The blood flowing through these two organs feeds back information to them about how much glucose it contains. When there is too little, your liver releases some glucose into your blood. When there is too much, your pancreas releases insulin to burn up some of the glucose. If one of these controls breaks down, it may cause illness or death.

In an area where there
eat, the deer populatio
goes up, the amount
down *(B)*. This feedba
bringing the deer pop
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(C). This is one of ma
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KEEP
UNDE

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will figure it out
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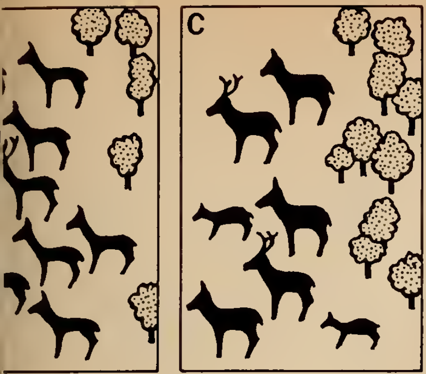

y of leaves and small twigs for deer to
o increase (*A*). As the number of deer
vailable for each individual deer goes
the female deer produce fewer young,
own again. Some deer may starve for
o eat the leaves and twigs, the food
g another rise in the deer population
hat feedback helps control the size of

G THINGS CONTROL

ictly how your shoulder, arm, hand,
be moved to pick up a pencil from
ou have a built-in "computer" that
he job for you. The "computer," of
it controls every movement of your

ıp a pencil many times before, there
emory that tells your brain how to
pick up a pencil. But the program
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the right direction. Your eyes keep
your brain about how far your hand
porting" of what happens as a result
to your arm is called *feedback*. Your
information to make your hand move
stop when it has reached the pencil.
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take place in nature, as well as the
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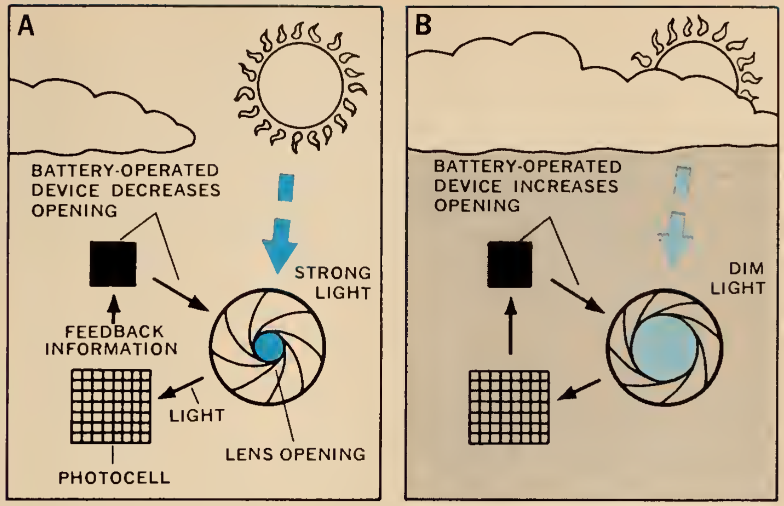
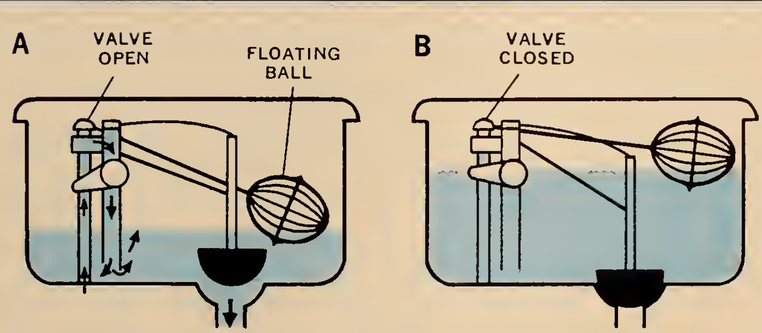
f some others? ■



The lens opening of some modern movie cameras is automatically changed in size to let just the right amount of light reach the film in the camera. An "electric eye," or *photocell*, in the camera constantly measures how much light is coming in through the lens. It feeds this information back to a battery-operated device that makes the lens opening smaller when too much light is coming in, and larger when the sunlight is dimmed by a cloud, for example.

When you ask or tell another person to do something, you can usually tell by the way he answers (or *doesn't* answer), by the expression on his face, and sometimes by motions of his hands, whether he really wants to do what you ask. If you "read" these feedback signals correctly, they can help you decide what to do next to "control" the situation. Most people who get along well with other people do this automatically, without thinking about it. Do you?



The floating ball inside a toilet tank feeds back information about the level of the water in the tank to a valve that supplies water to the tank. When you flush the toilet, water flows out of the bottom of the tank. The ball moves down on the surface of the water, pulling down a rod that opens the valve and lets more water into the tank (*Diagram A*). The ball rises with the water, making the rod close the valve when the water reaches the proper level (*Diagram B*).

WHAT'S NEW

Did dinosaurs growl, bellow, scream, roar? No one knows for sure. But at the Peabody Museum of Natural History in New Haven, Connecticut, you can stand before a dinosaur specimen and hear sounds something like those a dinosaur might have made 140 million years ago. The sound that is played on a tape recorder is the mating roar of an American bull alligator.

The Museum scientists chose this sound because alligators are considered the nearest living relatives of the dinosaurs. The study of dinosaur fossils shows that alligators and dinosaurs probably developed from a common ancestor. So it is likely that they had similar vocal cords and made similar sounds.

How caterpillars that become polyphemus moths get their favorite food—oak leaves—has been discovered by Drs. Carroll Williams and Lynn Riddiford of Harvard University, in Cambridge, Massachusetts. They found that the polyphemus moths will mate only if there are oak trees nearby. These leaves give off a gas that affects the antennae of the female moth, causing her glands to release a scent into the air. A male moth picks up the scent with his antennae and follows it to the female. They mate, and the female lays eggs where the hatching caterpillars will have a supply of oak leaves to eat.

Cars of the future might run on ammonia instead of gasoline, says Leon Green, Jr., a scientist with the Lockheed Aircraft Corporation in Washington, D.C. When gasoline is burned in an auto engine, it gives off carbon monoxide and other gases that pollute the air. But when ammonia burns, about all it gives off are water vapor and nitrogen—gases that are natural parts of the air.

Ammonia actually has been used to power some kinds of engines, but automobile engines would have to be changed to work well on ammonia. Also, since this gas burns the skin and is poisonous, ways would have to be found to handle it safely at filling stations and prevent leaks in the car.

The bite of a black widow spider won't kill a normal, healthy adult person, says Dr. John D. McCrone, a zoologist at the University of Florida, in Gainesville. But it can kill a healthy child or an adult with heart or kidney disease, and it can make a healthy adult very sick. An ounce of the black widow's poison is as powerful as an ounce of poison from a coral snake or a cobra, says Dr. McCrone. But the spider is much smaller than a snake, and it gives out far less poison when it bites.

The black widow got its name because the female sometimes kills her mate. The spider has a shiny black body with a red or yellow marking shaped like an hourglass on its abdomen. Dr. McCrone, who has been studying the black widow for four years, found that several different substances make up the spider's venom. One substance is poisonous to mammals, including humans, and the others are poisonous to insects, which the spider needs for its food.

Wearing ear plugs can help prevent stomach ulcers, hives, and mental illness, says Dr. Lee E. Farr of the University of Texas School of Public Health, in Houston. He explains it this way: Noise is getting worse as cities grow larger and people live closer together. Loud noises, even medium ones at night, tend to affect people's nerves and in time may help bring on different ailments. Wearing ear plugs when needed to shut out annoying sounds would help keep people healthier, says Dr. Farr, but few people bother to try this simple remedy.

The mystery of the Russian rocket that carried the first man into space is solved. Back in 1961, Cosmonaut Yuri A. Gagarin was launched into an earth-circling orbit aboard the spaceship Vostok I. U.S. space experts believed the Russians had used a single huge rocket, far larger than any this country had. Recently the Russians showed the launching vehicle for the first time. It is simply four booster rockets strapped to a fairly small two-stage rocket *(see photo)*. Here's how experts think it worked:

The four boosters and the first stage of the main rocket were fired together, providing the great push needed to lift the vehicle off the launching pad and into the air. The boosters quickly burned out, separated from the main rocket, and dropped away. After the main rocket's first stage burned up its fuel, the rocket coasted upward in a long arc. Then, at just the right moment, the second-stage engine fired and pushed the spacecraft off the rocket's tip and into orbit.

The Russians used a rocket like this, with four boosters attached, to send the first man into space. *(See text.)*

Most of the "flying saucers" people have reported seeing over the past 20 years have been traced to common objects such as meteors, kites, planes, and mirages. But a number of them are still mysteries. Scientists are just beginning to tackle . . .

THE CASE OF THE UFOs

by Andrea Balchan

■ On June 24, 1947, a pilot named Kenneth Arnold was flying his plane around Mount Rainier, in the state of Washington. It was about two o'clock in the afternoon, and a beautiful, sunny day. Mr. Arnold was looking out the window, enjoying the view, when he saw a bright flash of light reflected from the skin of his plane. Suddenly, about 25 miles away, he saw what looked like nine objects skipping across the sky the way a flat rock skips along the surface of a pond when you throw it properly.

The objects seemed to be at the same height as Mr. Arnold and he thought each was about the size of a small plane. The strange objects flew along and turned at the same time, almost as if they were linked together by an invisible chain. They darted between and around the mountain peaks, dipping up and down and shining brightly in the sun.

At first, Mr. Arnold thought the objects might be some kind of jet airplane, but he couldn't see any tails on them, and he knew they weren't moving the way planes move. In fact, they didn't look like anything he had ever seen before. He told newspapers and the United States Air Force about the mysterious objects, and the newspapers called them "flying saucers."

Since then many other people have reported seeing "flying saucers." They didn't all look like the ones Mr. Arnold saw, however. About two years ago, on the night of September 3, 1965, an 18-year-old boy was walking on a road near Exeter, New Hampshire, when he saw a huge bright object, about 80 feet wide and covered with red lights, come across a field toward him. He jumped into a ditch by the road, and watched the object circle over a house and then move away.

Later on, the boy and a policeman went back to the field and searched the area with flashlights. They heard the horses on a nearby farm begin to whinny and the dogs howled. Then they saw the same object the boy had seen earlier, rising slowly from between some trees. Another policeman driving up in a car saw it too. It was a brilliant red and covered the whole area in bright, eerie red light. It wobbled and fluttered around as it moved toward them, but it didn't make a sound. In a little while it went away. At first, everyone thought that it might have been part of a testing program the Air Force was carrying on in that area. But it turned out that the Air Force had finished their testing long before that time.

So far, no one has been able to explain what it was that Mr. Arnold saw flying around Mount Rainier or what the huge red object was that scared the boy in New Hampshire. Both are *unidentified flying objects*—UFOs, for short.

The Air Force and the UFOs

About the time of Mr. Arnold's experience, people in South America, Europe, and Asia, as well as in different parts of the United States, began to report that they had sighted UFOs. In the past 20 years, flying objects of many different shapes and sizes have been reported. Many were described as "very bright" objects that moved and sometimes turned "very fast." Some were high in the sky; others hung in the air just above the ground. Some of the people who saw them were able to photograph what they saw *(see photos on next page)*.

In 1947 the U.S. Air Force assigned a small group of

(Continued on the next page)

ABOUT THE COVER

The "flying saucers" on the cover were photographed near New York City. An alert photographer, Don Rice, saw them from inside a passenger train. In fact, the "saucers" are really the ceiling lights inside the train car, reflected in the glass of a window.

Among the UFOs that have been photographed are: 1) a saucer-shaped object seen in New Mexico; 2) an object that reportedly hovered over a Michigan lake for 10 minutes in January 1967; and 3), a formation of lights in the night sky at Lubbock, Texas. Many of the UFOs that people photograph can be identified. Some photos are "trick" pictures meant to fool people. A few of the UFOs captured in photos seem to have no explanation.

men to keep records of all reports of UFOs and to investigate them as fully as possible. Since then, these men have investigated more than 11,100 reports of UFOs. Most of the objects, they found, could be identified.

Many of the objects turned out to be artificial earth satellites. One day in September 1962, for example, people in six Midwestern states saw flaming objects shooting through the sky. Later, a chunk of metal was found partly buried in a street in Wisconsin. Scientists found that it was a piece from the Soviet satellite Sputnik IV, which had broken apart in space and burned up as it entered the earth's atmosphere.

Many more "UFOs" were found to be *meteors*—streaks of fire in the night sky that are made by particles of rock or metal from space as they fall through the earth's atmosphere. Other "UFOs" were actually huge weather balloons which are sent up to gather information about the atmosphere.

A lot of the "flying objects" were *mirages,* or tricks played on the sighters' eyes by unusual conditions in the atmosphere. A distant mountain top, for example, can appear to be floating in the air above the base of the mountain, as if it were not connected to it. This kind of mirage is caused by a layer of cold air near the ground with warmer air above it. In the cold layer, the air is more *dense,* or closely packed together, than in the warmer layer. As light from the top of the mountain enters the denser air on its way to your eyes, the light is bent. This makes the mountain top appear to be higher in the sky than it actually is *(see diagram on the next page).*

Some "UFOs" have been identified as stars or planets that appeared to be moving around in the sky. A layer of mist moving through the atmosphere can play such tricks on your eyes.

Scientists believe that some of the other UFOs are caused by *swamp gas.* When moist swamp weeds and grasses rot, they produce a gas which often is trapped in the frozen swamp during the winter months. In the spring, the ground begins to thaw and the gas is let go. It often pops and crackles as it leaves the ground and sometimes glows with light as it floats over the swamp. In some cases, people could have mistaken bright swamp gas for UFOs.

These are just some of the explanations. Other UFOs have been definitely identified as kites, clouds, planes, and other very ordinary things. But more than 900 of the UFO "sightings" reported to the Air Force in the past 20 years have still not been explained. In about a quarter of these sightings, so little information was reported that they were impossible to investigate. But many of the other UFOs were described in some detail by people who said they had time to watch them for many minutes.

Scientists and the UFOs

One man who thinks these still-unidentified flying objects should be more carefully studied is Dr. J. Allen Hynek, an astronomer at Northwestern University, in Evanston, Illinois. Dr. Hynek has been a consultant to the Air Force on UFOs for nearly 20 years. He has never seen a UFO, but he has talked with many people who have, and he has studied all of the sighting reports. For many years Dr. Hynek has been trying to convince fellow scientists that the UFOs deserve their attention. Many scientists refuse to take him seriously, and think that a UFO study would be a waste of time.

Dr. Hynek points out that many of the clearest, most detailed reports of UFOs have come from people who are intelligent and have had some kind of scientific or technical training. Such people—an airplane pilot, for example—would not be so likely to mistake a mirage, a meteor, or a satellite for a UFO. Nor would they be likely to make up a UFO story just for the fun of it. Many have asked that their names not be given out by the investigators, so they were probably not seeking publicity.

It has been said that UFOs have never been sighted on radar screens or photographed by cameras taking pictures of meteors or satellites. Dr. Hynek says that this is not exactly true, because "odd" spots do sometimes appear on radar screens or in photos taken by such cameras. They are usually assumed to be common objects that could be identified but aren't worth taking the trouble to identify.

Dr. Hynek has several hundred UFO reports that he thinks would make good "brain teasers" for discussion by scientists who study the ways people think and act, as well as by scientists who study matter and energy.

Recently, the Air Force asked a group of scientists at the University of Colorado, in Boulder, to study the reports of UFO sightings and see if they could explain them. The leader of the group is Dr. Edward U. Condon, a physicist at the University. Dr. Condon doesn't know whether his group will come up with any answers, but he agrees with Dr. Hynek that scientists should try to find out more about UFOs.

Dr. J. Allen Hynek examines a picture, taken in March 1966, that supposedly shows unidentified flying objects in the sky. He explained to reporters that the photo is actually a time exposure of the moon and the planet Venus.

Visitors from Another Planet?

Studying the UFOs will not be an easy job. The scientists can't make one appear so they can see it for themselves. All they have to go by are reports from other people. And UFO sighters often find it hard to describe what they saw. It would be helpful to have more photographs to study. Dr. Hynek would like to see every police car carry a camera ready to photograph a UFO.

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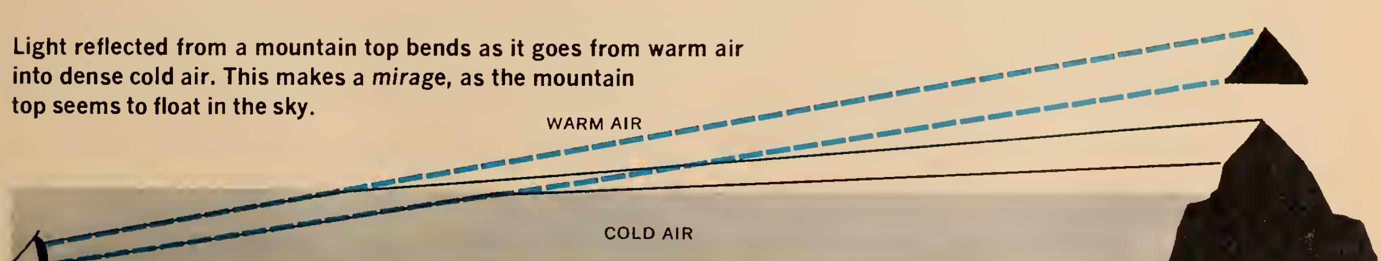
Light reflected from a mountain top bends as it goes from warm air into dense cold air. This makes a *mirage*, as the mountain top seems to float in the sky.



"I assure you, Madam, if any such creatures as you describe really existed, we would be the first to know about it."

DRAWING BY ALAN DUNN © 1966 THE NEW YORKER MAGAZINE, INC.

The Case of the UFOs (continued)

Dr. Condon's group will try to find out if there are patterns to the UFO sightings. Did several of them happen about the same time of day, for example? Or during the same kind of weather? If you marked on a map all the places where people saw UFOs, would you discover that some of the places were along a straight line, or in some other "arrangement"?

The scientists know, of course, that some of the sightings are "made up," and that in other cases people just imagined that they saw something. So the group will try to find out more about what makes people imagine UFOs.

An even harder question facing the scientists is this: Could the UFOs be visitors from another planet? The Air Force says that its investigators have found no evidence that UFOs come from space, or that they are "machines" that can move around in ways that we don't know about. Still, as Dr. Hynek says, as long as a "flying object" remains *un*identified, we can't really say what it is or is not.

Many scientists today think that there might be living things on other planets somewhere else in the universe. If there are, it is possible that some of them might have found a way to travel through the immense distances of the universe from their planet to the earth. To most scientists, though, it seems very unlikely that this has happened.

Dr. Condon and Dr. Hynek do not consider the present evidence is strong enough to suggest that the UFOs are visitors from space. But they know that when a scientist studies a problem, he must consider all the possible answers—even the most unlikely ones ■

If You Should Ever See a UFO . . .

If you should ever see a "flying saucer," you'll want to give the Air Force as much information as you can about it to help them study these objects. Try to remember as much as possible, and then write it down as soon as you can. Even the smallest detail may be important.

One of the first things for you to note down is where *you* were when you saw the UFO. Be specific. "At the corner of Main and Elm streets, Jamesville, Ohio" gives more information than "in front of my house." If you have a watch, note the exact time of your sighting, as well as the date. Otherwise, try to guess at the time.

Sky and weather conditions may also be important. Was it a starry night? Could you see the moon? Was there any rain, snow, or fog? What kind of clouds could you see? If it was daylight, was it bright or hazy?

Try to describe the shape of the object. Did it look like a ball, for example, or like a dish? Draw a picture if you can. What color was it? Did it seem to be lighted up? If the object moves in front of something, such as a tall building or a cloud, note whether you could see through it. Listen carefully for any strange sounds you might hear while the object is in your sight.

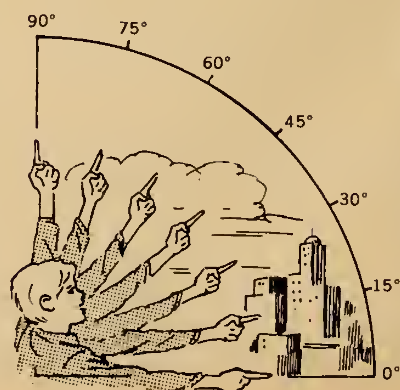
Did it ever appear to stand still, or did it move at a steady speed? Did it ever approach or actually touch the ground? Which way was it going? Did it seem to change its shape, color, brightness? Could you see any flashing lights? Did the outline of the object remain sharp the whole time you were looking at it, or did it sometimes get fuzzy?

If there are several objects, count the number. Do they all look alike? See whether they stay together, or move apart from each other. Draw a picture to show the pattern they made.

When you can no longer see the object, look at your watch (or take a guess) to see how long it was visible. Did it move behind something, or keep going until you could no longer see it? Did it seem to fade, or explode, or "just disappear"?

Finally, tell whether you can think of any familiar object that the UFO *could* have been. Also note whether you were looking through anything that might have made the object look different to you than to someone else—a telescope, for example, or even sunglasses or a window pane.

Write out all your notes as clearly as you can, and send them to the U.S. Air Force base nearest your home. Be sure to include your name, address, and phone number so that the Air Force can reach you if they have any more questions.



Where was the object in the sky? Put an "A" on the curved line to show where you first saw it; put a "B" on the line to show how high it was when you last saw it. You should also take a compass reading to help mark the location of the object.

Which Colors Will the Leaves Turn?

You can make a good guess by finding out which colors are hidden under their masks of green.

by Marlene Robinson

■ About this time of year the leaves in many parts of the United States begin to change color, from their summer greens to autumn yellows, oranges, and reds. The coloring matter, or *pigments,* that produce these bright colors are in the green leaves, but they are hidden by the green pigment called *chlorophyll,* which is used by plants to make food.

Right now, while some of the leaves may still be green, you can find out which other colored pigments they contain and try to predict what colors the leaves from each tree will become later in the autumn. Even if you live where the leaves change color very little, you can discover pigments of other colors that are hidden behind their mask of green.

A "Rainbow" of Colors

The pigments of different colors can be dissolved out of leaves and separated into a "rainbow" on paper. To do this, you will need a dozen small baby food jars with lids, some thin drinking straws, and some round pieces of filter paper about four inches in diameter. You can probably buy some paper coffee filters that size or larger at an appliance or department store. Be sure they are made of paper, and not fabric, and that they do not have a hole in the center. If you cannot find such filters, white paper towels that do not have a pattern pressed into their surface will work nearly as well.

You will also need a large bottle of rubbing alcohol (from a drug store). *Be sure to keep the alcohol out of the reach of younger brothers and sisters; keep it away from your eyes, mouth, or clothes.*

Collect several leaves—of different sizes, if possible—from each tree you wish to test. Put the leaves from each tree into a separate envelope, marked "tree 1," "tree 2," and so on. (If you know what kind of tree it is, write that down too.) You might make a simple map of your area and number the trees so you can remember which tree each sample of leaves came from.

Next, cut the leaves from one tree, stems and all, into small pieces, and put them into a baby food jar. Use a crayon or marking pen to write on the jar the number of the tree the leaves came from and the date you collected them. Pour alcohol into each jar to about one-half inch above the layer of chopped leaves. Use a clean wooden stick (or the handle of a wooden spoon) to mash the leaf

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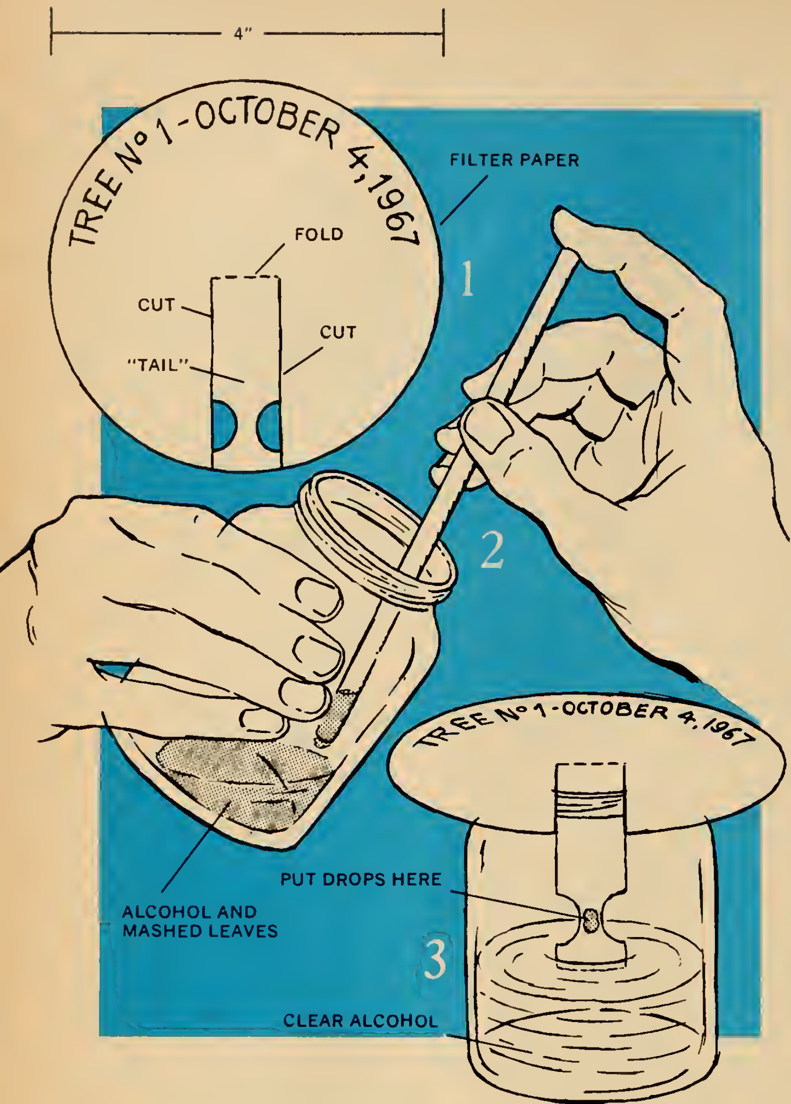


Which Colors Will the Leaves Turn? (continued)

pieces. Then cover the jars tightly and let them stand overnight.

The following day, pour alcohol into a clean baby food jar until it is one-half inch deep. Cut a circle of filter paper and label it with a pencil as shown in Diagram 1.

Open jar 1 and mash the solution with the stick. Push the leaves to one side, tip the jar and put the tip of a drinking straw in the liquid so that several drops are inside the straw. Cover the open end of the straw with your finger and lift it out of the jar *(see Diagram 2)*. Hold the bottom end of the straw over the "wasp-waist" of the filter paper and lift your finger off the top end, letting drops of the colored liquid form a spot on the paper. Next, fold the "tail" down and let it hang inside the jar so that it just touches the clear alcohol *(see Diagram 3)*.

You can see the clear alcohol climbing up the paper, just as ink or water climbs up a blotter. As the alcohol passes through the spot of color, it picks up the tiny pigments and carries them along with it. Pigments of some colors are lighter in weight than others, so they are carried farther up the filter paper.

You should have two bands of green, one blue-green and the other yellow-green. These are the chlorophylls. In the autumn, the leaf makes less and less chlorophyll, and the yellow and yellow-orange pigments that were always there can be seen.

You may wonder about the pigments that make some leaves bright red, or even purple. These pigments seem to form in leaves when sugars that are made in the leaves stay there instead of flowing to the tree's trunk and roots. This happens usually in the spring (when sugary sap is flowing upward in the tree) or the autumn (when a growth at the end of the leaf stem keeps the sugars from flowing to the branches).

To see if there are red pigments in the leaves now, collect more leaves from trees 1, 2, 3, and so on, and chop them as before. This time, boil each batch for 20 minutes in enough water to cover them by two inches. (The red pigments dissolve in water; the green and yellow pigments do not.) When the solution is cool, pour it into a baby food jar and insert the tail of a filter paper circle. Do the leaves contain any red pigments now?

PROJECT

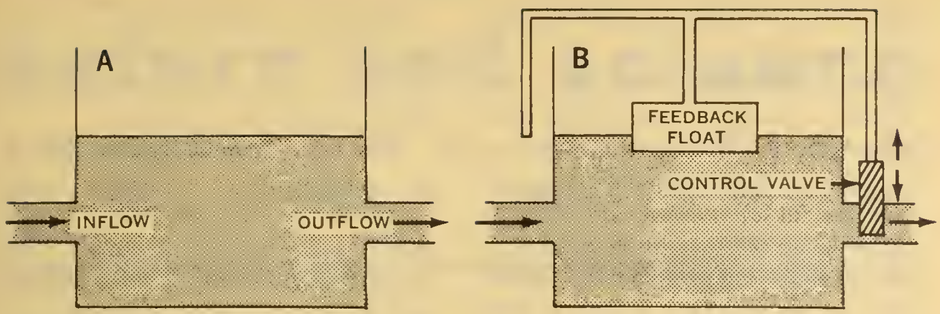
Do you think that the red pigments in leaves are the same as the ones that make flowers red? You might boil the petals of some red flowers and compare their "color bands" with those you get from boiled leaves.

Predicting Autumn Leaf Colors

See if you can guess, by comparing the green and red color separations from each tree, what colors its leaves may be in full autumn color. If the test papers for a tree show strong bands of yellow and red, think what color you get when you mix yellow and red paints. What color would you get by mixing yellow, red, and orange paints? If your leaves do not show any reds *now*, you might test them again in a few weeks and see if any reds appear.

If your color separation shows only very light or not very clear bands of color, you may have a solution that is too weak, or they may be leaves that will yellow only briefly before they fall off. If your color separation shows only different tones from blue-green to yellow-green, the leaves may not change color much before dropping off—or you may be testing an evergreen tree.

When your test trees are in full autumn color, examine the leaves and test them again to see how accurate your predictions were ■



Draw Diagram A on the chalkboard and ask your pupils what happens to the water level in the tank when the water flows in faster (or slower) than it is flowing out. Can your pupils think of a way to keep the water level steady when the inflow of water is changing? Add to your drawing the float and control valve shown in Diagram B. The float feeds back information about the level of the water to the control valve, which changes the size of the outflow opening until the amount of water flowing out equals the amount flowing in.

Using This Issue . . .
(continued from page 2T)

positive feedback. If the reports lead the company to make fewer machines, or to stop making them, the feedback is said to be *negative,* because the feedback from the action results in an opposite action.

• You might ask your pupils to figure out whether feedback is positive or negative in each of the examples shown in the chart. In all cases but one, the feedback is negative, because it results in an opposite action (raising the amount of glucose in the blood when it is too low, or reducing the glucose when it is too high; producing more heat when the air is too cool, or cutting off the heat when the air is too warm; reducing the number of deer when there are too many for the food supply; and so on). When a person's refusal to do what you ask makes you try harder to persuade him to do it, the feedback is positive, but if it makes you stop asking him to do it the feedback is negative.

• Examples of feedback at work are all around us. The ones described in the chart should help your pupils think of others, even though they may not understand exactly how they work. Here are examples you can bring out through questions:

When you touch a hot pan, feedback from the nerves in your fingers tells your brain to pull your fingers back quickly.

The speedometer on a car feeds back information about how fast the car is going so the driver can control his speed.

On a dark staircase where you can't see your feet or the steps, your brain depends on feedback from the nerves in your feet to control your movements.

Running makes your body use up oxygen more rapidly than walking does, and the shortage of oxygen makes you breathe faster to get more oxygen from the air.

A built-in thermostat makes you sweat when you get hot, and the evaporation of sweat from your skin cools your body. Cold makes your body shiver, and this motion has a warming effect on your body.

Feedback from a television camera on the moon guided scientists as they directed Surveyor III to probe the surface of the moon with a small shovel.

When a scientist publishes a report of an experiment he has performed, feedback from other scientists who have read the report and tried the experiment helps him decide whether his findings were correct or not, and whether he should continue to investigate the subject in the same way.

The Case of the UFOs

As the article explains, most UFOs become IFOs — identified as artificial satellites, weather balloons, stars, and the like. In science, it is logical to look first for a conventional explanation to a phenomenon. Just because investigators have not found a conventional explanation for *all* UFO sightings does not mean that something extraordinary is going on. It may mean that the investigation was inadequate and failed to find an ordinary explanation that exists. Since UFOs do not lend themselves to precise investigation, there will never be absolute proof that all UFOs are caused by some ordinary phenomenon.

The UFOs that have not been identified do not fall into any uniform pattern of motion, color, and lighting. If they did, it would be evidence that they had some common cause. Since the sightings vary so much, this suggests that they do not have a common cause.

As you discuss the article with your class, point out that there is a lesson about science itself in the case of the UFOs. Since science is the search for truth, scientists cannot simply dismiss the UFO reports. As Dr. Hynek says, "If you know the answer beforehand, it isn't research. No truly scientific investigation of the UFO phenomenon has ever been undertaken. Are we making the same mistake the French Academy of Sciences made when they dismissed stories of 'stones that fell from the sky'? Finally, however, meteorites were made respectable in the eyes of science."

The history of science is littered with similar examples. On the other hand, scientists have every reason to be skeptical of UFO reports. It is significant that the Air Force-financed study at the University of Colorado includes both physical scientists and *psychologists.* Besides investigating the possible identity of unidentified flying objects, the research team is also exploring the reasons that people "see" UFOs. This is not to suggest that all people who report UFOs are abnormal. Nothing could be more normal than a substantial difference between what is actually visible and what people think they see, or between what people thought they saw at one time and what they later reported to investigators.

Having psychologists evaluate the UFO reports is a new approach to the UFO "mystery." What is behind the tales told by people who claim to have contacted the "beings" inside "flying saucers"? Why does publicity about a UFO sighting spark additional reports?

(Continued on the next page)

Using This Issue . . .
(continued from page 3T)

Why are people so eager to believe that this planet is being visited by representatives of an advanced civilization from somewhere else in the universe? Many scientists suspect that the case of the UFOs may be solved by learning more about the workings of the human mind.

Which Colors Will the Leaves Turn?

Chromatography is basically a method for separating and analyzing the parts of a mixture of compounds. Its efficiency, simplicity, and versatility have led to many uses among the applied sciences. Some day it may be a standard procedure for such diverse fields as criminology and taxonomic botany.

Dr. Robert Manasse and Dr. Cecil Jack of the Boyce Thompson Institute of Plant Research (in Yonkers, N.Y.), who helped prepare this article, say that at present there are five types of chromatography.

Paper chromatography, the first method developed, is described in its simplest form in this article. If you can do this investigation in your classroom, with careful supervision, you might try using solvents that are stronger than the alcohols suggested in the article. Benzene *or* methyl (wood) alcohol plus a few drops of dilute hydrochloric acid will give dramatic and satisfying results and will enable your class to complete the experiment within an hour.

Paper chromatography was used by scientists in 1956 to analyze the structure of the amino acids of the insulin molecule. This led to the manufacture of synthetic insulin, an aid to diabetics.

Column chromatography differs from paper chromatography in that the mixture is separated and its parts are collected as they filter through a tube packed with some special material, such as powdered sugar.

Molecular sieve chromatography is a recent development. In this method, a mixture is separated into its components by passing it through a set of strainers, in this case, layers of molecules of decreasing diameters.

Thin layer chromatography spreads the components of a mixture across a film of "neutral" material in rings, rather than bands, of color. This method is used mostly for analyzing fatty mixtures. Crime laboratories use thin layer chromatography in narcotics detection. Also, this method recently revealed that the waxes on the surfaces of leaves differ from one species of plant to another. This may be the path to an entirely new way of classifying plants.

Gas-liquid chromatography is like the thin layer method, but it is used with volatile mixtures. Criminologists have used this method to find hit-and-run drivers. If some paint from the hit-and-run car is left at the accident scene, the paint can be heated to a gas and analyzed. This may yield enough information about the year, make, and color of the car to help police find the driver.

nature and science
TEACHER'S EDITION
VOL. 5 NO. 3 / OCTOBER 16, 1967 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Some Recent Physical Science Books for Your Pupils

by Fred C. Hess

Charles Proteus Steinmetz, Wizard of Electricity, by Erick Berry (The Macmillan Company, 42 pp., $2.95), is one of a series of biographies of men of science in the publisher's "Science Story Library." The person of Steinmetz is emphasized rather than his technical achievements. It is the story of genius and warmth of personality emerging from a deformed and misshapen body. Many young readers will find it inspiring, although the more technically oriented would wish for more detail about the scientist's accomplishments.

They Gave Their Names to Science, by D. S. Halacy, Jr. (G. P. Putnam's Sons, 160 pp., $3.29), presents interesting biographies of 10 men whose names have become scientific terms or laws in the modern age—names like Mach, Doppler, Geiger, Mohorovicic, and Van Allen. In each story, the evolution of the man's scientific contribution is developed along with his personal history. An illustration of the first page of the principal scientific paper of each man introduces his biography, giving the whole book a mark of authenticity. It all adds up to excellent reading.

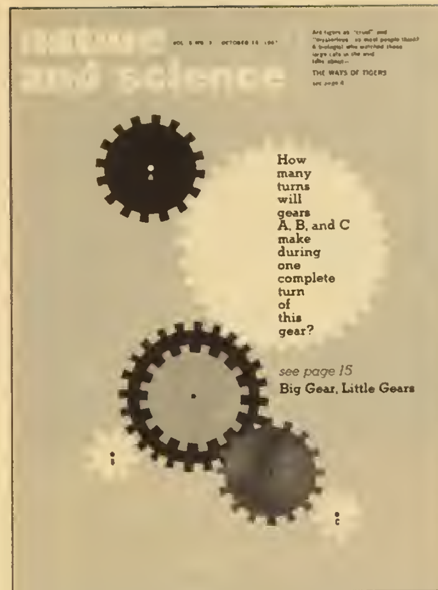
Science Projects and Experiments for the Junior Scientist: Book One: **The Five Senses;** Book Two: **Materials and Elements;** Book Three: **Machines and Energy;** Book Four: **Nature and Energy;** all by Eric J. Barker and W. F. Millard (Arco Publishing Company, 80 pp. each, $4.50 each). This set probes into a wide selection of topics in science and applied science with emphasis on the home environment. Each topic is discussed briefly and a series of projects is suggested and the keeping of records is urged. The projects are simple, not of the Science Fair variety, and many of them are highly achievable, interesting, and novel. The use of British terminology will perhaps seem strange to some pupils, but this can also be a source of interest and breadth. Despite an error in the identification of Jupiter in Book Four, the topics are well presented. Lack of an index is a serious handicap for the sporadic user.

Probability: The Science of Chance, by Arthur G. Razzell and K. G. O. Watts (Doubleday and Company, Inc., 48 pp., $2.50). If you overlook the garish red color of some of its pages and stick with it through a rather weak introduction, you will find that this book offers a highly useful and interesting approach to the field of probability. Projects involving the reader in both learning and thinking about statistics and probability form an especially strong point of this presentation. It should interest many in the intermediate elementary grades.

This Is 4: The Idea of a Number, by Arthur G. Razzell and K.G.O. Watts (Doubleday and Company, Inc., 48 pp., $2.50) is a different sort of book, describing and discussing a variety of mathematical subjects from arithmetic and geometry which are all related to the set of four. Rectangles and diamonds, squares and squaring, games and puzzles, seasons and quarters, and they all involve four. It all comes out moderately inter-

(Continued on page 3T)

Dr. Fred C. Hess is a Professor of Physical Sciences at State University of New York Maritime College, Fort Schuyler, N.Y.



IN THIS ISSUE

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

Spooning the Moon
Scientists found it easier to get a soil-sampling shovel to the moon than to find out how hard it had to dig to move the soil.

● **The Ways of Tigers**
This biologist's story of his experiences with tigers in India will change your pupils' ideas about these big cats.

Puzzling Patterns
Your pupils can test their awareness of patterns and textures by trying to identify the objects of these photos, and finding other patterns to photograph, to make their own "puzzlers."

Brain-Boosters Contest

● **Sleepy Seeds**
With some lettuce seeds, plastic sandwich boxes, aluminum foil, and colored cellophane, your pupils can investigate the effects of light on seed germination.

● **Big Gear, Little Gears**
Investigations with "three-speed" bikes can help your pupils to find out how "high" and "low" gear ratios provide more power or speed.

IN THE NEXT ISSUE

A special-topic issue on deserts . . . How animals and plants are adapted to live in the desert . . . An expedition to the Gobi in search of fossils . . . How man makes and unmakes deserts.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

The Ways of Tigers

To many people, the "image" of tigers, and that of other predatory animals, is that of "ruthless killers." Slowly, humans are beginning to realize that such terms can be applied only to man; a tiger does not make value judgments when it seeks the food it needs for life *(see "The Big Good Wolf,"* N&S, *Sept. 19, 1966).*

Biologists, in study after study, have discovered that predatory animals seldom have a long-lasting, serious effect on a healthy prey population. In fact, studies such as that of the moose-wolf relationship on Isle Royale National Park show that predators have a beneficial effect on the prey population, as they weed out sick and aged individuals.

An appreciation of the predator's role in nature is growing in this country. In some states, predatory animals are now protected by law for part of the year and are considered game animals, not "vermin." The federal government, long active in indiscriminate predator control in western states, is attempting to shift the emphasis of its program to selective control of individual animals that prey on livestock.

Activity

• Suggest that your class investigate the status of predatory animals in your state. One source of information is your state game laws, available wherever hunting and fishing licenses are sold. Also, you might arrange to have a wildlife biologist of your state conservation department come and speak to the class.

Topics for Class Discussion

• *How are tigers adapted for their roles as predators?* An adaptation is a characteristic of an animal, developed over thousands of years, that helps the species to survive. It may be a way of behaving, a structure, or a process within the animal. The author mentions a possible behavioral adaptation: By living alone, tigers may get more food than if they lived in groups.

Some other adaptations of tigers: sharp teeth and claws, coloration that blends with the surroundings, stealth, and the ability to go many days without food.

• *What are some adaptations of the animals on which tigers prey?* Prey species have many adaptations that enable them to survive despite predation; without these adaptations they would not survive. Many of the deer and other hoofed animals on which tigers prey live in herds; the keen senses of many individuals are alert for tigers. When danger is suspected, a signal warns the whole group. Also, most of these animals can run faster than a tiger. Prey animals also produce enough young so that the species continues despite predation, disease, and other losses.

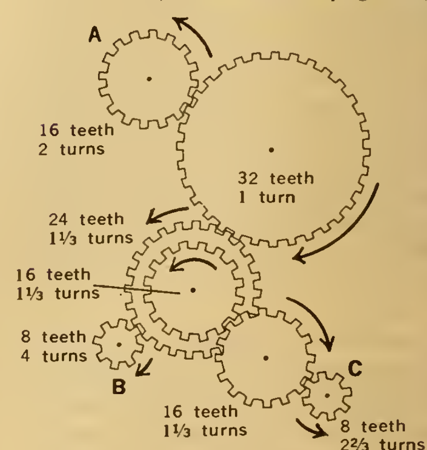
Sleepy Seeds

This investigation can be done by an entire class (perhaps divided into groups with different tasks), or assigned to an individual who can handle the challenges of planning and interpretation in the SCIENCE WORKSHOP. Even though all of your students may not investigate photo-dormancy in seeds, a reading of the article will give them some insight into the ways of setting up an experiment.

The goal of the first part of the investigation is to test one factor that may influence seed germination: light duration. Therefore it is important to eliminate other factors that might affect germination. Ask your students to name some other factors, and how they are eliminated. Their list might include: 1) seed variability (this factor is minimized by using great numbers of seeds and making sure that the seeds are fresh and of the same variety); 2) temperature (by keeping all seed chambers at the same, ideal temperature for germination, this factor is eliminated); 3) moisture (this factor is eliminated by putting the same amount of water in all seed chambers).

Also stress the importance of controls in experiments. Without a light and dark control among the six germination chambers you couldn't draw any conclusions about the effect of light on the seed germination. Only when you have the germination percentage from the light and dark chambers can you conclude that the percentages in the other four chambers were influenced by light duration.

(Continued on page 3T)



TO SAVE YOU TIME—This diagram of the gears on the cover of the student's edition shows the number of teeth on each gear and how many times it turns with each full turn of the largest gear. You might have your pupils figure out which direction each gear will turn if the large gear turns clockwise (see arrows).

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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

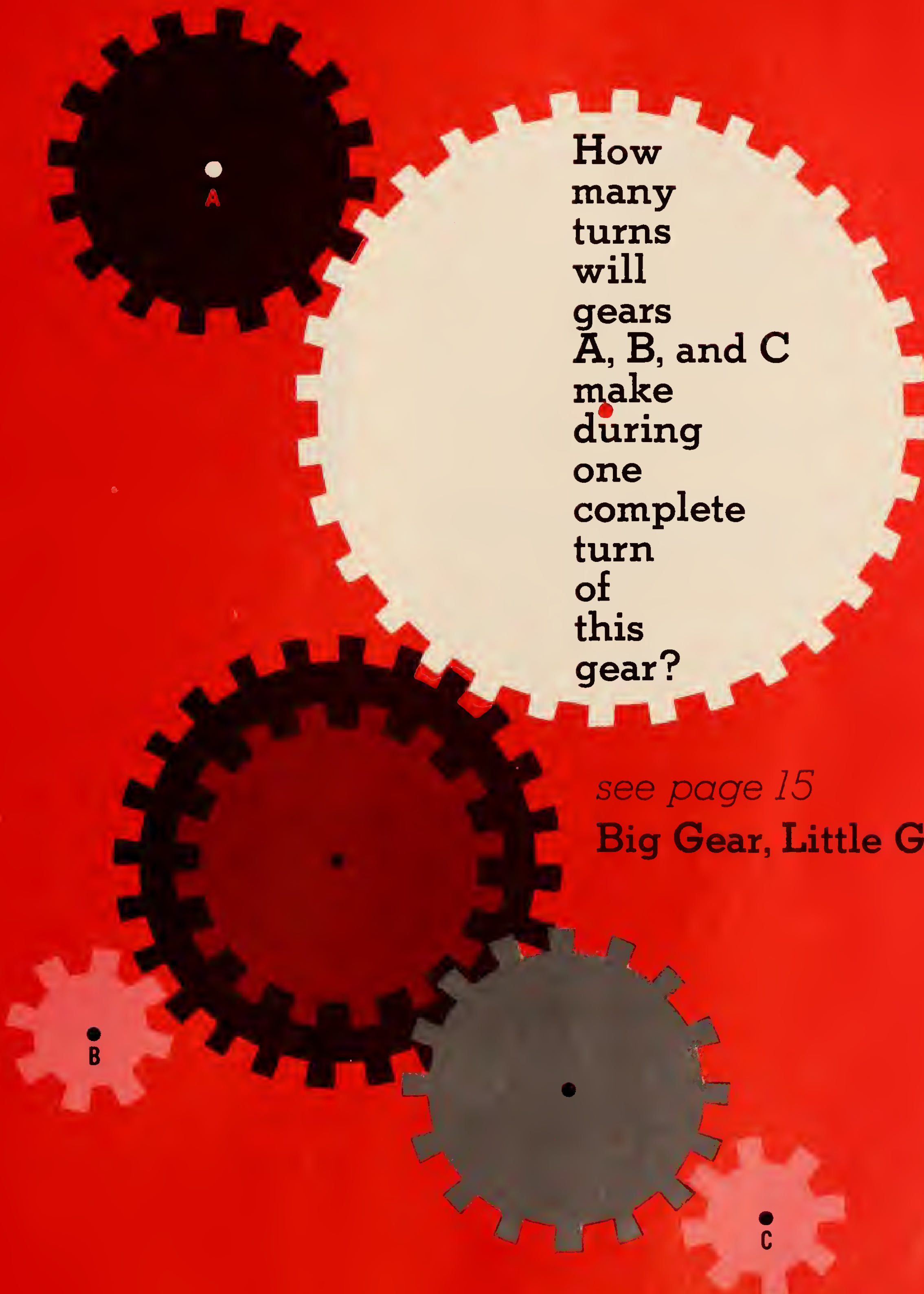
nature and science

VOL. 5 NO. 3 / OCTOBER 16, 1967

Are tigers as "cruel" and "mysterious" as most people think? A biologist who watched these large cats in the wild tells about—

THE WAYS OF TIGERS

see page 4



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Big Gear, Little Gears

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PICTURE CREDITS: Cover, pp. 5, 11-13, 15-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, Jet Propulsion Laboratory; pp. 4-7, photos from George B. Schaller; pp. 8-9, Phil Brodatz; p. 10, left photos from Bausch & Lomb Incorporated, right photo by David Webster; p. 14, National Aeronautics and Space Administration.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** R. J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Roma H. Gans; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen
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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, December through April; monthly September, November, May, and July (July special issue). Second Class postage paid at Garden City, N.Y. and at additional office.

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Spooning

**You may have read about how a tiny shovel helpe
scientists find out something about th
material on the moon's surface. Here
the story *behind* that stor**

■ The tiny shovel that scientists of the National Aeronau tics and Space Administration sent to the moon wi Surveyor III last April almost didn't get to go along. Th shovel was to "spoon the moon" for "soil" samples th could be examined by other instruments on board th spacecraft. But the instruments turned out to be too heav to take along. Without the instruments, there seemed to b no reason to send the shovel.

Why the Shovel Went Alone

Then Dr. Ronald F. Scott, Professor of Civil Enginee ing at the California Institute of Technology, suggeste that the shovel could get some useful information abo the moon's surface even without the heavy instrument With small instruments to measure how hard the shov had to be pushed and how fast it moved through the moo "soil," the spacecraft could send back information abo the soil's *texture,* or "feel."

Dr. Scott was told to go ahead with his plan, *if* he coul fit everything he needed into the spacecraft in the tim remaining before the launch. One television camera wa removed to make room for the shovel and instruments. Bu the instruments could not be fitted to the electrical an mechanical connections that had been made for the cam era. When launch time came, only the shovel itself ha been installed; there were no instruments to feed back in formation from the shovel.

Dr. Scott and the engineers working with him though they might be able to get some information from the fou electric motors that ran the shovel. Each motor could b made to run for either 2 seconds or 1/10 of a second at time. The amount of electricity the motor used woul depend on how hard it had to work. So, by measuring th electricity that went through the motors, the engineer could find out whether the soil was giving the shovel "hard time." But when Surveyor III landed on the moon the device that would have sent back signals from th motors was damaged.

There was still a way to get information about hov hard the motors were working. The scientists knew tha

he MOON

A television camera mounted on Surveyor III took this photo of the "moon spoon" at work on the moon's surface. The small black dots were added by the camera to help the scientists measure distances.

ie distance the shovel moved would depend on how long ach motor was running. It would also depend on how nuch of a "load" there was on the motor, and how hot the notor was.

From a room at the California Institute of Technology, Dr. Scott and Mr. Floyd Roberson, another engineer, could ontrol the motors. They could also estimate how hot the notors were, and they could tell from pictures sent by a elevision camera on Surveyor III how far the shovel had noved. Using all this information, they could figure out he load on the motor. This would tell them whether the hovel was working hard or easy to dig into the moon's urface.

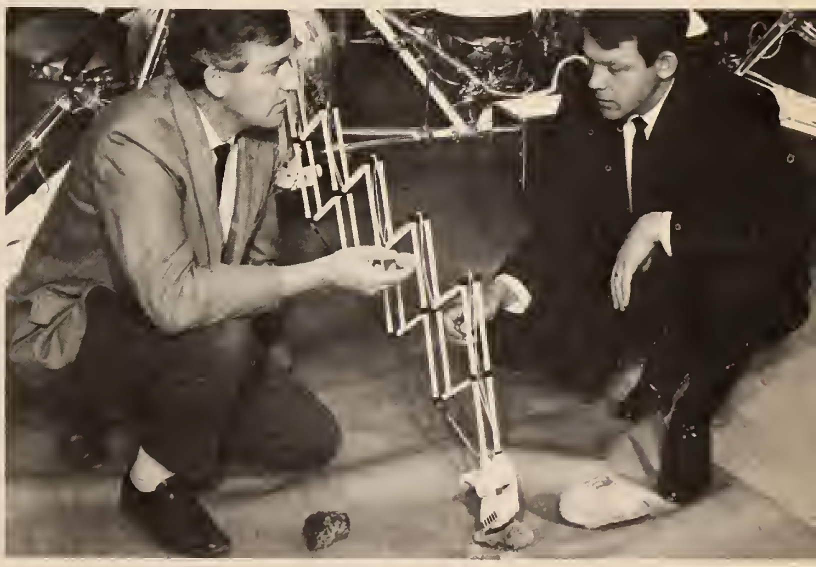
esting the Moon's Surface

The two scientists used the tiny shovel (you can get an lea of its size from the photo) to investigate an area only few feet wide and long. From the pictures taken by the elevision camera they could see that the moon soil wasn't oft enough to be squashed when the shovel was pushed r dropped onto it. Instead, the soil was pushed off to the sides, the way sand is pushed away when you force something into it.

Digging down into the surface, the scientists found that the soil a few inches down was harder than the surface soil—just as the sand at a beach gets harder as you dig deeper. The soil seemed to be fairly dry, because it didn't stick to the sides of the shovel very much, the way wet soil or wet sand would. In fact, the scientists decided that the moon soil might be something like fine, dry earth sand.

Dr. Scott and Mr. Roberson wanted to find out what rocks on the moon were like, but they weren't able to. One "rock" that they picked up was crushed when the shovel "door" closed on it, showing that it was really just a clump of soil. They did manage to pick up one rock, and tried to bring it closer to the camera for a better view. But when they opened the "door" of the shovel to get a look at the rock, it fell out and rolled out of the shovel's reach.

Even though the spacecraft had no instruments to measure the work done by the shovel, the scientists were still able to find out something about the moon's surface. Future Surveyor flights may be able to carry more equipment to the moon, to enable scientists to "dig deeper" into the subject ■



Dr. Scott (holding a rock) and Mr. Roberson tested their tiny shovel carefully before sending it to the moon. By radio signal, they could make four motors move the shovel back and forth, up and down, and side to side on its long folding arm, and also open or close its small "door."

Are tigers as "cruel and mysterious" as most people believe them to be? A biologist who watched these big cats for months in the forests of India tells what he found out about—

The Ways of Tigers

by George B. Schaller

■ Much has been written about tigers—how to hunt them, how large and fierce they are, and how a few tigers prey on humans. The tiger is the largest member of the cat family—bigger than a lion. A large male tiger weighs as much as 500 pounds and measures 10 feet from its nose to the tip of the tail. A tiger usually hunts alone and at night, and so is rarely seen. Because of this, and because of the stories about tigers, most people fear them and think tigers are cruel and mysterious beasts.

Yet we admire the tiger's beauty, its speed and strength, and the way it can *stalk,* or sneak up on, other animals to kill them. We even name athletic teams and military units "tigers," and say that a certain kind of gasoline "puts a tiger in the tank" of an automobile.

The trouble is that most people who write about tigers are hunters, not scientists. They are more interested in how to shoot a tiger than in how it lives. With all that has been written about tigers, we really know very little about them.

How To Be a Tiger-Watcher

I had a chance to learn something about these cats when I went to Kanha National Park in India *(see map on next page)* in 1964 to study the wildlife there. I was interested in tigers because they were the most important killers of deer and other hoofed animals in the park. I wanted to study how tigers affected the numbers of the other animals.

This article was adapted from The Deer and the Tiger, a Study of Wildlife in India, *by George B. Schaller, published by The University of Chicago Press, Chicago, Illinois. Copyright © 1966 by The University of Chicago. Printed by permission of the publisher.*

Few people have seen a tiger stalk, attack, and kill an animal, because tigers are shy and, whenever possible, they move through dense thickets. To observe tigers, I traveled both day and night through the forests and meadows, or waited at places where I expected them to pass. The best way to watch a tiger is at its kill, for if the prey is large, the tiger may remain beside its meat supply for several days until the last scrap is eaten.

I watched the tigers from *blinds,* or hiding places, such as a small wooden shelter, a flimsy screen of grass and leaves, and sometimes my car. One tigress with cubs grew so used to my being near her kills that they sometimes just retreated about 100 feet while I walked back and forth to the blind. The tigress became so bold that she once returned to her kill and dragged it away while I stood 45 feet from it. Most tigers in this park had not been shot at or harmed by man for many years, so several of them easily became used to me.

To find out exactly what tigers in Kanha Park ate, I collected and studied the animal remains in 335 tiger *feces,* or droppings. More than half of these droppings contained the hair and bones of chital deer, the most common deer in the park. The remains of other species of deer, wild and domestic cattle, pigs, and monkeys were in most of the rest of the droppings. But a tiger eats whatever animals it can catch including birds, lizards, frogs, snakes, and locusts. It even eats grass and earth. We don't know why.

Today, because most wildlife in India has been killed off by man, tigers in most forests kill tame animals—mostly cattle and buffalo. Horses, donkeys, camels, goats, and dogs are also killed and eaten. Twice a tiger broke into our shed at Kanha, once taking away a sheep, another time several chickens. Tigers also will eat the rotting flesh of animals that have died from disease, and we once saw a tigress steal a deer carcass from a leopard.

Kanha National Park, about 97 square miles, is in the center of India. Tigers and other animals there are protected from hunters.

How a Tiger Hunts

Tigers hunt usually at night, walking through their range, or hunting area, searching for prey. At Kanha I saw them often on forest roads where travel was easier, quieter, and faster than in the high grass or dead leaves of the forest. The bottoms of the many dry stream beds were also much used by tigers for traveling, probably because the banks provided hiding places and there was a good chance of meeting some victim at a waterhole. During a night of active but unsuccessful hunting the tiger may travel 10 to 20 miles, and sometimes 30 miles.

The tiger spots its prey mainly by sight and—at night—also by hearing. I saw no signs that tigers use their noses to locate live prey.

The tiger has to approach to within 30 to 80 feet of a swift-footed animal before it can catch it with a surprise final rush. But if the prey is already alert, even an attack from 40 feet may be too far, because deer and other animals can run faster than a tiger can. Animals on a short-grass meadow where tigers cannot hide very well seem to know that they are not in much danger and they will even walk to within 120 feet of the cat, seemingly out of curiosity. A deer's alarm bark in the direction of a hidden tiger seems to show the cat that more stalking is useless. The tiger then usually stands up and walks away.

Although tigers can climb, I never saw them chase monkeys and other prey by climbing trees. Sometimes a

(Continued on the next page)

Gaur *(left photo)* often become food for tigers, but their size makes them dangerous to attack. Below, a mother sambar deer's raised tail warns of danger. Alerted, these fast animals can escape a tiger.

tiger hides along a game trail or at a waterhole—waiting for an animal to pass.

Many people think a tiger can catch a meal whenever it wants to, but the tigers at Kanha had to work hard for their food. I often saw tigers whose bellies were very lean, showing that they had not eaten a good meal for at least 3 days. For every hoofed animal a tiger stalks and catches, probably about 20 get away. When it attacks a large animal, the tiger has to be careful not to get hurt. Even tame buffalo can be dangerous fighters, and they sometimes charge tigers and gore them with their horns.

After the prey has been killed, the tiger usually drags or carries it to a hiding place where there is shade and, if possible, some water, and where the vultures cannot see it. An adult tiger is extremely strong. With its jaws it can drag a 400-pound animal that three men would have trouble moving. By weighing carcasses before and after the tiger had eaten from them, I found that it can eat 40 to 60 pounds of meat during a night. The amount a tiger eats in one meal may total as much as one-fifth of its body weight. Then, of course, it does not have to eat again for several days.

Tigers Are Loners

A large and powerful male tiger usually will not allow other males to live within his range. He will share it only with one or more females and their cubs. But some males will share ranges, and some are nomads, moving from forest to forest and never settling down in one spot.

Even though several tigers may share a range, they are rarely all together. Usually they hunt alone and rest alone. Only a tigress and her cubs travel together. This does not mean that the tiger is unsociable. Tigers may meet for a short time on the trail, or, if there is a lot of meat, they may share it. Then they go their way alone.

Dr. Schaller is now on Africa's Serengeti Plain in Tanzania, studying how lions hunt. He has also investigated the ways of mountain gorillas in the Congo.

Yet even when alone, the tigers keep track of each other's doings. One way a tiger shows its presence on its range is by spreading scent from glands under its tail onto plants as it walks along. Besides showing other tigers whose range it is, the scent trail may also show how long ago the tiger passed, and, in the case of a tigress, whether or not she is looking for a mate. Tigers also roar a loud *aa-uuu* that at night can be heard two miles in the stillness of the forest. Another tiger may answer, and the two roar and roar again until they find each other.

A tigress with four cubs lived in my study area. When the cubs were small, the tigress left them hidden while she went hunting. After she killed something, she led them to the carcass, where they stayed until the meat was eaten. Then she went hunting once more. The cubs grew rapidly. When they were a year old, they had big appetites, and

Dr. Schaller watched this tigress and her nearly-grown cubs attack and kill a buffalo shortly before the family broke up. **Tigers usually attack such large animals from the rear so they can't charge and gore the tiger with their horns.**

the tigress had trouble catching enough food for them.

At that time the male cub sometimes went hunting on his own. When I last saw the family, the cubs were 16 months old and almost as large as their mother. Either the tigress or the male cub was away most of the time, hunting alone. Soon after that the cubs probably stopped needing their mother at all.

Although the cubs' need for more food seemed to start the breakup of the family, I believe that there was a more basic reason—a liking for being alone. This liking may be an *adaptation*—a trait developed over thousands of years that helps the species to survive. Much of the tiger's food is small mammals such as pigs and deer. Such animals are often hard to find in the forest. If an animal like that were shared with several adult tigers, it would not be enough meat for them all. By living alone, a tiger can probably get more food for itself than it could get living in a group.

Are Tigers Dangerous to Man?

Although humans are the easiest animal to catch in all parts of the tiger's range, they are rarely eaten. Scientists don't know why. The few tigers that eat humans probably began to do so for one of several reasons: 1) They could not catch their usual prey because something had hurt them, such as a gunshot wound or porcupine quills stuck in their paws and face; 2) there was no other food in the area; 3) they copied the habit from their mother; 4) they killed a man by accident, then tasted the meat and liked it; or 5) they first ate unburied human corpses, and later switched to living human prey.

Fear caused by the few man-eaters has made many people believe that tigers are vicious animals that attack without reason. But persons who are familiar with tigers all agree that tigers are generally shy and avoid humans.

One evening I sat with my back to a rock watching the remains of a cow which a tiger had killed the night before in the valley 200 feet below. When a leaf rustled, I quietly raised myself and looked over the rock. A tigress stood 10 feet away looking at me. She left at a fast walk.

Another time I silently approached a large boulder in a bamboo grove. A large female tiger cub, 14 months old, looked over the edge of the rock. Our faces were three to four feet apart. The tiger roared, and I leaped aside and backed away quickly and quietly for 100 feet. It jumped off the rock and bounded toward me—out of curiosity, I believe—and I climbed 15 feet up a tree. The tiger lay down 75 feet away, watching.

Ten minutes later, the large male cub arrived and rested 60 feet away without noticing me. After a few minutes I said "Hello there," in the tone I would use in talking to a person. The male cub looked slowly around. When his eyes focused on me, he growled once and ran away. The female cub was joined by her two sisters, and all three of them watched me. After half an hour in the tree, I shouted at the tigers and they scampered off.

As these two meetings show, tigers are not likely to attack other animals except for food. All they want is to lead an undisturbed life in their forest home ■

A tiger usually stays near a large kill until all of the meat is eaten, even if this takes several days.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo shows the lighted filament of a light bulb.

What would happen if? Track 'D" would make the marble roll fastest.

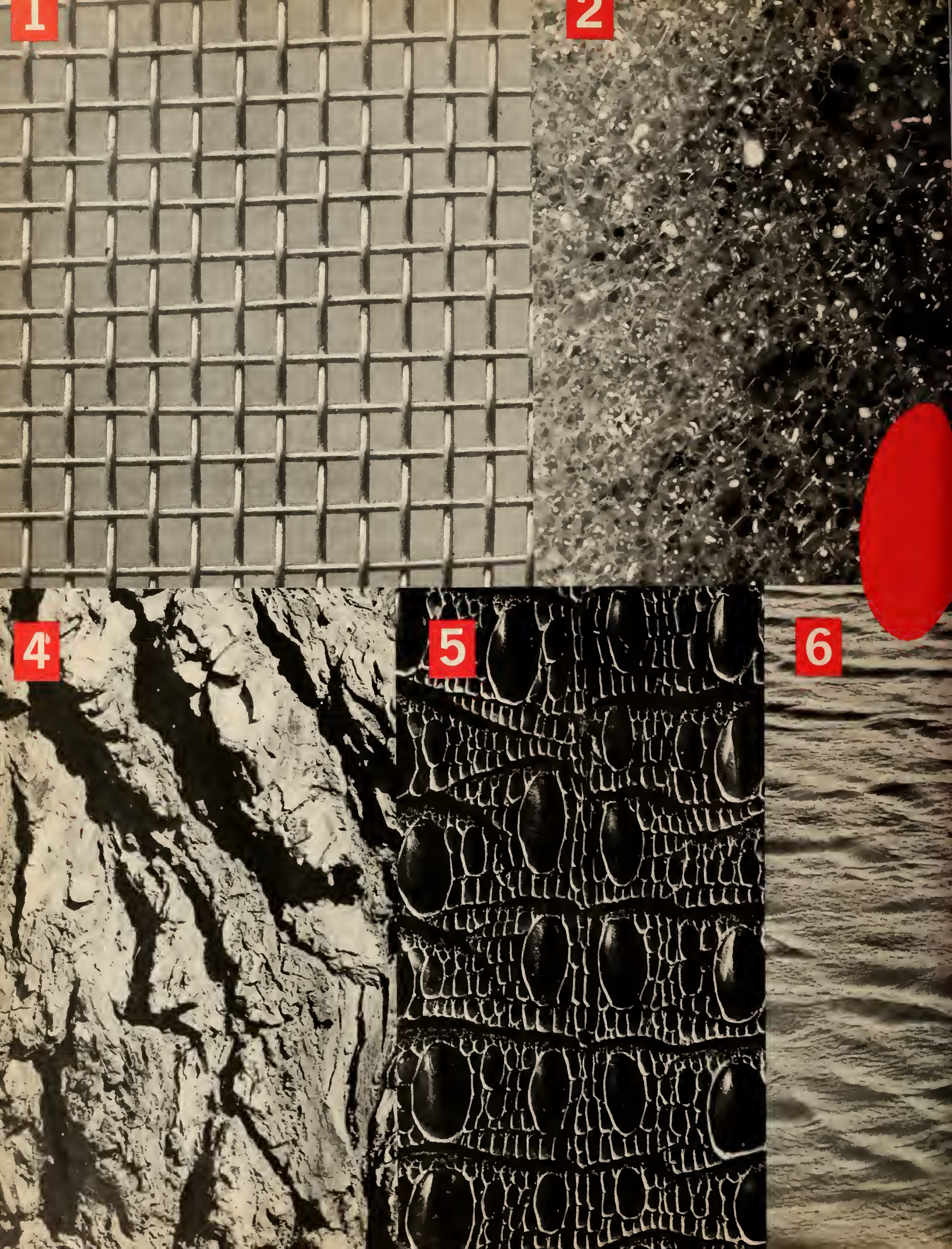
Can you do it? To blow up a balloon in a bottle, first heat the air inside the bottle by running hot water over it. Quickly insert the balloon and then cool the air in the bottle by placing it in the freezer. Will the balloon get smaller if the bottle is heated again?

Fun with numbers and shapes: Here are two more ways for arranging the nine digits to equal 100.

$$\begin{array}{r} 56 \\ 8 \\ 4 \\ +3 \\ \hline 71 \\ +29 \\ \hline 100 \end{array} \qquad \begin{array}{r} 95\frac{1}{2} \\ +4\frac{38}{76} \\ \hline 100 \end{array}$$

For science experts only: When wood burns, moisture and air inside the wood expand. After the pressure builds up, the gas breaks open the wood fibers with a loud snap. Does pop corn "pop" for the same reason?

Just for fun: If a balloon is blown up with Alka-Seltzer tablets, the balloon will contain a mixture of air and carbon dioxide.


1
2
4
5
6

3

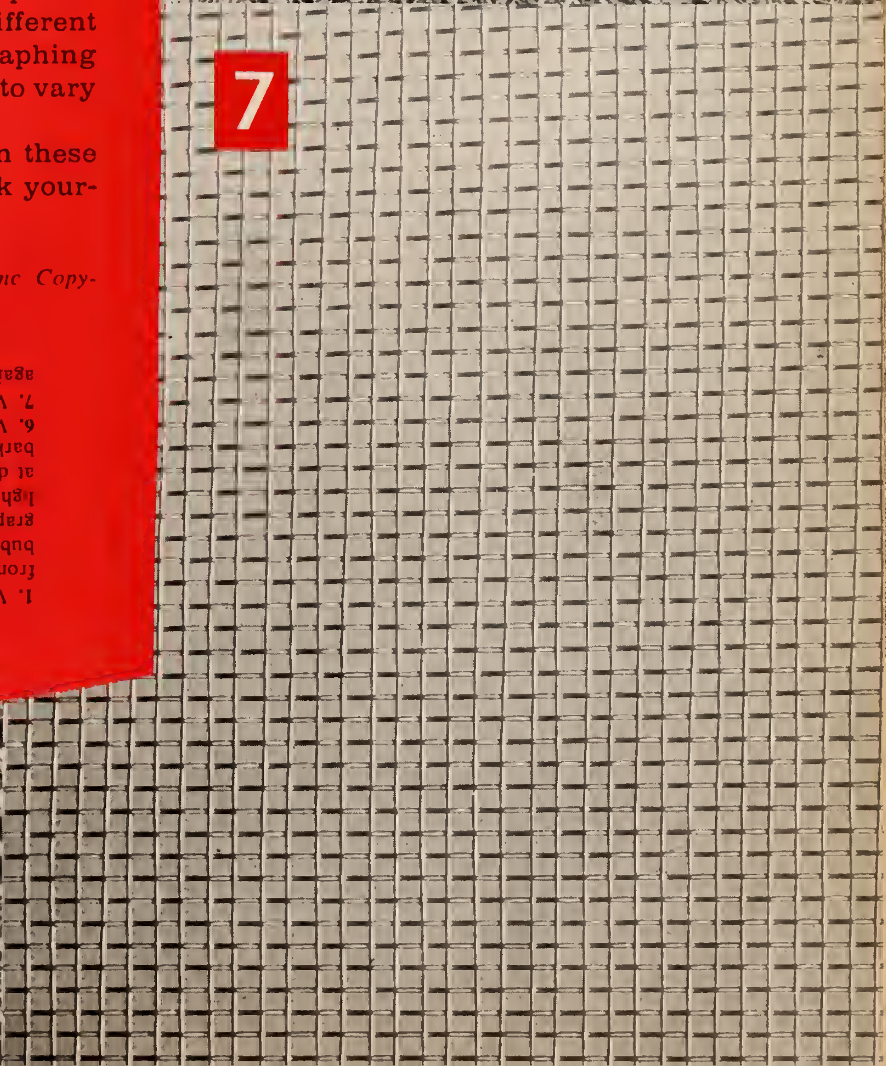
Puzzling Patterns

■ A few years ago, photographer Phil Brodatz began taking pictures of patterns and textures that caught his eye. He took pictures of tree bark, cloth, pebbles, wire screening. People who saw the photos were often surprised to learn the identity of the pictures. They suggested other subjects "Try water." "What would bricks look like?" "Try wood grains."

Mr. Brodatz is still finding new subjects to photograph. Even if you have a simple camera, you can also take pictures of unusual textures and patterns that you see. For closeup photographs, you will need a portrait lens which fits on the front of your normal lens. Like Mr. Brodatz, you may want to experiment with lighting on your subject. Something photographed in the morning may look completely different when photographed at noon. If you are photographing an object indoors, you can move lamps around to vary the lighting on it.

Seven of Mr. Brodatz's photos are shown on these pages. Try to guess what they are. Then check yourself by reading the caption below ■

1. Woven aluminum wire, magnified eight times, with light coming from the upper left. Compare this with number seven. 2. Soap bubbles. The light was shining down on the bubbles. Try photographing bubbles by putting them on a piece of glass and shining light *through* them. 3. Lawn grass. Photograph part of a lawn at different times of day to see how the texture changes. 4. Tree bark. Which side was the light coming from? 5. Crocodile skin. 6. Water. How many other patterns can you find in water? 7. Woven aluminum wire, magnified two times, and photographed against white paper. Compare this with number one.



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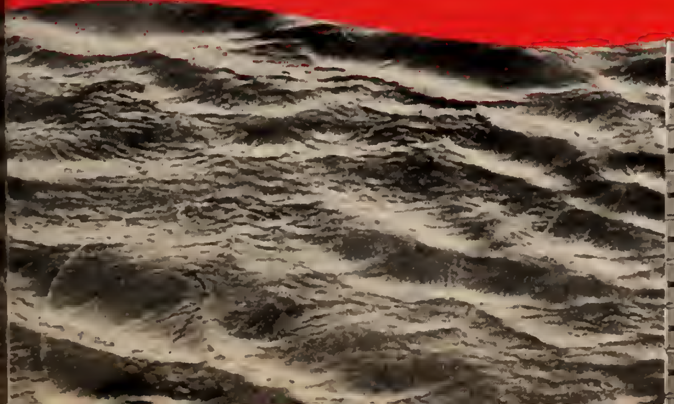
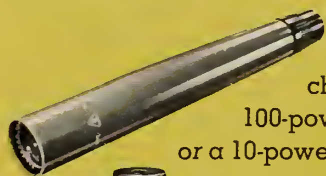
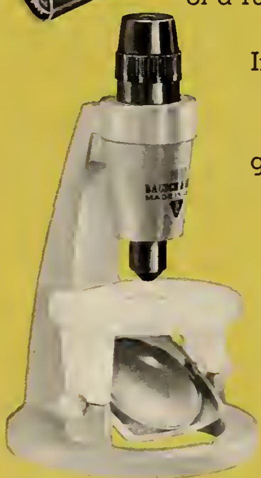


Brain-Boosters CONTEST

You may win a telescope or microscope





First prize is your choice of a 10-power or a 100-power student microscope, or a 10-power telescope *(see photos)*, courtesy of Bausch & Lomb, Incorporated. A first prize will be awarded to the winner in each of these five groups: 4th grade and below; 5th grade; 6th grade; 7th grade and above; teachers and other adults. Three runners-up in each group will receive copies of *Crossroad Puzzlers*, a new brain-boosting book by Mr. Brain-Booster himself.

To enter the contest, send the answers to as many of these brain-boosters as you can to:

Mr. Brain-Booster
Bedford Lane
RFD #2, Lincoln, Mass. 01773

Answers must be mailed by October 30, 1967. *Be sure to mention your address, age, and grade in school, or whether you are an adult.* We will publish the names of the winners and some of their answers in the February 19, 1968 issue of *Nature and Science*.

Good Luck!

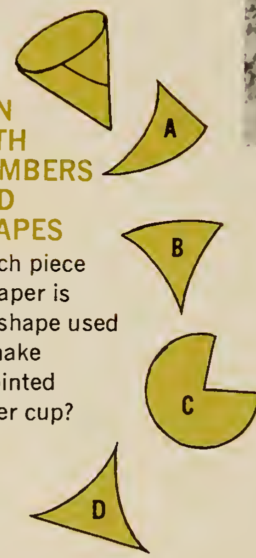
A challenge to all readers of Nature and Science

MYSTERY PHOTO

What made this strange track in the sand?

FUN WITH NUMBERS AND SHAPES

Which piece of paper is the shape used to make a pointed paper cup?

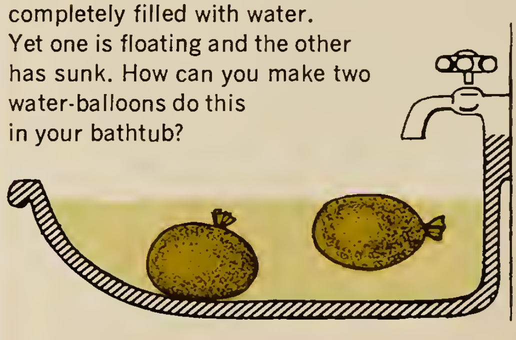


WHAT WILL HAPPEN IF...

...you put ice cubes on some dirt, on a rock, on the top of a car, and on the street at the same time? In what order will the cubes melt? Why don't they all melt at the same time?

CAN YOU DO IT?

Both balloons shown in the drawing are completely filled with water. Yet one is floating and the other has sunk. How can you make two water-balloons do this in your bathtub?



FOR SCIENCE EXPERTS ONLY

Why does catchup come out faster when the bottle is held at a slant than if the bottle is straight up and down?

Submitted by Melody Stone, Edmonds, Washington

Answers to Brain-Boosters in the last issue appear on page 7 of this issue.

SLEEPY SEEDS

by Richard M. Klein

The growth of seeds is affected by many things. Here are some ways for you to investigate how one condition—light—can affect the sprouting of a seed.

■ Did you ever plant some seeds and then wait . . . and wait . . . and wait for them to sprout, until you finally gave up? Perhaps you finally decided that they were "dead," or just "no good." It's very possible that your seeds weren't "dead" at all, but were just sleeping!

What makes a seed "sleep"? How can you make it grow? In this SCIENCE WORKSHOP you can investigate one of the reasons why good seeds may fail to sprout, or *germinate*.

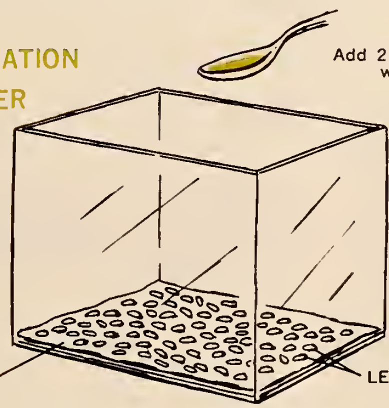
One Cause of "Sleepiness"

Plant scientists have spent many years studying how plants grow, and why they will not grow under certain conditions. When the kind or amount of light keeps a seed from growing, the effect is called *photo-dormancy*. To be sure it is really *photo*-dormancy that you are studying, you can plant the same kind of seeds under the same conditions, then give them varying amounts or kinds of light. If one batch of seeds grows better than another batch, then you can be quite sure that it was the difference in the amount or kind of light that caused the difference in growth.

To begin, you'll need a half-dozen clear plastic sandwich boxes (available from any housewares or dime store) and a supply of large white desk blotters. Cut up the blotters so that each piece will just fit into the bottom of a box. Then sprinkle about 50 to 75 seeds onto each of the blotters *(see diagram)*.

The kind of seeds that you use is important. One of the best seeds for you to use in this experiment is lettuce, especially the "Grand Rapids" variety (available from the Harris Seed Company, Rochester, New York 14624). It's best to get your seeds from a seed company, rather than a grocery or hardware store, because the seed company's seeds are usually fresher. You can order your seeds from the company by mail. But be sure that you get all your seeds from the same seed company at the same time, and that they're all the same variety.

After you've put in the seeds, add just two tablespoons of water to each box. (That way you'll know that your results won't be affected by the amount of water available.) Then put the covers back on the boxes, and wrap each box separately in a double thickness of aluminum foil. Now your sandwich boxes have been converted to *seed germination chambers*. Number them 1 through 6 (with a crayon or paper label), and set them aside in a dark place for one hour to allow the seeds to take up water. The room temperature should be about 65° to 70° F.



When the hour is up, unwrap chamber 2 and expose it for 15 seconds to the light of a 40-watt incandescent bulb placed three feet away. Then rewrap 2. Next expose the other chambers to the same light as follows: chamber 3 for 30 seconds, chamber 4 for 1 minute, chamber 5 for 5 minutes. Unwrap chamber 6 and leave it exposed to the light overnight. Keep chamber 1 covered throughout the experiment. These two chambers are "controls" on your investigation. You can compare the growth of the seeds in these two chambers with the seeds in the other four chambers.

At the end of 24 hours, unwrap all the chambers (chamber 6 is already unwrapped), and count separately for

(Continued on the next page)

Dr. Richard M. Klein is Professor of Botany at the University of Vermont, in Burlington.

each chamber the *total* number of seeds, and the number of *germinated* seeds. You can count a seed as germinated if you can see the tip of the root sticking out through the seed coat *(see diagram)*. Since you will have different numbers of seeds in each chamber, just comparing the numbers of germinated seeds won't give you a true idea of the effects of the light. So, for each chamber you will have to figure out the *percentage* of the seeds in that chamber that have germinated.

To do this, divide the number of germinated seeds in the chamber by the total number of seeds in the chamber, then multiply the result by 100. For example, if 21 of the 57 seeds in a chamber germinated, you could figure the germination percentage like this: $\frac{21}{57} \times 100 = 36.84\%$. (You can round off to the nearest whole number, making the percentage in this case 37%.) This percentage tells you what *part* of the total number of seeds in a chamber germinated. By comparing the germination percentages, you can compare the results in the different chambers even though they do not contain exactly the same numbers of seeds. Figure out the germination percentage for each chamber. Put your results in Table 1.

How is the germination percentage affected by longer or shorter exposure to light? Is there a great difference in germination percentage between chambers 5 and 6? Do you think there might be a point at which the seeds have *just enough* light, and more (or less) light won't increase the germination percentage? How could you find out?

Changing Light Distance

How do you suppose the results of your experiment would be affected if you exposed the seeds to light of a different strength, or *intensity*? You can find out by exposing the seeds to the same bulb at different distances. Try the experiment again with fresh seeds in their chambers, using the lamp-to-chamber distances given in Table 2. This time, however, expose each chamber to the light for just one minute. Remember also not to expose chamber 1, your control.

How do the differences in light intensity affect germination? Do the figures you put in table 2 show bigger differences in the germination percentage than you expected? Remember that when you move the lamp twice as far from the seeds you get *one-fourth* as much light. When you move it *half* the original distance to the seeds you get *four times* as much light.

TABLE 1

SEED GROWTH: VARYING DURATION OF LIGHT
(Distance: 3 feet; Light Color: White)

GERMINATION CHAMBER	LIGHT DURATION (minutes)	GERMINATION PERCENTAGE
1	0	
2	¼	
3	½	
4	1	
5	5	
6	CONSTANT	

TABLE 2

SEED GROWTH: VARYING DISTANCE OF LIGHT
(Duration: 1 minute; Light Color: White)

GERMINATION CHAMBER	LIGHT DISTANCE (feet)	GERMINATION PERCENTAGE
1	(NO LIGHT)	
2	6	
3	4	
4	2	
5	1	
6	½	

As you know, "white" light is really made up of all the colors of the rainbow. Do you suppose that some of the colors in white light affect germination more than others?

Changing Light Color

To find out, first set up five different germination chambers. Keep one chamber dark and one exposed to white light, as before, for controls. Then expose each of three chambers to a different colored light—two minutes each at a distance of two feet from the bulb.

For blue light, cover a 60-watt bulb with two thicknesses of dark blue cellophane. (You can get colored cellophane in a stationery or art supply store.) For green light, cover a 60-watt bulb with one thickness of dark green and one of dark amber (not yellow) cellophane. For a red light, cover a 40-watt bulb with one thickness of dark red and one of dark amber cellophane. For the white light, use a 20 or 25-watt bulb. The different bulbs are used to make the intensity of light about the same in spite of the cellophane filters. In all cases, use *standard,* not "long-life" bulbs, which don't give as much light.

After exposing the seeds to the colored light, rewrap the containers and leave them for 24 hours. Then see how many seeds germinated. Enter your results in Table 3. Which color seems to have the least favorable effect on germination? Do you think you could increase its effect by increasing the time or intensity of exposure? ■

TABLE 3

SEED GROWTH: VARYING COLOR OF LIGHT

(Light Duration: 2 minutes; Distance: 2 feet)

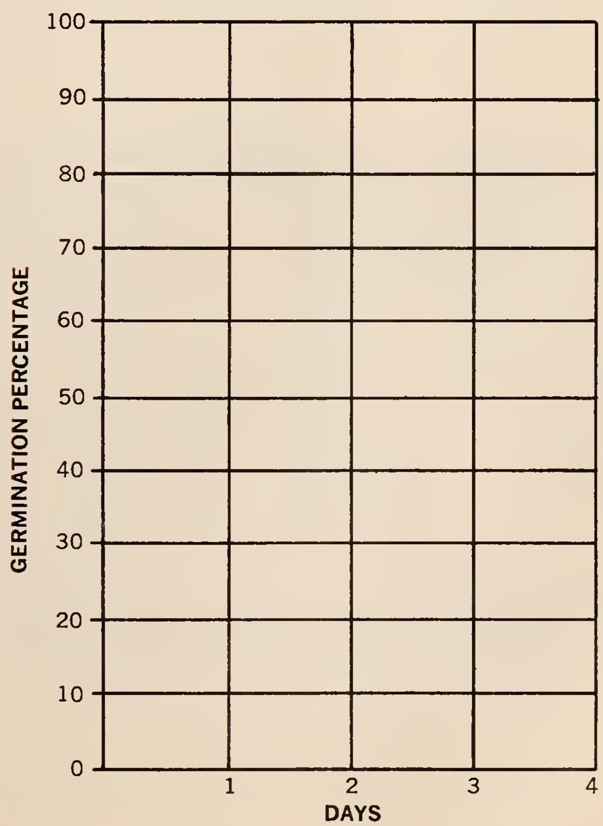
GERMINATION CHAMBER	LIGHT COLOR	GERMINATION PERCENTAGE
1	(NO LIGHT)	
2	WHITE	
3	BLUE	
4	GREEN	
5	RED	

INVESTIGATIONS WITH OTHER SEEDS

Although lettuce is a particularly good seed to use for these experiments, most other seeds will give similar results. Some seeds, however, such as the California poppy *(Escholschia)* and love-in-a-mist *(Nigella),* are actually made *dormant* by light. You can study the effects of light on the germination of these seeds just as you did for lettuce, but allow two days for these seeds to germinate.

Certain seeds, such as radish, will germinate in either light or darkness, but do better in one than the other. To find out which condition is better for the seeds, put four germination chambers of radish in the dark and four in the light. Then, each day, figure out the germination percentage of one dark chamber and one light chamber. If you plot your findings on a graph like the one shown here, you will have an easy way of comparing the results. (You might use a pencil to plot the daily findings for the dark chambers and a pen to plot the findings for the lighted chambers.)

EFFECT OF LIGHT ON RADISH SEEDS



WHAT'S NEW

The earliest known reptile was a foot long and looked somewhat like a lizard. It lived 300 million years ago in Nova Scotia, which was then a tropical swamp. That was 100 million years before the first dinosaurs roamed the earth, and about 25 million years before other known reptiles lived.

This discovery was made through the teamwork of Dr. Donald Baird of Princeton University, in New Jersey, and Dr. Robert L. Carroll of McGill University, in Montreal, Canada. Both are paleontologists—scientists who study fossils for clues to prehistoric life.

Dr. Baird and others found the front half of the reptile's skeleton embedded in rock on a Nova Scotia beach in 1959. Dr. Baird identified the remains as those of a reptile. Dr. Carroll, an expert on early reptiles, studied the fossils and decided that they are the remains of the earliest reptile so far discovered.

Large poisonous toads from Central and South America are hopping around southern Florida these days. No one knows how they got there, but they are increasing rapidly. When this marine toad is surprised or attacked, poison something like that of a cobra oozes out of small holes in bumps on the toad's back.

The poison can kill a dog, cat, or other small animal that bites the toad, and it can also harm humans. In Miami, a girl tried to wipe the poison from the teeth of her dog after it had bitten a marine toad. She scratched her thumb on the teeth, and the poison made her sick for a month. The dog died shortly after biting the toad.

Why are the cities warmer than the countryside around them? New studies suggest several reasons, reports Dr. William P. Lowry of Oregon State University in *Scientific American*.

For one thing, cities store heat. Building and road materials such as concrete soak up a lot of heat from the sun and warm the air around them. Tall buildings block the wind, so it can't carry off much heat. Polluted air overhead holds down the heat like a blanket. If rain or snow remained on the ground, it could cool the city as it evaporated, but most rain flows down the drains and snow is cleared off the streets.

Cities produce heat, too—from furnaces in winter and from fuel-burning factories and motor vehicles all year around. Even air conditioners warm the outside air by pumping heat out of buildings. No wonder cities are 5 to 15 degrees warmer than the countryside. This is hard to bear in summer, says Dr. Lowry, but it does help bring city people milder winters, lower heating bills, and a longer gardening season.

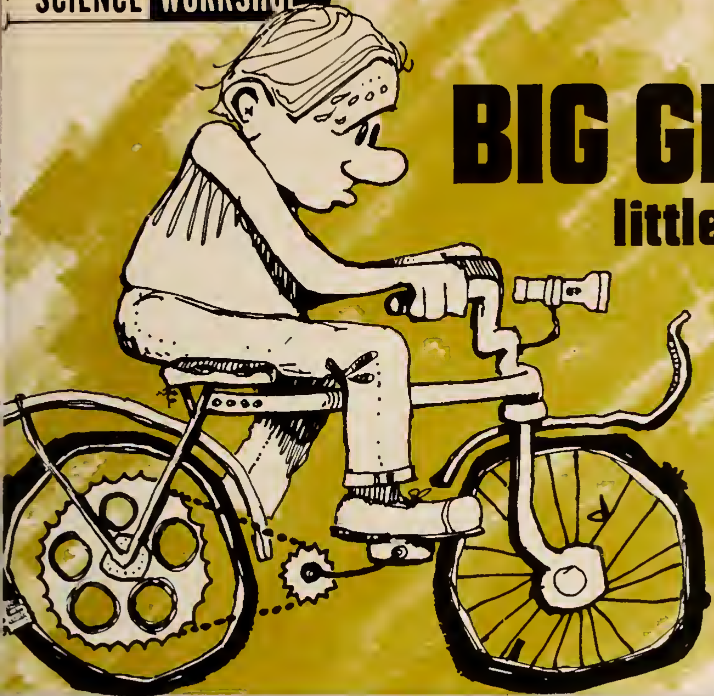
The first American city to get its fresh water from the sea is Key West, near the tip of the Florida keys. A large desalting plant opened there recently. It works by *distillation*. When the sea water is boiled, water bubbles out as steam, leaving the salt behind. The steam is then condensed, or changed back into water which goes into another container. The plant can produce 2½ million gallons of pure water a day—enough for the city's 50,000 people.

Fresh water has always been scarce around Key West. The city used to get fresh water through a pipe from the mainland, more than a hundred miles away. But hurricanes sometimes damaged the pipeline and cut off the supply. Now the city has the whole ocean as its reservoir.

Covering teeth with a thin coat of plastic can prevent decay. This was shown in a recent study made by Dr. Eriberto I. Cueto and Dr. Michael G. Buonocore of the Eastman Dental Dispensary in Rochester, New York. They covered the biting surfaces of 600 healthy teeth with a clear plastic coating. After six months, they repeated the simple, painless process on the same teeth. Another group of 600 healthy teeth were left uncoated, to serve as "controls."

A year after the experiment started, the plastic-coated teeth had 86 per cent fewer cavities than the uncoated teeth. What's more, these few cavities had formed only where the plastic coating had broken. Tooth decay is caused by bacteria acting on food that has collected in the grooves of the teeth. The plastic coating prevents decay by keeping food out of the grooves.

Astronauts of the 1970's may ride through space on mechanical "horses" like this one. Called a "maneuvering work platform," it would be launched from a parent spacecraft under its own power and would be used for jobs such as repairing satellites and building space stations. The "head" and "front legs" end in grippers that can hold the platform in place for working. The "tail" is a radio antenna.



BIG GEAR, little gears

by R. J. Lefkowitz

By testing a "three-speed" bicycle, you can find out how different combinations of gears make it easy to start the bike, speed it up, and pedal up hills or on long trips.

■ If you have a "three-speed" bicycle, you've probably realized by now that it doesn't have three "speeds" at all. After all, you can change the speed of your bike by just pedalling faster or slower—no matter which "speed" it's set for. What it really has is three different *gear combinations* that make it easier for you to start up, pedal up a hill, or go fast on level ground.

You know that pushing the pedals of your bike turns the large gear wheel, or *front sprocket*. The moving teeth of the front sprocket pull the endless *drive chain*, which turns a smaller *rear sprocket*. And the rear sprocket turns the hub of the rear, or *drive*, wheel, pushing the bike along.

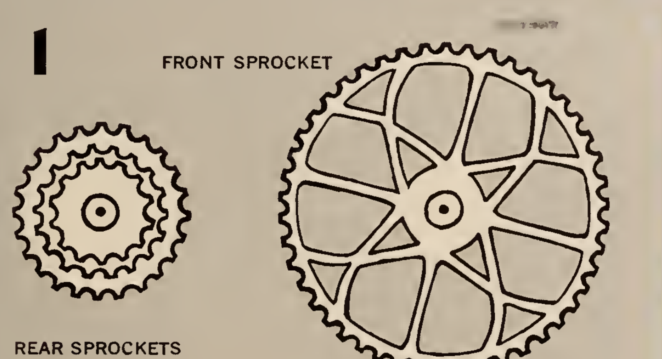
A "three-speed" bike has three rear sprockets of different sizes *(see Diagram 1)*. If you can see all three of these rear sprockets on your bike, you can also see the drive chain move from one rear sprocket to another when you press the lever to shift gears.

You probably know also that each time you pedal the front sprocket around once, it moves the rear sprocket and the drive wheel around farther than one full turn. How many times the rear sprocket goes around depends on the *gear ratio*—a figure you can find by dividing the number of teeth on the front sprocket by the number of teeth on the rear sprocket. For example, if the front sprocket has 45 teeth and the rear sprocket 18, the gear ratio is $45 \div 18 = 2.5$. This means that the rear sprocket goes around 2½ times for each full turn of the front sprocket. (How far will that move your bike?)

If you can see the rear sprockets of your bike, try to figure out the gear ratio when each rear sprocket is being turned by the front sprocket. If some of the rear gears are enclosed in the wheel hub *(see Diagram 2)*, you might figure the gear ratios for the sprockets shown in Diagram 1. Which size rear sprocket gives the highest gear ratio?

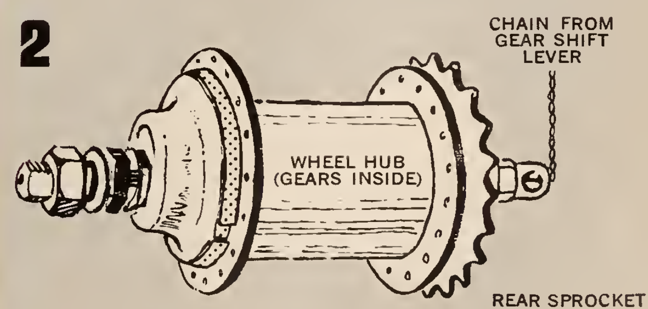
(Continued on the next page)

1



Can you figure out what the gear ratio is when each of these rear sprockets is being turned by the drive chain and front sprocket? Which is the high gear and which is the low gear?

2



Some "three-speed" bikes have only one rear sprocket. The other gears are inside the *wheel hub*. Shifting gears pulls a different set of gears together inside the hub. (If you have a bike like this, don't try to open the hub—you may have trouble getting it back together again.)

PROJECT

Can you imagine a bicycle that would have a gear ratio of less than 1? Can you draw a sketch of how its sprockets might look? When and where would such a bike be useful?

The higher the gear ratio, the farther the bike travels during a single turn of the pedals. This means that when you are using the "high" gear (number 3) you can pedal a mile faster, and with fewer turns of the pedals, than you could in "normal" (number 2) or in "low" (number 1) gear. It doesn't mean that a high gear ratio gives you "something for nothing," though. Moving your bike and body a given distance over level ground will take the same amount of work no matter which gear you are using. So while you can cover the distance with fewer turns of the pedals in high gear, you will have to pedal harder than you would in low gear.

The lower the gear ratio, the shorter the distance the bike travels with each pedal turn, so it takes less push to turn the pedals. You can feel this difference by riding the bike at the same speed in high gear, then in normal gear, and then in low.

A low gear ratio is especially helpful when you are starting from a dead stop. As you probably know, it takes a certain amount of push just to get you and your bike moving at all; the heavier you and the bike are, the more push is needed. When your bike is in low gear, more of your first push on the pedals goes into getting you started, and less of the push into covering much distance. It also takes some extra push to increase your speed, so it is easier to speed up in low or normal gear than in high gear.

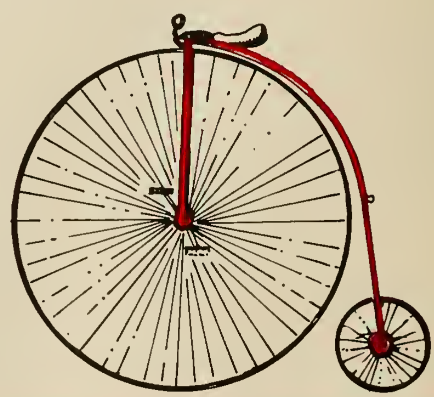
Once you have gotten up speed, riding a long distance is easier in high gear, because it takes fewer turns of the pedals to cover the distance. If you have to ride up a hill, though, you will probably shift into normal, or even low, gear. Can you explain why?

Testing Your Use of Gears

Here are some ways to find out how the different gear ratios on your bike affect your bicycling. All you need is a safe street, a friend with a bike like yours, a watch with a second hand, and a pair of roller skates.

- Mark off a distance of 20 feet on the pavement. Have your friend time you as you go from a dead stop to a distance of 20 feet, first in low gear, then in high. Which way was faster?
- Have your friend time you from a stop to the length of a whole block, first in low gear, then in high, then using all three gears in order. Which way was fastest? Which was second best? Can you explain why?
- Start your bicycles from rest, with your own in high gear and your friend's in low gear. Keep pace with each other. Which of you seems to be doing more work at low speed? Who seems to be working harder at higher speed? Who will seem to work harder if you come to a hill?
- The "pulling power" that a gear ratio gives you is called *traction*. Have your friend hold onto the rear of your bicycle while wearing roller skates. Does high gear give you enough traction to start your bike? Can you do it in middle gear? Which gear makes it easiest? ■

The first bicycles with pedals to turn the wheels had the pedals attached directly to the front wheel, as they are on a tricycle (see *diagram*). Do you think that such a bike was easier or harder to start than a modern bike? Could it go as fast as a modern bike?



Many automobiles today have gears that shift themselves automatically, so people don't always think about them. But there are still many cars with hand-operated gearshifts, and even automatic gearshifts have to be changed by hand in certain situations. Ask your father or someone else who drives a car which gear he uses for highway traveling. Which does he use going up a steep hill? Which does he use if he's caught in snow and needs a great deal of traction? Do you think an automobile's *reverse* gears have a higher or a lower gear ratio than its forward gears? Why do you think this is so?

Using This Issue . . .
(continued from page 2T)

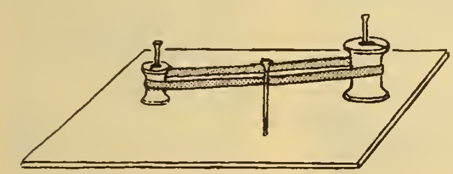
Big Gear, Little Gears

Your pupils may already have experience with "three-speed" bicycles; this SCIENCE WORKSHOP investigation will help them understand how the different gear ratios obtained by shifting the gears make it easier to start the bike, ride up hills, or ride fast on level ground.

Suggestions for Classroom Use

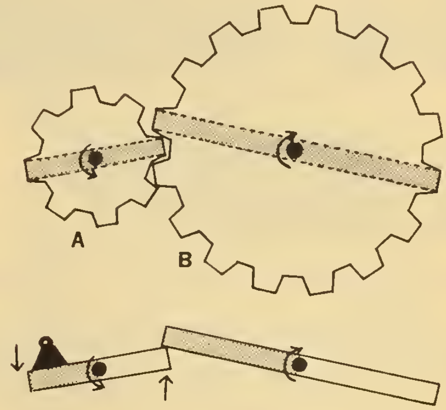
• Some of your pupils may wonder if the length of the drive chain has anything to do with the gear ratio. Here is a way they can find out.

Drive two nails into a board, far enough apart to stretch a rubber band slightly between them. Place a small wooden spool over one nail and a larger spool over the other nail, so the spools turn freely. Stretch the rubber band around both spools, as shown in the diagram, and mark the edge of each spool with a pencil. Turn the large spool through one complete turn and see how far the small spool turns. Next, drive another nail farther away from the large spool and move the small spool to it. The rubber band will then be longer when stretched around both spools. Turning the large spool around once will turn the small spool the same distance as before.



• If your pupils know how levers work, you can show them that a gear works like a first-class lever *(see diagrams)*. This will help them understand why a low gear ratio increases power at the expense of speed, while a high gear ratio provides speed at the expense of power.

You can think of a gear as an arrangement of first-class levers that turns around the center of the gear (fulcrum). When you push the side of a gear tooth (the end of one lever), the gear turns its axle with turning force, called *torque*. The amount of torque depends on the amount of pushing force on the tooth and the distance between the point where the push is applied and the center of the gear. In the same way, torque applied to the axle is changed to pushing force at the gear teeth.



One gear turns another gear just as one lever can turn another lever. In the example shown, gear A is half the diameter of gear B. 1 pound of torque turning the axle of gear A makes its tooth push a tooth of gear B with a force of 1 pound. Since gear B's levers are twice as long as gear A's, the 1-pound push on gear B's tooth gives 2 pounds of torque to the axle of gear B. But gear A has to go around twice to turn gear B once, so a bicycle with such a low gear ratio could not be pedalled very fast. If gear B were driving gear A (higher gear ratio), each turn of the pedals would turn the wheels twice, but each pound of pedalling force would only deliver ½ pound of torque to the bike's drive wheel.

N & S Reviews . . .
(continued from page 1T)

esting, even surprising, considering how far a number can go, but surely it will start no revolution in mathematical instruction.

The Stars, by Colin A. Ronan (McGraw-Hill Book Company, 32 pp., $2.95), is an introduction to astronomical objects with stars serving as the theme of the discussion. A simply written text is combined with extensive illustrations to tell the story of the stars we see, the solar system, the organization of the stars into the universe, and the methods of obtaining information from the stars. It lists some planetariums and observatories as sources of additional information. It should be useful to pupils in the lower and intermediate grades.

The Junior Science Book of Water, by Ottis Peterson (Garrard Publishing Company, 64 pp., $1.98) is the story of water in the air, in living things, and in the ground. Both the use and misuse of water are discussed. The coverage is excellent and timely. The style of type, the format, and the control of language are combined to make this a most readable offering. This book is highly recommended to those in grades two to five.

Waves, Tides, and Currents, by Elizabeth Clemons (Alfred A. Knopf, 114 pp., $3.75) is an authoritative and thorough description of the fascinating phenomena that are found where the land meets the sea. Tides and their characteristics, wave formation, the destructive tsunami, and the mighty ocean currents are all carefully examined. Modern oceanographic activities are discussed. This extremely well-prepared book contains a glossary, an index, and a bibliography. It should prove most interesting and useful to those in the intermediate and advanced grades.

The River, by Roger Pilkington (Henry Z. Walck, 64 pp., $3). Although no particular river is described in this book, the Thames of England is the stream of basic reference. This is the general story of rivers and canals from headwaters to the sea. It is a mixture of history and explanation; like a river, it sometimes rambles. But it also turns up many curious and fascinating facts as it explores river transportation, pollution, flooding, and the meeting of a river with ocean tides. It has no index, and its illustrations, though interesting, often are not really related too closely with the text. It is written for the intermediate grade level.

Machines, by Irving and Ruth Adler (The John Day Company, 48 pp., $2.29) is one of the series of "Reason Why Books" by the authors. In this, they first identify the fundamental machines and explain them. Then the more complex machines that have evolved in our civilization are discussed. The illustrations are well matched to the text, and pronunciation is given for terms that may be new to the reader. A brief glossary is appended. Most satisfactory for intermediate grade pupils.

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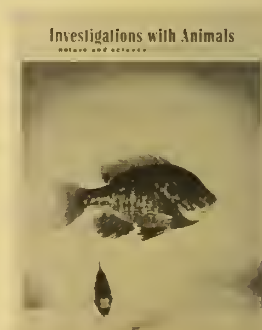

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nature and science
TEACHER'S EDITION
VOL. 5 NO. 4 / OCTOBER 30, 1967 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

This special-topic issue deals with what is called a *biome*—an area of land that has characteristic climate, plants, and animals. The biomes of the world include the desert, tundra, prairie, and several kinds of forest.

The boundaries of a biome are not exact; in North America, for example, it is impossible to say where grassland ends and desert begins. Also, there may be considerable diversity within a biome. Still, the idea is a useful one. We often think in terms of biomes; the words "desert" or "prairie" bring to mind certain characteristic animals and plants.

This issue tells some of the ways in which plants and animals are adapted for life in the desert, and some of the ways human beings have managed to live in deserts. After your class gets a glimpse of life in deserts, you might suggest that they compare the desert biome with the biome in which they live.

A Desert Is...

In 1918 a German scientist, Dr. Wladimir Köppen, devised a classification system for the biomes of the world. In this system, a desert is defined as having high temperatures and 10 inches of rain or less a year. Fourteen per cent of the earth's land surface has this sort of climate. Another 14 per cent gets 10 to 20 inches of rain a year (these are dry prairies, or *steppes*).

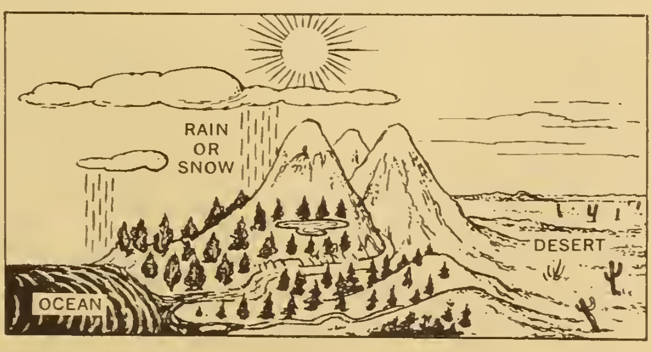
Topic for Class Discussion

• *What causes deserts?* One cause is the "rain-shadow effect," which results when mountains block moisture-laden air from inland areas *(see diagram).*

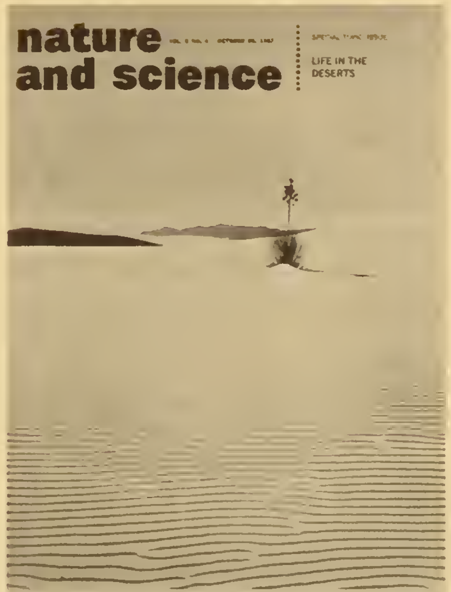
When discussing the "rain shadow effect," remind your pupils of some common examples of water vapor condensing out of the air (droplets forming on the outside of cold bottles and pitchers; eyeglasses clouding up when brought into a warm, humid room; and the cloud of water droplets your breath forms in the air in very cold weather).

The article also tells how cold ocean currents rob the air of most of its moisture before it reaches coastal deserts. Dry winds also help cause deserts.

(Continued on page 2T)



Mountains along the California coast "shade" inland areas from rain by forcing moist ocean air upward. The rising air cools and loses its moisture as rain or snow on the ocean side of the mountains.



IN THIS ISSUE

(For classroom use of articles preceded by •, see pages 1T-3T.)

• A Desert Is . . .
An overview of the location, similarities, differences, and causes of the world's deserts.

Survival in the Desert
A scientist finds out how certain desert animals are adapted to survive in deserts.

• Making the Water Last
This WALL CHART shows how certain desert plants are adapted to gather, store, and use scarce water efficiently.

• Man Against the Desert
Photos show how some of the human desert-dwellers have adapted their ways of living to the environment.

• Expedition to the Gobi
A famous scientist takes your pupils on a search for dinosaur fossils in a desert that was once a jungle.

• Making a Desert Bloom
Man's efforts to farm dry land by bringing water to it sometimes make the soil less productive.

IN THE NEXT ISSUE

The Grand Canyon as a window to life in the past . . . SCIENCE WORKSHOPS: Finding your center of gravity; Using a balance . . . Mystery of the Maya civilization . . . How oxygen was discovered.

Using This Issue...
(continued from page 1T)

The prevailing winds around the middle of the earth are usually dry, having lost their load of water vapor farther to the north or south. Also, the winds that reach far-inland deserts, such as the Gobi, have dropped most of their moisture before reaching the interior.

Activity

From your local weather bureau, find out the annual rainfall in your area. Is the precipitation spread evenly through the year? How does the amount of precipitation and its distribution through the year affect plants and animals, including humans, in your area?

Making the Water Last

Desert plants can be lumped into two groups: evaders and resisters. The evaders are *annual* plants, which live just long enough each year to produce the seeds for the next year's plants. They have no need for water-conserving adaptations. Their seeds, however, are different from those of annual plants in moister areas. The seeds of desert annuals have specialized protective coats (another kind of adaptation to an environment) that allow the embryo plant to sprout only after enough rain has fallen to enable the plant to grow.

The resisters are *perennial* plants, which live throughout the year. This WALL CHART shows how some of the resisters are adapted to live year around in the desert. Discussing the following questions should help your pupils grasp the basic concept (exemplified in this article and in "Survival in the Desert") that *living things are adapted in structure and function to their environment.*

Topics for Class Discussion

• *How does a species of plant or animal become* adapted *for survival in a particular environment, such as the desert?* The members of a single species are slightly different from each other. Some individuals have certain characteristics that help them survive in desert conditions. They tend to live longer and produce more young (or new plants) than individuals that do not have these favorable characteristics. Generation after generation, the number of individuals that have inherited the favorable characteristics increases until they make up most or all of the population of that species. (This process of *evolution by natural selection* is illustrated in a WALL CHART in *N&S*, Nov. 14, 1966, page 8.)

• *Why do desert plants have waxy leaves, or no leaves at all?* Plants lose considerable water from their leaves through *transpiration.* (A full-grown apple tree may transpire about 1,800 gallons of water in a six-month growing season.) Plants that live year around in the desert can't afford to lose much water through transpiration.

• *Which is more important to desert plants, light or water?* Green plants cannot survive without both light and water. In areas of high rainfall, such as in forests, the greater competition is for light; plants are eliminated by being shaded. In the desert, the chief struggle is for water, so the plants are often spaced regularly over the ground, each soaking up all the available water within reach of its roots.

• *Why do cactus plants have bristles?* Bristles and thorns have evolved on plants in many parts of the world, but not all for the same reason. Scientists believe that cactus bristles are an adaptation that protects these plants from losing their water-storing tissues to grazing animals. It is significant that cacti growing in Australia have no bristles; there are no native grazing animals there.

• *Can you think of other living things in the desert whose lives are affected by the brief rainy season and the long drought that follows?* The same rain that triggers the sprouting of annual plants' seeds and the flowering of perennial plants also induces insects to emerge from their dormant stages. Like the annual plants, many desert insects begin and end their lives during the rainy season.

See *N&S*, Sept. 18, 1967 for directions on setting up a desert terrarium. If you plan to keep horned lizards, use a heating lamp or incandescent bulb to give them three to four hours of 107-110° temperatures each day. Without such heat, the lizards can't digest their food and will die.

For best results, water cacti only once every two or three weeks. Most cacti grow best in soil made of four parts sand and one part loam.

Expedition to the Gobi

This article has two ingredients that children find especially appealing—an expedition and dinosaurs. Besides revealing something about how paleontologists search for and collect fossils, it gives a picture of an unusual, high-altitude, relatively cold desert, whose climate has changed over a long period of time. Eighty million years ago, when dinosaurs roamed the Gobi, the area had more abundant water and plant life, and a milder climate.

Examples of climatic changes can also be found in this country. Some of your pupils may have visited the Petrified Forest National Park in the Painted Desert of Arizona. The fossil trees are remnants of a lush forest that grew about 150 million years ago.

Since Roy Chapman Andrews led his expeditions, other scientists have made important finds in the Gobi. Bones of the world's oldest known mammals were recently uncovered at the Flaming Cliffs. The expedition that found them, led by a Polish woman, brought back 35 tons of fossils, mostly of dinosaurs and lizards.

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

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VOL. 5 NO. 4 / OCTOBER 30, 1967

SPECIAL-TOPIC ISSUE

LIFE IN THE DESERTS

nature and science

VOL. 5 NO. 4 / OCTOBER 30, 1967

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

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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, December through April; monthly September, November, May, and July (July special issue). Second Class postage paid at Garden City, N.Y. and at additional office.

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A Desert

■ Heat . . . dryness . . . sand . . . silence.

This is a desert, as most people imagine it. But deserts are as different as people. In parts of the vast Sahara *(see map)*, you will see only sand dunes. But in the deserts of North America you can travel for 100 miles without seeing a single dune.

Some scientists point out that even parts of the cold Arctic regions can be called deserts. The water in the Arctic is "locked up" in ice and snow, so it is practically useless to plants and animals most of the time. The one thing that all deserts have is a scarcity of water—usually less than 10 inches of rain (or snow) in a year.

Deserts are usually hot places, although the night temperatures can be surprisingly cold. Summer temperatures often reach 120 degrees. But, again, there is a great variation in the temperatures of the world's deserts. Snow falls in some deserts, including parts of the Sahara and especially the Gobi of Mongolia *(see map)*.

How Deserts "Happen"

The dryness of a desert can be caused by several things. One way or another, deserts are shut off from moisture-filled air. In North America, the great mountain ranges along the west coast act as barriers to moist ocean air. The air is cooled as it rises up the western mountain slopes. When water vapor is cooled it forms tiny droplets which may then join other droplets to form raindrops or snowflakes. Most of the water vapor falls as rain or snow on the west side of the mountains, leaving little for the other side.

The map on this page shows the location of the world's deserts. You'll notice that some of them are on the coasts of continents. This may seem odd—the moisture of the ocean is so handy to them. In these cases, there are cold currents in the oceans near the coasts. This cold water cools the air above it so that the air loses a lot of its water vapor before it reaches the coasts. Usually this air is warmed as it moves inland, so very little water vapor leaves the air as it passes over the desert.

Understanding a Desert

People have managed to live in deserts for thousands of years *(see page 10)*. The problems of life in a desert are great, however, and man's attempts to change deserts to his liking are sometimes disastrous *(see page 15)*.

As the world population grows, more and more people will be calling a desert "home." How many people can live in deserts? How *well* will they live? The answers to

is a hot, cold, dry, snow-covered, dune-covered, plant-covered, lifeless, lively place.

Snow falls in some deserts, such as this one in southwestern Arizona. Not many deserts are as barren as the one shown on the cover. It is part of the White Sands National Monument, in southern New Mexico.

these questions will depend on what man can learn about deserts as they exist today. Scientists have investigated the lives of some desert plants and animals *(see pages 4-9)*, but there is still much to learn.

Many times in the past, humans have used such things as rivers and cropland without much understanding of what makes them "tick." Now the rivers are polluted, the cropland eroded and useless. The same thing may happen to the world's deserts unless humans try to understand these great dry lands.—LAURENCE PRINGLE

■ Look in your library or bookstore for these books about deserts and the life in them: **The Life of the Desert,** by Ann and Myron Sutton, McGraw-Hill Book Company, New York, 1966, $4.95; **The Desert,** by A. Starker Leopold, LIFE Nature Library, Time Inc., New York, 1962, $3.95; **The How and Why Wonder Book of Deserts,** by Felix Sutton, Grosset & Dunlap, New York, 1965, $1.25.

Dry winds, cold ocean currents, and mountain barriers all help keep much moisture from reaching the world's deserts, shown in orange on this map.

SURVIVAL IN THE DESERT

by Ruth Kirk

There's lots of life in Death Valley and other deserts. Scientists are still learning about the ways in which animals such as camels and kangaroo rats survive in the hot, dry, desert world.

■ No human can survive for long without water in the summer heat of the desert. Yet many animals live there year around—even in Death Valley, California, where the temperatures in July go higher than anywhere else in the world. A few years ago when some scientists decided to find out exactly how certain animals survive in the desert, they began to study a big-eyed, furry, long-tailed mammal called the *kangaroo rat (see photo).*

First the scientists studied the world in which the kangaroo rat lives. This world is not the desert as humans experience it. The scientists found, for example, that the temperature of the ground beside a kangaroo rat's burrow may climb as high as 180°F. This is 50 or 60 degrees above the highest summer air temperatures in the desert. But the "official" temperatures taken by the United States Weather Bureau are not measured at the height of a kangaroo rat. Weather Bureau thermometers are housed in white boxes set five feet above the ground—and that is not where you find kangaroo rats!

Neither do you find them out scurrying around on the blistering noonday sand. They dig underground to where it is relatively cool. To find out how "cool," Dr. Knut Schmidt-Nielsen, a *mammalogist* (a scientist who studies mammals), attached tiny recording thermometers to kangaroo rats he had trapped. Then he let the rats go.

When they ran underground he found that the average temperature inside their burrows was 20 to 30 per cent below the official air temperature for the day. For humans, the outdoor temperature was 110°F. In the underground world of kangaroo rats and other burrowing animals, it was only about 80°F.

You might think that kangaroo rats can stand the heat better than other animals. But scientists have found that desert animals can't stand heat much better than similar animals in cooler areas. In tests, a group of kangaroo rats was exposed to high temperatures. At 100° several of the animals died in less than three hours. At 105°, most of the animals could last no longer than an hour and a half.

The kangaroo rat gets its name from its way of bounding along the ground, like a kangaroo. It escapes the great heat of the desert day by staying in an underground burrow.

Kangaroo rats obviously couldn't survive in the open during the desert day.

Like the kangaroo rat, many kinds of animals survive in the desert by simply avoiding the worst of the heat. Badgers, kit fox, and coyotes burrow underground. Ringtail cats (which are not cats but are related to raccoons), coati mundis (also related to raccoons), and peccaries (wild pigs) rest in caves or old mine tunnels through the day and forage at night. Lizards streak from the shade of one bush to the shade of the next, running on tiptoe and holding their tails high off the hot ground. Snakes stay beneath a protecting rock or deep within a burrow during the day and come out to hunt and eat at night. Ground squirrels go into a sort of deep sleep, like *hibernation,* when summer comes. They *estivate* through the hot season in the same way that woodchucks and marmots "sleep" through the winter in cold climates.

Finding the Water of Life

Avoiding heat is one way in which animals survive in the desert. But there are other ways. Watching kangaroo rats in a desert-hot laboratory, scientists learned that the rats did not drink water even when full dishes of it were in their cages. How could the animals live without drinking? All living things must have water. The question was not whether the kangaroo rats need water, but how much they need and where they get it.

Some mammalogists suggested that kangaroo rats' burrows might go down to water. Others thought that the rats got water by eating *succulent,* or water-storing, plants. Or perhaps the rats lapped dew each morning.

Some animals do get their water in these ways. Coyotes smell water and dig to it. Several kinds *(species)* of ground squirrels eat green leaves that hold lots of water. Grasshopper mice get most of their water from insects, whose bodies are as much as 80 per cent water.

These are examples of *adaptations*—characteristics developed over thousands of years that help a species to survive. But none of these adaptations could explain the case of the kangaroo rats, for they eat mostly dry seeds. This, the scientists reasoned, left only one possible source of water. If the animals do not drink water or get it in food, they must *make* it. And not only that, they must be able somehow to get along on the tiny bit that they make.

How the Kangaroo Rat "Manufactures" Water

Actually all animals, including humans, "manufacture" water as they digest their food. This kind of water is called "metabolic water" because it is produced as food is *metabolized,* or digested. For most mammals it is only an unimportant part of the total water needed to stay alive.

But for kangaroo rats it is usually the total supply.

Dr. Schmidt-Nielsen decided to find out how this could be possible.

"Metabolic water never amounts to much," Dr. Schmidt-Nielsen reasoned, "yet kangaroo rats don't try to drink more water even when they can easily. This must mean that they 'use' an exceptionally small amount. But why? What is it within their bodies that makes this possible?"

(Continued on the next page)

Here are just four of the many animals that live in deserts of the southwestern United States. They are (from top to bottom): kit fox, red racer, antelope ground squirrel, and ringtail cat. Desert animals are most active at dawn and dusk. They burrow underground or stay in shady places during the day. Some kinds of ground squirrels go into a deep sleep during the hot summer, just as some mammals do in cold regions in wintertime.

To find out Dr. Schmidt-Nielsen began to feed the kangaroo rats in his laboratory a diet of nothing but soy beans. These beans differ from wild seeds in one important way: They are high in protein (about 47 per cent) while most seeds are high in starch and fat. And protein takes more water to digest than starch and fat do, especially to help the body get rid of its wastes.

The kangaroo rats lost weight on the soy bean diet, and after about two weeks they died. The soy beans were nutritious enough, but it took more water to digest them than the kangaroo rats could produce. The kangaroo rats had no other source of water, so they began to die of lack of water *(dehydration)*.

This was the clue Dr. Schmidt-Nielsen was looking for. "It is their kidney that helps kangaroo rats get along in the desert without drinking," he said. "The kidney concentrates the wastes of the animal's food so much that very little water is lost from the body—so little that metabolic water is usually all that the kangaroo rat needs."

Water from a Camel's Hump?

Another desert animal that has puzzled humans is the camel. If you ask someone how camels can get along in the desert, you probably will be told that their hump is full of water. This is not true. The hump is mostly fatty tissue. It serves more as a reserve food supply than as a water reservoir. When a camel has no food or water it begins to digest the fat stored in its hump. As the fat is digested, hydrogen is released. This combines with oxygen that the camel breathes in, and some metabolic water is produced in this way. So camels do get some water—indirectly—from their humps. But this is not the most important of the adaptations that help camels survive in the desert.

Camels can live for months without drinking as long as they have green plants to eat. When water is available, a camel may drink as much as 25 gallons in a few minutes.

Dr. Schmidt-Nielsen found that camels are adapted in several ways to get along on little water. Like kangaroo rats, camels are able to concentrate wastes from digestion so that little water is lost when the wastes leave their bodies. Dr. Schmidt-Nielsen and other investigators also discovered that a camel's body temperature rises as the day gets hotter. For humans a temperature rise of only two or three degrees above normal means fever. But for camels, "normal" body temperature can range from about 87° to 105° as the day goes from the cool of morning to the heat of mid-afternoon. This way they don't have to sweat a great amount of water to keep cool, as humans do.

The tissues inside a camel's body can dry out much more without harm than a human's tissues can. A man driving a car on a 110-degree day sweats about a quart of water an hour to keep himself at normal body temperature (between 98° and 99° F). He must drink enough to keep up his body supply of water. If he doesn't, his tissues lose too much water, his body temperature suddenly rises, and he dies.

But not the camel! They have been known to lose more than 27 per cent of their body weight by dehydration, yet be none the worse for it once they were given water. A man will die if he loses water equal to about 15 or 20 per cent of his body weight.

Camels also avoid the heat as much as they can. If there is no shade they lie together in tight clusters, so close that the body of one keeps the sun from striking the body of the next. They lie down early in the morning while the sand is still relatively cool, and they stay down all day. This way they continue to use a "cool" spot instead of taking on heat by moving to a place that the sun has warmed. The camels keep turning as the sun arcs across the sky. They face directly into it, or directly away from it, so that its rays strike as little of their bodies as possible.

During many thousands of years in deserts, different kinds of animals have evolved ways of living successfully in this hot, dry world. For humans, life in the desert may seem harsh. But for other kinds of animals it is as natural a home as a swamp is for crocodiles, or an ice floe for polar bears ■

BRAIN BOOSTERS

prepared by **DAVID WEBSTER**

WHAT WILL HAPPEN IF?

Throw a large ball against a partly opened door. Then with the same force, throw a wet washcloth at the door. Which one makes the door move more, the ball or the wet washcloth?

CAN YOU DO IT?

Can you throw a ball and make it come right back to you without allowing it to hit anything?

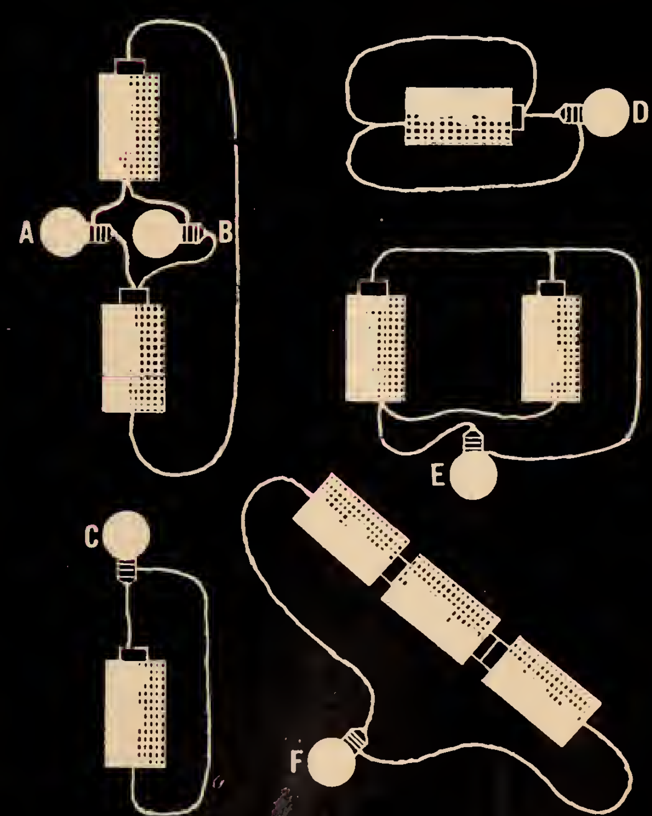
Submitted by Kenneth Linney, San Jose, California

MYSTERY PHOTO

One of the front teeth in this woodchuck skull has grown around and gone right through the bone. Can you explain what could happen to a woodchuck to make its tooth grow like this?

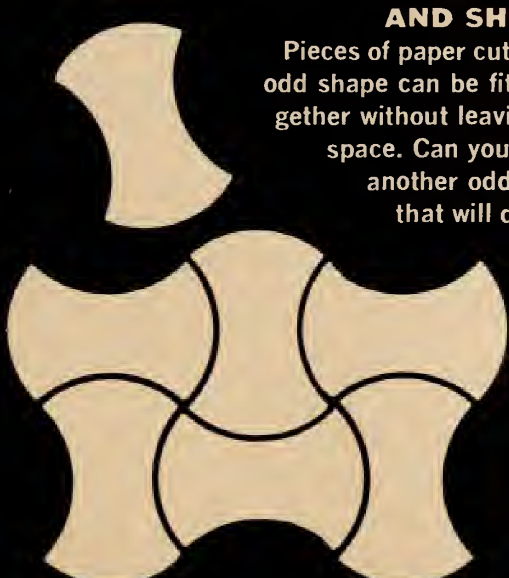
FOR SCIENCE EXPERTS ONLY

Which of these bulbs would be brightest?



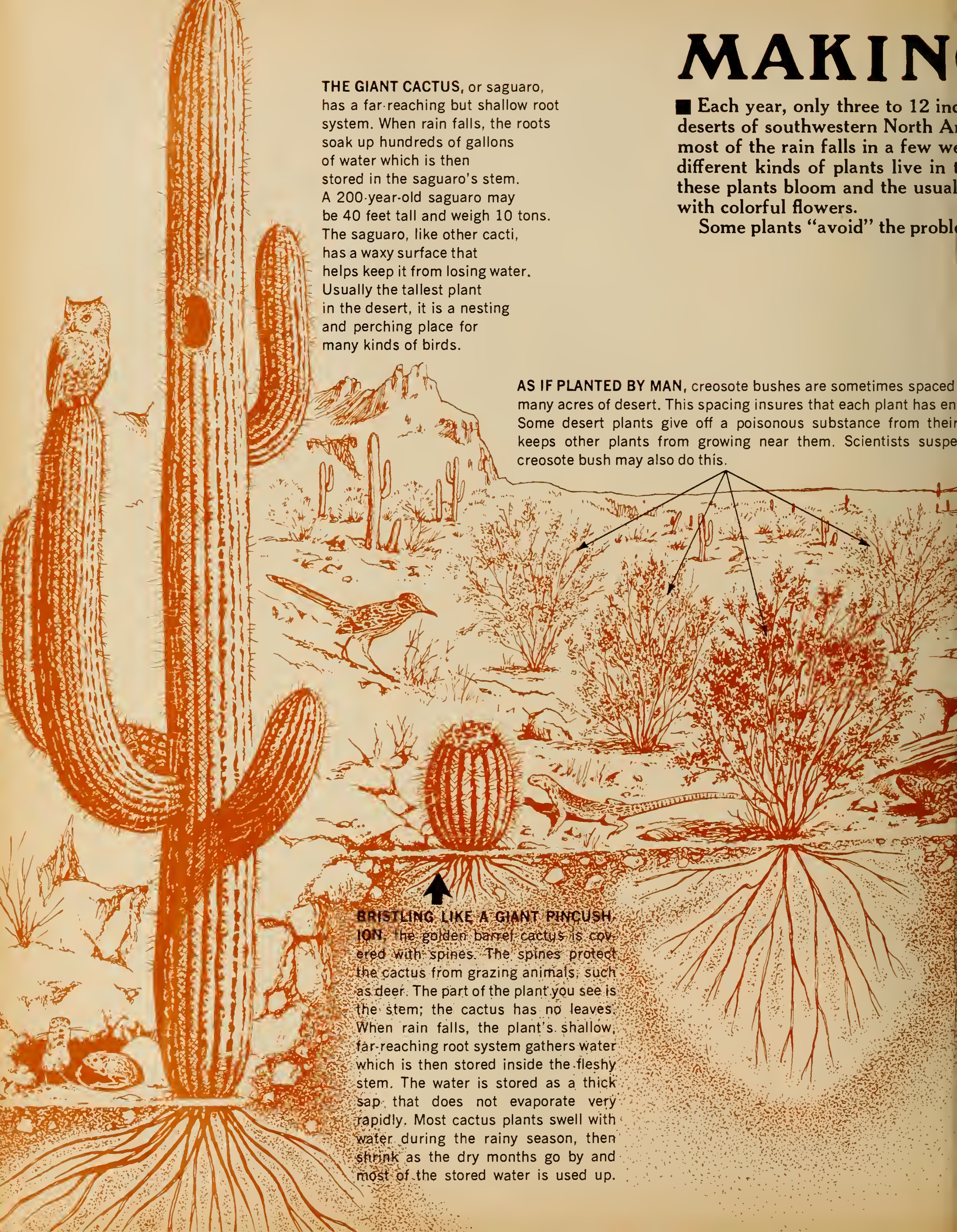
FUN WITH NUMBERS AND SHAPES

Pieces of paper cut to this odd shape can be fitted together without leaving any space. Can you invent another odd shape that will do this?



MAKIN

■ Each year, only three to 12 inc
deserts of southwestern North Ar
most of the rain falls in a few we
different kinds of plants live in t
these plants bloom and the usual
with colorful flowers.
Some plants "avoid" the probl



THE GIANT CACTUS, or saguaro, has a far-reaching but shallow root system. When rain falls, the roots soak up hundreds of gallons of water which is then stored in the saguaro's stem. A 200-year-old saguaro may be 40 feet tall and weigh 10 tons. The saguaro, like other cacti, has a waxy surface that helps keep it from losing water. Usually the tallest plant in the desert, it is a nesting and perching place for many kinds of birds.

AS IF PLANTED BY MAN, creosote bushes are sometimes spaced
many acres of desert. This spacing insures that each plant has en
Some desert plants give off a poisonous substance from their
keeps other plants from growing near them. Scientists suspe
creosote bush may also do this.

BRISTLING LIKE A GIANT PINCUSHION, the golden barrel cactus is covered with spines. The spines protect the cactus from grazing animals, such as deer. The part of the plant you see is the stem; the cactus has no leaves. When rain falls, the plant's shallow, far-reaching root system gathers water which is then stored inside the fleshy stem. The water is stored as a thick sap that does not evaporate very rapidly. Most cactus plants swell with water during the rainy season, then shrink as the dry months go by and most of the stored water is used up.

THE WATER LAST

ꜰ rain fall on the great
.. Water is scarce, and
ime. Yet, hundreds of
deserts. In the spring,
l landscape is covered

water supply entirely; during the brief rainy season they sprout, grow, flower, leave seeds, then die. Tough coats protect the seeds until the next rainfall.

Many other kinds of plants grow year around in the desert. One way or another, they make the water last. The drawings on these pages show how some of these plants survive in a land of little rain ■

THE MESQUITE, like other thorny desert shrubs, has a tremendous root system for gathering water. A mesquite has a deep taproot that may reach 60 feet into the soil. This shrub gets enough water from the soil to have tender green leaves; many desert plants have no leaves at all.

over
ter.
that
the

LL WAXY LEAVES grow
he ocotillo during the
season. Then, as the dry
on begins, the leaves
off. Even without leaves,
ver, the ocotillo lives. Its
contains chlorophyll, the
n substance needed for
-making.

WHEN THE RAINS STOP, the night-blooming cereus may seem to die. But this cactus lives on, with food and water stored underground in a thick, beet-like root. The cactus quickly grows, flowers, makes and stores food again during the next rainy season.

MAN AGAINST THE DESE

Deep in the Sahara, the Tuaregs herd sheep and sometimes grow food plants around water holes. They wear long, flowing cotton robes and live in huts made of dry grass (see *photo*) in warm weather, in leather tents when it is cooler.

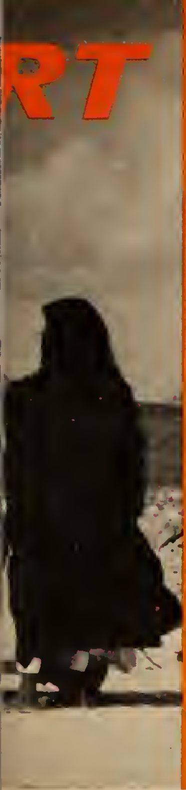
■ Living in the desert is harder for humans than for other desert animals whose bodies have become adapted to survive on very little water *(see pages 4-6)*.

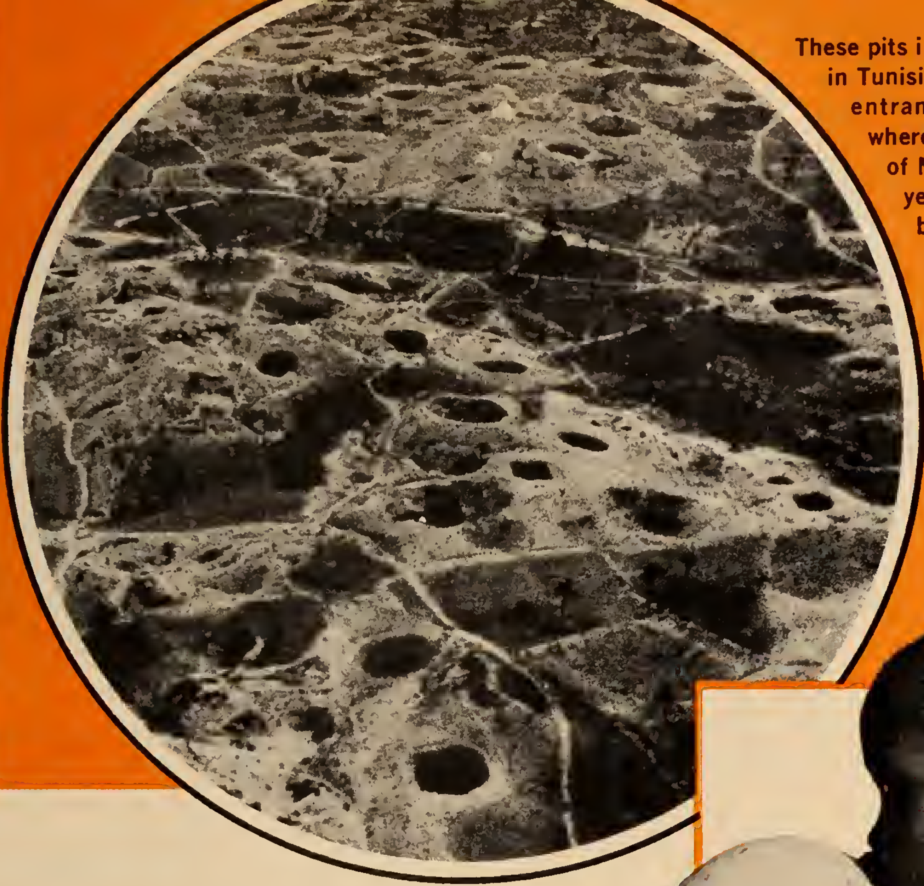
A person's body gradually makes some adjustments to the dry desert heat. His blood circulates faster, bringing heat to the surface of his body where it escapes into the air. And his sweat glands work harder, bringing more of his body water to the surface of his skin, where it evaporates and cools his body. But in a single hour of desert heat, his body may lose a quart or more of salty water through perspiration. Unless this water and salt are soon replaced, his cooling system will fail and his body temperature will rise to a deadly level.

Keeping his body supplied with water is the main problem of a desert dweller. But the shortage of water in a desert often makes it hard to find or raise plants and animals for food. The weather is harsh: In many places sizzling hot days are followed by bitter cold nights, and strong desert winds sometimes whip up violent sandstorms. The sun's ultraviolet rays are an additional hazard to desert dwellers with light colored skin, for sunburn damages their sweat glands.

Despite all of these problems, people have been living in deserts for more than 5,000 years. In the Sahara, Arabian, and Gobi deserts, people of many different tribes herd animals such as sheep and goats for meat and wool. They roam the desert on horses, camels, or donkeys, searching for water and grass for their herds. These people wear long, loose-fitting robes or clothes of cotton, wool, or felt that shield them from the heat, cold, sun, sand, and

A Mongol tribesman covers the frame of his *yurt*, a portable tent, with animal skin to protect his family from the cold Gobi desert wind. The Mongols herd *yak*, a long-haired ox that provides meat, wool for the Mongols' heavy felt clothing, and skins for the yurt. It even carries the packed-up yurt when the tribesmen move to new pastures.





These pits in the surface of a desert area in Tunisia, in northern Africa, are the entrances to underground caves where people called the troglodytes of Matmata have lived for 2,000 years. Like the kangaroo rat's burrow, these underground houses protect the Matmatis from heat and cold.

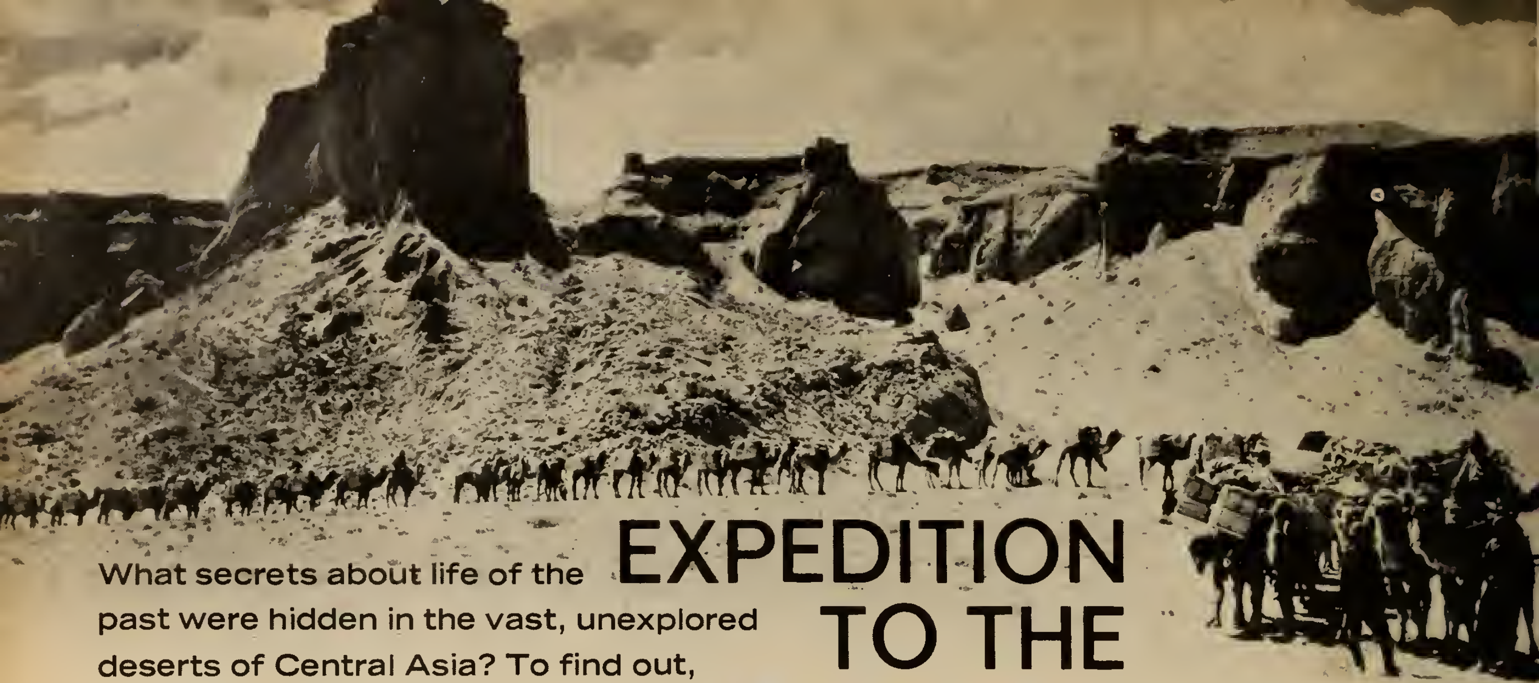
wind, and help keep their body moisture in.

The Bushmen of the Kalahari and some aborigines in the Australian desert travel on foot, hunting water holes or rain puddles, game and plants for food. Dark colored skin protects both of these peoples from sunburn, and the few clothes they wear are for decoration.

The photos on these pages show some of the ways of living that help different groups of people survive in the desert ■

The Bushmen use emptied ostrich eggs for water "canteens" and often store them deep in the sand for recovery in the dry season. Some Australian aborigines have no containers at all, so they must lap water from rain puddles.

Bushmen of the Kalahari hunt game and food plants in the morning and evening, resting during the midday heat in whatever shade they can find. On cold nights, they sleep huddled together in a pit near a fire.



What secrets about life of the past were hidden in the vast, unexplored deserts of Central Asia? To find out, scientists set out on an . . .

EXPEDITION TO THE GOBI

by Roy Chapman Andrews

■ The Gobi, Asia's greatest desert, stretches 2,000 miles east and west through the center of Mongolia *(see map on page 3)*. It is a thirsty land, bitterly cold in winter, burning hot in summer. A gravel desert with only sage brush, clumps of wire-like grass, and thorny bushes. Gazelles, wild asses, and wolves range the marching sands.

Until about 45 years ago people knew very little about the fossil history of Central Asia. I thought that Asia might be the place where the ancestors of many of the animals of Europe and America had lived. So, in 1922, I gathered an expedition for The American Museum of Natural History. We wanted to search the Gobi for fossils and living birds, animals, and plants, and to map the country.

From a town about 100 miles north of Peking, China, I set out with 40 men, eight cars, and 150 camels. After three days we came to a bare gravel bluff on the edge of a wide basin. The *paleontologists* (scientists who study past life on earth) in our group stopped to look for fossils. I went on with the others to make camp. At sunset the paleontologists' cars came roaring into camp. Dr. Walter Granger pulled some pieces of fossil bone out of his pockets and his shirt. "These are the first fossils ever found on the Mongolian plateau," he said.

That evening Dr. Granger found many more fossil bone fragments around the camp. But we weren't sure what animals they were from. Next day, when we found a whole bone that was surely dinosaur, we felt like prospectors who had struck a rich gold mine.

Clues to a Great Lake

On the second morning, searching alone about a half mile from camp, I saw many fragments of what had been big bones. Wind and frost had worn away the rock they were buried in and had broken up the bones.

At last my eyes caught the glint of a piece about five inches long sticking out of the sand. When I pushed it with my foot, it didn't move. I tried to pull it out. No use. The bone was solid in the rock. I hurried back to camp for help.

Dr. Granger and his assistant set to work with whisk brooms, small brushes, and chisels to remove the top covering. There, only a foot or two beneath the surface, was a great mass of bones. It was surely dinosaur! A new kind of dinosaur!

For a month the expedition worked in this one spot and even then did not take out all the fossils. We would uncover the end of a leg bone, only to find that it ran under another bone, which must be removed before the first could be touched.

More than 80 million years ago, in the Age of Reptiles, this area had been a great lake. When the dinosaurs died, their bodies must have been carried into a whirlpool in the lake. The bones sank into the soft mud, and after many,

This article is adapted from All About Dinosaurs, *by Roy Chapman Andrews,* *© 1953 by Roy Chapman Andrews (Random House, New York).*

At the Flaming Cliffs, surrounded by miles of hot, dry desert, scientists spent months searching through sand, gravel, and rock for fossils.

many years they were *petrified,* or changed to stone.

About 80 million years ago, this country was warm and rainy. A thick jungle of palm and fig trees and other tropical plants rolled away in waves of green. Countless dinosaurs swarmed over the land and splashed in the waters of the lake. Today only wolves, white-tailed gazelles, and Mongol tribesmen on horses trot across the dry plains.

Discoveries at the Flaming Cliffs

We moved deeper into the Gobi. Sometimes we sat huddled in the tents for hours while sandstorms raged. After some weeks, we were far out in the waterless desert. But the weather was getting colder. Sometimes a light snow powdered the ground. If we were caught by a blizzard, we might never be able to get out.

We started back. Our water bags were almost dry, and for 100 miles there had been no sign of water. We were thirsty, but every drop had to go into the cars. On the third day, an hour before sunset, I saw far away a tent—the kind used by the Mongol people who live in the desert. Where there were people, there must be water!

We camped there that night, among beautiful stone mounds and cliffs that looked like animals or old castles. The setting sun made the rocks look on fire. We named the place the "Flaming Cliffs."

One of the men found a skull of a new kind of dinosaur lying on the ground. Bits of white bones were everywhere. Parts of skeletons were sticking out of the rock. There wasn't time to take them out, because night was on us.

In the morning it was hard to leave such a wonderful place, but the feel of snow was in the air. We might be trapped if we waited one day more, so we pushed ahead. Two days later the heavy snow came. By then we had reached the main trail and were safe.

Link with America

The skull we had found on the ground turned out to be from a dinosaur that was the ancestor of a big American plant-eating dinosaur called *Triceratops,* which means "three-horned." The new animal was later named *Protoceratops* (first horned) *andrewsi,* in honor of my expedition.

The next summer we went back to the Flaming Cliffs. We decided that I would go ahead to the cliffs with part of the expedition. The slower camel train, led by a Mongol named Merin, would come later. We knew some of the camels would die from the hard work of carrying supplies across the hot, dry desert.

At the Flaming Cliffs we collected many fossils. Most of them were Protoceratops, but there were two or three kinds of small, meat-eating dinosaurs too. We also found parts of a crocodile. That shows there must have been a stream or small lake in the basin at some time.

Though we were having great success, I was worried. Food was low, and Merin had not arrived with our supplies. I sent Mongols on horseback to search for the camels, but they found nothing. Luckily, hundreds of gazelles lived on the plains not far from the Flaming Cliffs. From horseback I killed three or four a day for food.

Only two sacks of flour were left. We needed flour to make paste for removing fossils *(see "Collecting Dinosaur Fossils," on this page).* When that was gone, work must stop. I asked the men what we should do. As food, the flour would last only a few days. As paste, it would be enough to take out many bones. Everyone voted to use the flour for work. *(Continued on the next page)*

COLLECTING DINOSAUR FOSSILS

People speak of "digging for fossils," but sometimes very little digging is done. When a large fossil is found in the face of a stream bank or hillside, the searcher may have to scrape away the surface with a shovel to get to the fossil. A dinosaur skeleton sometimes spreads over a wide area, so a lot of topsoil has to be taken off by scrapers and even dynamite. To remove smaller specimens, the rock is chipped away with small steel instruments. The dirt and sand are brushed off with whisk brooms and camel's hair brushes.

As the bone is exposed, it is soaked with shellac. This hardens the loose pieces. Then pieces of soft, tough Japanese rice paper are worked into all the cracks and small spaces. These are soaked with shellac and allowed to dry.

After one side of the fossil has been exposed, strips of heavy cloth soaked in flour paste are laid on it. When this is dry, it forms a hard shell. The bone is turned over and "bandaged" on the other side. When the fossils reach the museum, the cloth cover is softened with water and stripped off. The bone is there, just as it was removed in the field.

(Most paleontologists today use plaster of Paris instead of flour paste for making the shell around the bone.—THE EDITORS.)

This nest with 18 Protoceratops eggs in it was found at the Flaming Cliffs.

A model shows how scientists think Protoceratops dinosaurs may have looked as they hatched from eggs.

Expedition to the Gobi (continued)

A few days later, one of Merin's Mongols rode into camp. Soon after, the camel train arrived. Many of the camels had died, but 30 had come through, weak and thin, carrying food and gasoline.

Dinosaur Egg Hunting

Until we went to the Gobi, no one knew how dinosaurs produced their young. It was supposed that they laid eggs, because dinosaurs were reptiles and most reptiles lay eggs. Still, no dinosaur eggs had been found.

On our second day at the Flaming Cliffs, George Olsen found three objects that looked like huge eggs. They were eight inches long and pointed at both ends. When we picked them up they felt heavy. The inside was solid red sandstone. The shell was broken, but it looked just like regular egg shell, only thicker. We thought they were dinosaur eggs. We had absolute proof later when a large rock was chipped open and we found two eggs that had unhatched baby dinosaurs inside them.

Under the sand near the eggs Dr. Granger found the skeleton of a small dinosaur. It was only about two feet long and had no teeth. It was later identified as a new kind of dinosaur, and was named "oviraptor," meaning "the egg stealer." We think it had lived by sucking the eggs of other dinosaurs. Perhaps it was digging up these eggs when a sudden windstorm buried it.

Conditions have to be exactly right to preserve such delicate things as eggs. The desert was an especially good place. We think that the female dinosaurs laid their eggs in shallow holes, then covered them with sand. The sand had to be loose so air and the sun's heat could get to the eggs. The unhatched dinosaurs got air through the shell, as birds do.

Probably during a windstorm, many feet of sand were heaped over some of the nests. This cut off warmth and air. The eggs never hatched. As more and more sand piled up, it became heavy enough to crack the eggs, and the liquid inside ran out. At the same time, sand sifted into the shells and filled them up. This kept the eggs from being crushed out of shape. After many thousands of years the sand over the eggs was pressed together into rock.

Besides Protoceratops and fossil eggs, we also found the remains of mammals that had lived at the time of the dinosaurs. The Flaming Cliffs of the Gobi proved to be one of the most important discoveries of fossils in the world ■

The author examines dinosaur eggs found by an expedition he led in Mongolia in 1925 for The American Museum of Natural History. Dr. Andrews was director of the Museum for eight years. He died in 1960.

People once thought that deserts could be changed to croplands by simply adding water. Now we know that it is no easy task to . . .

MAKE A DESERT BLOOM

■ How can you change a desert into farmland?

Man has struggled with this problem for thousands of years. The recipe seems simple enough: just add water. The desert soil is fertile. When enough water is added, crops thrive in the desert.

For 3,000 years, Romans, American Indians, and other peoples have built dams, dug canals and wells, and worked in other ways to bring water to dry lands. But often these people have learned that the recipe "just add water" is too simple; adding water sometimes *ruins* desert soils.

Too Much Water, Too Much Salt

In the dry, sandy Salt River Valley where Phoenix, Arizona, now stands, a tribe of Indians called Hohokam once lived. Two thousand years ago the tribe "improved" their desert homeland by digging canals that carried water from the Salt River to thousands of acres of farms.

Their crops grew well at first. But when the water evaporated or was used by the plants, it left some salt in the soil. As more and more salt collected around the roots, the Hohokams' plants began to die. Many kinds of plants can't survive in salty soil.

The Hohokams ran into other problems. Water didn't drain away easily from their flat farmland. It seeped into the soil, raising the level of underground water up to the roots of the plants, "drowning" them *(see diagram)*.

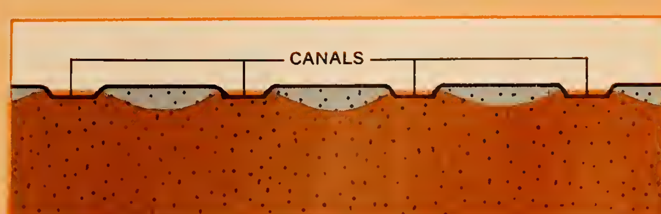
The Indians tried planting their crops on higher grounds. They dug new canals to irrigate the new fields. This worked for a while, but then even higher sets of canals had to be built. About 500 years ago the Hohokam disappeared. No one knows why, but scientists think they could not dig

(Continued on the next page)

SOME PLANTS SUCCEED IN SALT

Scientists hope that fresh water, made from the salty water of oceans, will someday help change deserts into croplands. But recently scientists have discovered that some plants grow very well when they are irrigated with *salty water*. This seems to work only in soil that is mostly sand and gravel, where water drains easily and where air easily reaches the roots of plants. In such soils, scientists in Israel are now raising crops of barley, rye, sugarcane, melons, and tomatoes—all watered with salty water.

In the level Salt River Valley, underground water does not drain away very fast. Before the Hohokams dug canals, though, it only came up to the surface near the river bed.

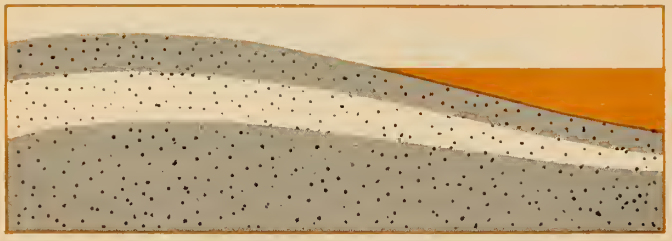


The Hohokams' irrigation canals leaked water into the soil like many little rivers, bringing the level of the underground water high enough to drown the roots of food plants.

more canals through the rocks along higher parts of the Salt River. The twin troubles that helped wipe out the Hohokam—salty soil and "drowned" plants—have also ruined land in Egypt and Pakistan.

Case of the Sinking Soil

Another problem in "just adding water" to a desert was discovered in the early 1950s, in the San Joaquin Valley of California. Irrigation ditches were dug through thousands of acres of flat desert land. After a year or two of irrigation,



Air trapped between grains of dry, loose soil may fill half the space in a layer of desert earth. When water is spread over the land, its weight squeezes the soil in the layer together, making the land above it sink.

however, the land began to sink. Ditches that had been three feet deep and five feet wide became 15 to 20 feet deep and 50 feet wide. They had to be abandoned because they were too far below the level of the land that needed the water in the ditches.

In the fields, the land began to sink wherever a pool of water formed. Within a few years the formerly level land was a bumpy mess. The sinking soil also damaged pipelines, roads, wells, and buildings.

A close look at the soil showed why the irrigation water caused this problem. The ground had never had a heavy load of water. The little rain that falls in deserts doesn't sink very far into the ground, so the soil was dry and loose—sometimes having as much as 50 per cent air space. When the plentiful water of irrigation was spread over the land, the soil was squeezed together, or *compacted (see diagram).*

It takes many years for the compaction of desert soils to stop. Scientists are now investigating ways of making desert soils compact quickly—and evenly—so that the land can be farmed soon after irrigation starts.

People are learning that there is no quick, easy way to solve the problems of water supply in the desert. To solve these problems, and to learn to live with the desert, is an important goal of scientists. One biologist, Dr. A. Starker Leopold of the University of California at Berkeley, says, "There are no longer any 'waste' spaces on the earth. Up to now men have treated the deserts as if they made no difference. One of these days, when survival no longer can be taken for granted on a crowded, used-up earth, they may make all the difference." ■

LEARNING TO LIVE WITH THE DESERT

Instead of trying to change the deserts, men might sometimes have been better off making good use of the plants and animals already living in these dry lands. Scientists think that about half the world's deserts get enough rain so that some kinds of livestock can live in them. In the past, men have killed off many desert animals in order to bring in cattle, sheep, and plants that need a lot of water. This has often been wasteful. Often too many livestock were raised. They destroyed the desert plant life so that the land had to be abandoned.

Recently in the U.S.S.R. the wild Saiga antelope, once almost wiped out, has been allowed to grow in numbers in desert lands. Herds of

these antelope *(see drawing)* are now a regular source of meat for man. They take the place of cattle that didn't do well in the desert.

Some plants can grow well on very little water. North of the Sahara, in places where almost no water can be found, ways of dry farming have been developed. Olive trees, for example, are planted far apart in light sandy soils that catch and hold the nighttime dew. The fruit and oil are used for food.

HOW TO MAKE A "DESERT"

Even with little rainfall, deserts can support many plants and animals. The roots of the native plants hold the soil and the plants store water. Attempts to raise crops on these lands often lead to erosion. The native plants are destroyed if too many livestock are allowed to graze the land. The result: wasteland.

Using This Issue...
(continued from page 2T)

Make a Desert Bloom

In textbooks and other references where information must sometimes be condensed, irrigation is often pictured as a simple panacea for developing arid lands. This article describes two problems resulting from irrigation of certain desert areas. Such difficulties are inevitable when humans tamper with an environment they don't understand.

You might discuss with your pupils these and other water supply problems. Irrigation water, for example, usually comes from huge lakes created by damming rivers. By spreading the river's water over a broad area, man has unwittingly caused a great increase in the amount of water lost to evaporation. (The lakes have a much greater surface area than the rivers did, so there is more surface area from which water can escape into the air.) Scientists are now investigating a way of reducing this loss by use of thin films of harmless chemicals on the water surface.

Another problem arises when farms depend entirely on water pumped from deep underground. This water is replaced very slowly; not by rain that falls on the ground but by seepage from distant mountains. In the southwestern United States, many farms are dependent on this water. As it is used up, thousands of acres of land have to be abandoned.

The greatest source of water for deserts lies in the future—in desalted ocean water. But scientists are also looking at opportunities for making the most of deserts as they are *(see "Learning To Live with Deserts," page 16).* In Saudi Arabia, for example, orange and lemon trees are being grown in a humus formed with the aid of a foam rubber "cushion" under the sand. In other areas, oil is being sprayed on sand dunes to stabilize them, enabling plants to take root. Man has ruined thousands of acres of arid land *(see diagram)*, but now there is hope that the land can be made productive again.

Brain-Boosters

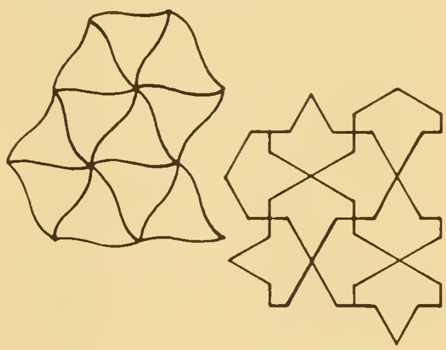
Let your pupils try to solve these B-Bs by discussion and experiment before you give them the answers.

Mystery Photo: The upper and lower incisors of rodents grow continually, and are kept at the proper length by rubbing against each other. The skull shown came from a woodchuck whose lower incisor had been broken off, allowing the upper incisor to grow unchecked.

What will happen if? Have someone throw a playground ball and a wet rag, both about the same weight, with equal force at a partly opened door. The door should swing quite a bit farther when hit by the rag. When the ball strikes the door, some of its force is "used up" in bouncing back. Since a wet rag does not bounce, almost all of its force is transferred to the door.

Can you do it? When an object is thrown straight up in the air, it comes back without hitting anything.

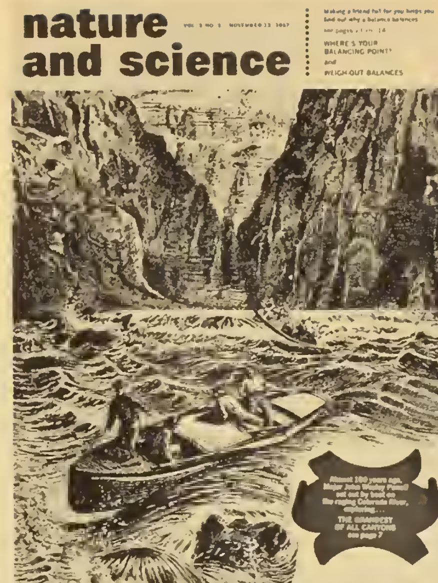
Fun with numbers and shapes. Here are some shapes that fit together without leaving any space:



For science experts only. Let small groups of your pupils experiment in their free time with these materials: 3 flashlight batteries, 2 bulbs, and 5 pieces of wire. They should find that Bulbs A and B are brightest. These two bulbs are "in parallel" with two batteries that are "in series." Arranged in this way, each bulb receives 3 volts of electricity (1½ volts from each battery). Bulb C will be only half as bright as A or B, since it gets only 1½ volts. Because its battery is "shorted out" with a wire, Bulb D will not light at all. Bulb E will have the same brightness as C, since the two batteries are in parallel and therefore supply only 1½ volts. Bulb F will be about as bright as a bulb with one battery. The two batteries with E will last longest; the one with D the shortest.

nature and science
TEACHER'S EDITION

VOL. 5 NO. 5 / NOVEMBER 13, 1967 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Grand Canyon

The article and WALL CHART on the Grand Canyon tell something of its formation and its importance as a record of past changes on earth.

Most of the rocks in the walls of Grand Canyon are *sedimentary*—made of sand, mud, or other sediments that were gradually changed into rock. Normally, younger rocks are found on top of older ones. This fact, coupled with the characteristic fossils in each layer of rock, helps scientists to determine the age of the rocks.

The layers of rocks in Grand Canyon yield clear evidence of evolution: The older rocks reveal fossils of simple organisms and the younger rocks contain fossils of more complex plants and animals.

No place on earth has had continuous sedimentation. The WALL CHART tells of times when the land was above sea level and was eroded by streams and rainfall. These periods when no sedimentation occurs are called *unconformities.*

An unconformity occurs between the Muav Formation and Temple Butte Limestone, as well as between other rock layers at Grand Canyon. With only the canyon's walls as evidence, an unconformity represents an unknown period of earth history. Elsewhere on the earth, however, sediments were being laid down at the same time erosion was occurring in the Grand Canyon area. By combining evidence from several sources, geologists can figure out the gap in time represented by an unconformity in the Grand Canyon.

Remind your class that it is not the Colorado River alone that has created Grand Canyon. Side streams and rainfall have eroded the country on both sides of the river. This will continue, geologists predict, until the canyon is at least 50 miles wide and the walls are bluffs, not cliffs.

Most people think erosion is something to be avoided. This is true for our gardens, farms, and forests. Through his activities, man sometimes speeds the erosion process on such lands, allowing topsoil to be washed or blown away. But if it weren't for the forces of erosion there would be no soil to lose. There was no soil, only rock, when the earth formed. Soil began to form through the wearing away of the rock.

You might have your pupils consider the future of another spectacular site of erosion—Niagara Falls. The water of the Niagara River is wearing away the rock over which it flows. The falls has moved about seven miles upstream during the past 25,000 to 30,000 years. It continues to wear away the rock of its bed and is expected to keep moving upstream. Have your pupils look in geology books to find out the expected fate of Niagara Falls.

To anyone standing on the rim of the Grand Canyon, it seems a beauti-

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by •, see pages 1T-4T.)

IN THE NEXT ISSUE

Why do people have skins of different color? . . . Mystery of the Mayas, Part 2 . . . How to watch a meteor shower . . . Be a twig detective . . . WALL CHART on the planets . . . How 'possums "play possum."

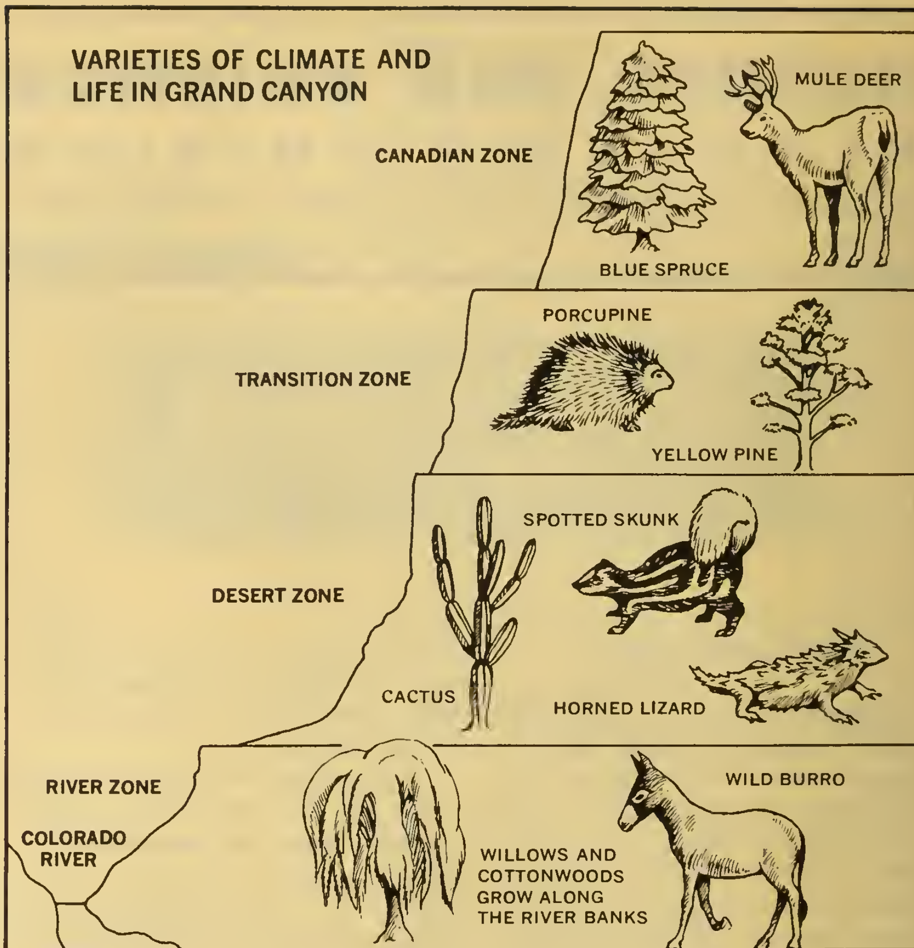
Using This Issue . . .
(continued from page 1T)

ful but barren place. The canyon is so vast that its plant and animal life seems "lost." Yet, there is a great variety of life, including 60 species of mammals, about 220 of birds, and 1,000 of plants. The variety is mostly due to the great range of climate from the canyon's top to its floor. The floor of the canyon gets less than 10 inches of rain a year; the northern rim country gets 26 inches. The diagram on this page shows how the canyon's vegetation and animal life varies with elevation.

Activity

- *Have your class investigate the proposal that one or more dams be built in the Grand Canyon.* This controversial plan has been introduced (in various forms) in Congress during the past two years. The object of the plan is to bring needed water to the southwestern United States. The dam (or dams) in the Grand Canyon would not provide the water, but would produce electricity that would help pay for other features of the project. In 1966, the Department of the Interior supported the idea of dams in the Grand Canyon; in 1967, it opposed the dams and suggested alternate ways for paying the project's costs. Public opinion was strongly against the dams, and this seemed to influence the change in the position of the Interior Department.

To examine both sides of the story, your class can seek further information from the Bureau of Reclamation (Washington, D.C. 20240) and from the Sierra Club (1050 Mills Tower, San Francisco, Calif. 94104).



Balancing Point

Drops and flops are fun when your pupils are trying to balance a banana on their own bodies. In addition, this SCIENCE WORKSHOP and the activities suggested below will give your pupils some insight into the physics of balance that will help them find the rule for using a balance scale and understand why some balances are more useful and precise than others *("Weigh-Out Balances," page 14).*

For classroom use of this workshop, you will need a few rulers, yardsticks, curved bananas, small tree branches (curved or angled), wood blocks about 3 inches high and an inch or so thick, and an empty pop bottle.

After your pupils have completed these investigations, you might discuss the following points with them.

Topics for Class Discussion

- *What keeps an object from falling when its center of mass is supported?* An object falls because gravity is pulling it toward the earth's center of mass. Gravity pulls on the object at its center of mass. When the object's center of mass is supported—that is, pushed or pulled away from the earth's center of mass with a force equal to or greater than the pull of gravity—the object will not fall.
- *Is the* mass *of an object the same as its* weight? No. The mass of an object is the quantity of material that makes it up; its weight is a measure of the pull of gravity on the object. An astronaut's body would have the same mass on the moon as on earth, but it would weigh only about one-sixth as much on the moon as on earth, because the pull of the moon's gravity is only about one-sixth as strong as the earth's. The same object weighs less at the top of a mountain than it weighs at the foot of the mountain, be-

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

nature and science

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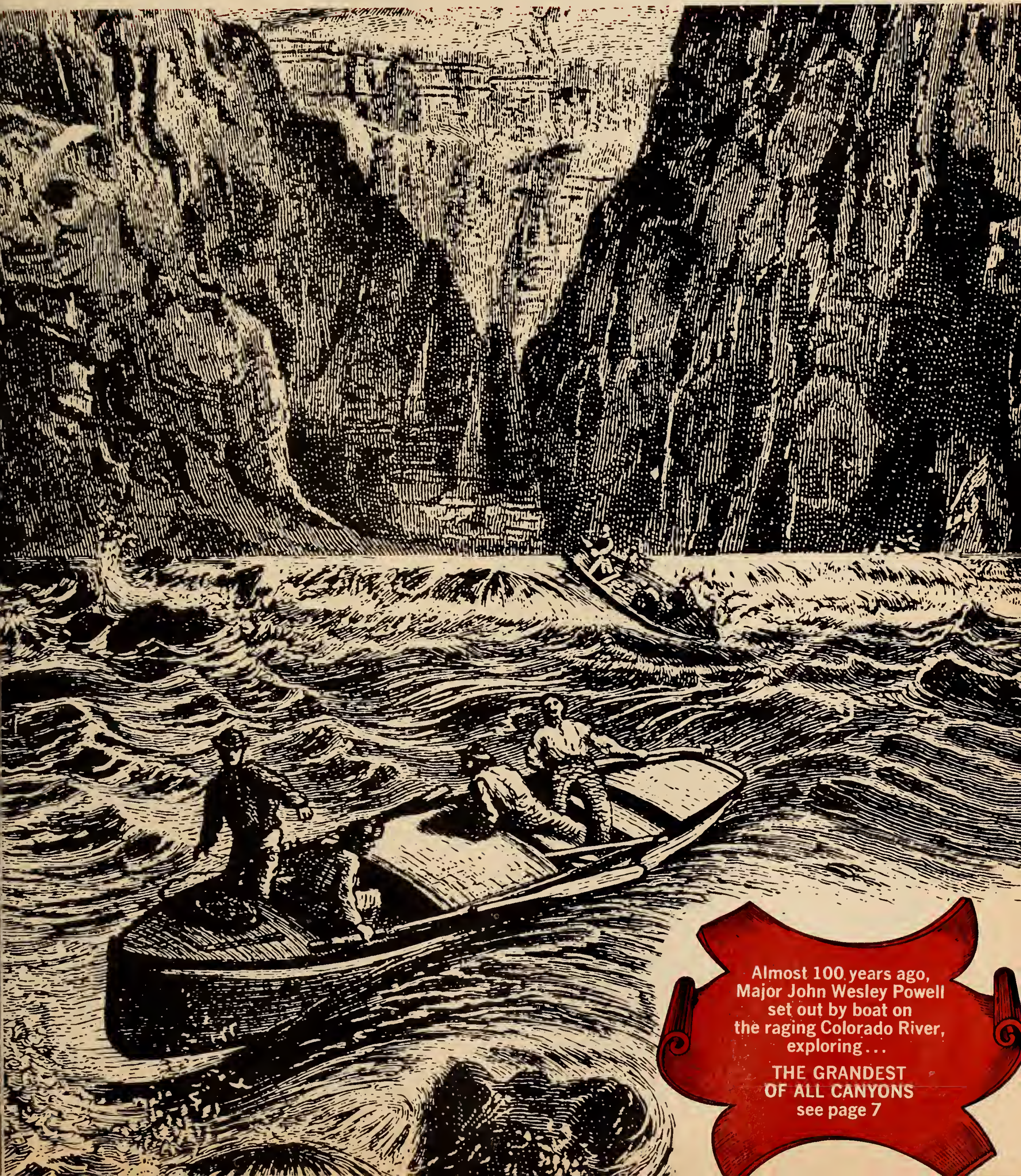
find out why a balance balances
see pages 13 and 14

WHERE'S YOUR BALANCING POINT?
and
WEIGH-OUT BALANCES



Almost 100 years ago, Major John Wesley Powell set out by boat on the raging Colorado River, exploring . . .

THE GRANDEST OF ALL CANYONS
see page 7

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** R. J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Roma H. Gans; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen
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THE MYSTERY OF THE MAYAS

Part 1

by Diane Sherman

The ruins of once-beautiful cities in the forests of Central America tell scientists much about the amazing people who built them—but not why these cities were suddenly abandoned about 1,100 years ago.

■ In the late 1700s, a group of explorers cutting their way through a forest in Central America came upon the ruins of an ancient city. Under a tangle of trees and vines, they found large, well designed stone buildings and handsome stone monuments. Some of the stones were covered with a strange kind of writing. Carvings on other stones showed that at least some of the people who had lived in the area long before were highly advanced.

In the next 150 years, more cities were discovered. They seemed to be part of a great civilization stretching across 500 miles of forest (*see map*). In 1881, an Englishman named Alfred Maudslay led the first big scientific expedition to study the ruins. Maudslay was an *archeologist*, a scientist who studies the remains of ancient communities for clues to how the people lived. Other expeditions followed, but at first they found more questions than answers: Who built the cities, and when? How had the people lived,

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Act of October 23, 1962; Section 4369, Title 39, United States Code) 1. Date of filing: October 1, 1967. 2. Title of publication: Nature and Science. 3. Frequency of issue: Fortnightly October, December through April; monthly September, November, May and July. 4. Location of known office of publication: 501 Franklin Avenue, Garden City, Nassau, New York 11530. 5. Location of the headquarters or general business offices of the publishers: 501 Franklin Avenue, Garden City, New York 11530. 6. Name and addresses of publisher, editor, and managing editor: Publisher: James K. Page, Jr., 277 Park Avenue, New York, N.Y. 10017; Editor and 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. 11530. The names and addresses of stockholders owning 1% or more total amount of stock are: Brown Brothers, Harriman & Co., 59 Wall Street, New York, N.Y. 10005; King & Company c/o First National City Bank, P.O. Box 2791, Grand Central Station, New York, N.Y. 10017; C. A. England & Co., c/o Chemical Bank New York Trust Co., Box 1316, Church Street Station, New York, N.Y. 10008; Gerlach & Co., c/o First National City Bank, P.O. 2791, Grand Central Station, New York, N.Y. 10017; Ellen Doubleday, Nelson Doubleday, Janet Doubleday, Nellie Sings, Madeleine V. Martin, Lawrence McNaughton, Robert McNaughton, and Ellen Violett (all c/o Doubleday & Company, Inc., 277 Park Avenue, New York, N.Y. 10017). 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. Non-applicable. 10. Extent and Nature of Circulation: The average number of copies each issue during the preceding 12 months are: (A) Total number of copies printed (net press run): 269,453; (B) Paid circulation (1) Sales through dealers and carriers, street vendors and counter sales: 375; (2) Mail subscriptions: 232,658; (C) Total paid circulation: 233,033; (D) Free distribution (including samples) by mail, carrier or other means: 2,929; (E) Total distribution (Sum of C and D): 235,962; (F) Office use, left-over, unaccounted, spoiled after printing: 32,491; (G) Total (Sum of E&F—should equal net press run shown in A): 269,453.
The number of copies single issue nearest to filing date are: (A) Total number of copies printed (net press run): 282,000; (B) Paid circulation: (1) Sales through dealers and carriers, street vendors and counter sales: 375; (2) Mail subscriptions: 213,256; (C) Total paid circulation: 213,631; (D) Free distribution (including samples) by mail, carrier or other means: 910; (E) Total distribution (Sum of C and D) 214,541; (F) Office use, left-over, unaccounted, spoiled after printing: 67,459; (G) Total (Sum of E&F—should equal net press run shown in A): 282,000.
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James K. Page, Jr.
Publisher

This temple, as high as a 14-story building, was built about 1,300 years ago in the Mayan city of Tikal (see *map*). The photo below was taken 10 years ago, when scientists and workmen had only begun to clear away the plants.

here in the middle of a rain forest? Most puzzling of all, what happened to them?

Gradually some of the answers have been pieced together. Today, living in parts of Mexico and Guatemala, there is a brown-skinned Indian people called the Mayas. Scientists believe that the ancestors of these Indians built the cities and carved the stone monuments.

Temples and Palaces

Dates carved on some monuments show they were put up between 300 and 800 A.D., but bits of buried pottery tell us that the Mayas had lived in some of their cities for hundreds of years earlier. At the height of Mayan civilization, there must have been over two million people living in and around hundreds of beautiful towns and cities.

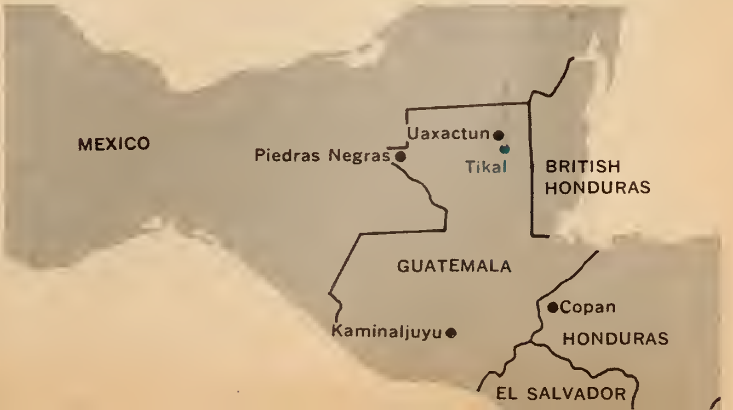
Archeologists digging in these cities have uncovered roads, a few water reservoirs, and temples built one on top of another. Handsome pictures made of sculptured plaster and painted in bright colors were found on the walls of buildings. Painted pots and pieces of carefully carved jewelry were discovered in tombs under the floors of temples. These pictures and objects showed much about the Mayas' life. There were scenes of people working, people at war, nobles holding court, priests in fantastic costumes, and Mayan gods.

For a long time, archeologists worked only on uncovering large Mayan structures, such as temples, palaces, and ball courts. Little effort was made to find the remains of smaller buildings, such as houses. The seeming absence of houses led people to believe that the cities were only the homes of priests and rulers, who lived in the palaces. They thought the ordinary people probably lived in the countryside and came to the cities only for religious ceremonies.

A New View of Mayan Life

In recent years, new evidence has been uncovered at a number of Mayan cities by different groups of archeologists. The University Museum of the University of Pennsylvania, in Philadelphia, has just finished a 12-year study of Tikal, the biggest of the Mayan cities. More than 100 small houses in Tikal were dug up. Room arrangements

(Continued on the next page)



were often different, and the contents of the houses varied too. Some had many remains of finely-decorated pottery. Others had fewer and plainer pieces. The houses were very close together, with little space to raise food, except in small gardens.

These new findings changed our picture of Mayan life. Dr. William R. Coe, Director of the Tikal project, says Tikal must have been a real city after all, at least for part of its history. It must have had a big population. The differences in the houses show that there were many different classes of people. Perhaps some were craftsmen—the stonecutters, sculptors, and painters who worked on new temples and monuments.

Stone monuments like this, which the Mayas put up in their cities, may be records of what important persons did. Scientists study the words and pictures carved on the monuments for clues to the ancient language and customs.

As archeologists studied the Mayas, they became more and more impressed by how much these people had been able to do. In other parts of the world, people were using metal tools before they began building cities. They also had wheels and carts to help move loads, and domesticated animals to push or pull them (*see "Around and Around," N&S, September 18, 1967*). The Mayas had none of these things. Their only tools were made of wood or stone. Yet they cut and moved rocks weighing thousands of pounds, and built temples over 200 feet tall.

Writers, Mathematicians, Astronomers

But the Mayas could do more than just make buildings and works of art. One of the most important things they did was learn to write. When some of the Mayan writing was figured out, archeologists discovered how much the Mayas knew about other things, too.

In mathematics, they could count up to the millions. They were the first people to figure out how to use the zero with other numerals to make working with large numbers easier.

In astronomy, too, they were way ahead of other ancient peoples. Records show that the Mayas had observed the skies for centuries, keeping track of what they saw. They knew how long the moon took to go around the earth, and how long the planet Venus took to come back to the same place in the sky. They could predict eclipses, and they worked out a calendar of eighteen 20-day "months" and one five-day "month" that measured the year as accurately as the calendar we use today.

Beginning about 800 A.D., something mysterious happened to the Mayan civilization. Activity stopped in one city after another. For 500 years before, new monuments had been set up regularly every 5, 10, or 20 years. Now, there were no new monuments. No more temples were built. In one place, work stopped so suddenly that walls were left unfinished. In other places, the foundations for new buildings were left bare. In every city, the last dated monument was set up sometime between 800 and 900 A.D. Archeologists believe that was about the time when most of the people moved out of the cities.

What could have happened? Were the Mayas driven out of their cities by invaders? Or by disease? Did their food supply fail? Did they revolt against their rulers? In the next issue, the second part of this article will tell how scientists have examined some of these theories in trying to solve the mystery of the Mayas ■

Scientists believe the center of Piedras Negras (see *map*) looked like this when it was a bustling city that produced the finest sculpture in the Maya world.

In Search of a Gas

Scientists didn't know what they were looking for when they began to investigate air, and it took a century of experimenting by many men before they realized what they had discovered.

by John S. Bowman

It is everywhere around us, but we never see it, taste it, feel it, or smell it. We cannot live without it or build a fire without it. "It," of course, is oxygen, one of the gases of the air we breathe. Yet it was less than 300 years ago that scientists began to investigate the air, and less than 200 years ago that they collected pure samples of this "gas of life" and named it oxygen.

Before then, men had believed that air was a single substance. That idea was started by ancient Greek thinkers who taught that all things were made of mixtures of only four substances—air, earth, fire, and water. For example, one man claimed that the bones of our bodies were made up of one-half fire, one-quarter earth, and one-quarter water. These substances came to be known as "the elements," but they are not what scientists call elements today.

When scientists of the 1600s and 1700s began to experiment with air, the old "four elements" idea could no longer explain many of the things scientists were discovering. New ideas and new words had to be tried.

The "Material of Fire"

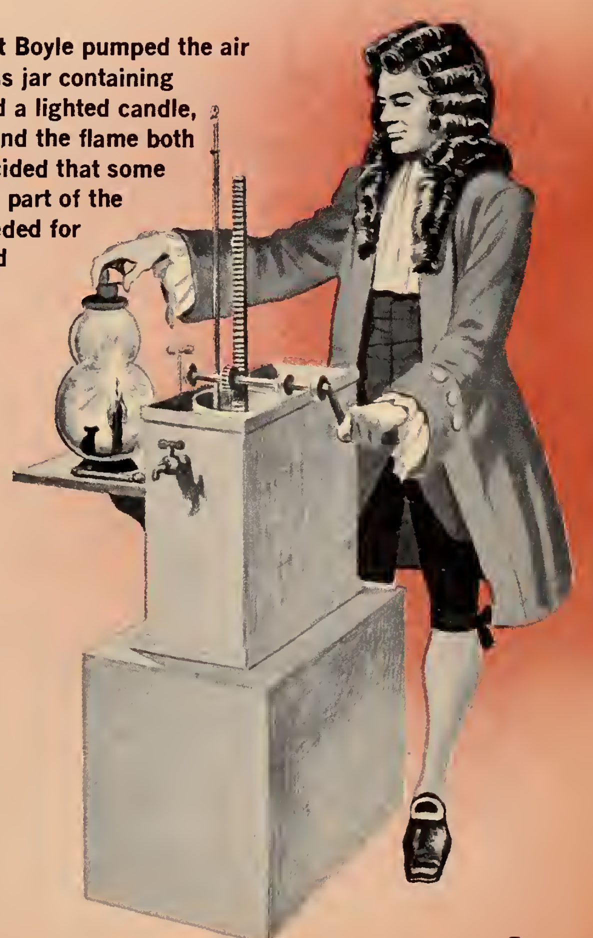
About 300 years ago, the great English chemist, Robert Boyle, was especially interested in understanding air. He placed a small bird or a mouse in a glass container with air. The container was sealed off from the air outside, and Boyle found that the animals could not breathe if left in the container too long. He saw, too, that candles could not burn very long in such a container. Yet he knew there was still some air left in the container.

Boyle came to believe that there was some "mysterious part of the air" that allowed a candle to burn. He also suspected that the same "part" of the air allowed animals to breathe. But he was unable to separate this "mysterious part" from air.

Other scientists were investigating air about the same time as Boyle. They were also coming to see that there was some connection between air and breathing and between air and burning. But by 1700 most scientists became sidetracked by a theory that later turned out to be false.

This theory claimed that the link between air and breathing and air and burning was a "material of fire" called *phlogiston* (flo-gis-tun, from a Greek word meaning "flammable"). According to this theory, all substances that burned had some phlogiston, and as they burned they released this phlogiston into the air. The air given out by breathing also contained phlogiston. How did it get into the bodies of men and animals? In the food they ate, so the theory went.

Air itself, according to this theory, could hold only a limited amount of phlogiston. When air became filled up with this substance, it could no longer hold any more of the phlogiston given off by breathing or burning. That was why animals stopped breathing, and candles stopped burning after a short time in a space that was sealed off from the outside air. *(Continued on the next page)*



When Robert Boyle pumped the air out of a glass jar containing a mouse and a lighted candle, the mouse and the flame both died. He decided that some "mysterious part of the air" was needed for both life and burning.

Today we may find it easy to laugh at the idea of a "material of fire." In its day, though, the phlogiston theory seemed to explain many of the basic facts of nature. Still more important, the theory encouraged scientists to proceed with their work. During the first half of the 1700s, many men were investigating air and gases. We now know that some of them even collected fairly pure samples of oxygen. But they did not know what they were working with, so we cannot say they discovered oxygen.

Who "Discovered" Oxygen?

By 1770, various scientists recognized that air was a mixture of gases. And by 1773, the Swedish chemist Carl Scheele had prepared a gas that he called "fire air," because other substances burned so rapidly in it. We now know that this gas was oxygen. But Scheele did not announce his findings until several years later, so his work did not affect other scientists. And by 1774, the French chemist Pierre Bayen had also obtained oxygen. He did this by heating mercury that has oxygen combined with it. The heat released the oxygen from the mercury. Bayen realized that the gas he got was different from air, but he did not know what it was and made nothing out of his findings.

At this same time, the Englishman Joseph Priestley was conducting his own experiments with gases. By 1772 he probably had obtained pure oxygen, but he did not realize it at the time. And by 1774, he may have heard of the work of Pierre Bayen. In any case, by August 1774, Priestley was experimenting with the same substance that Bayen had used. He set up a large magnifying glass to focus the sunlight on the substance and heat it. Then, in a series of steps, he collected a gas in a jar. He put smoldering splinters of wood into the jar, and they burst into flame. He put a lighted candle in, and it burned much more brilliantly than in ordinary air.

In March of 1775 he collected more of this new gas in a sealed jar. He placed mice inside the jar. With ordinary air they would have survived only about 15 minutes. But Priestley observed that one mouse lived "at two different times a whole hour and was taken out quite vigorous." Priestley himself breathed some of the gas and found it made him feel "light and easy."

Priestley had been giving this new gas various names as his work proceeded. Now he decided it was "dephlogisticated air"—that is, common air with its normal portion of phlogiston removed. In fact, Priestley had isolated oxygen. And because he made these deliberate experiments, because he realized he had a new gas, and because his work influenced other scientists, Priestley is given credit for discovering oxygen. But to the end of his life he believed in the phlogiston theory.

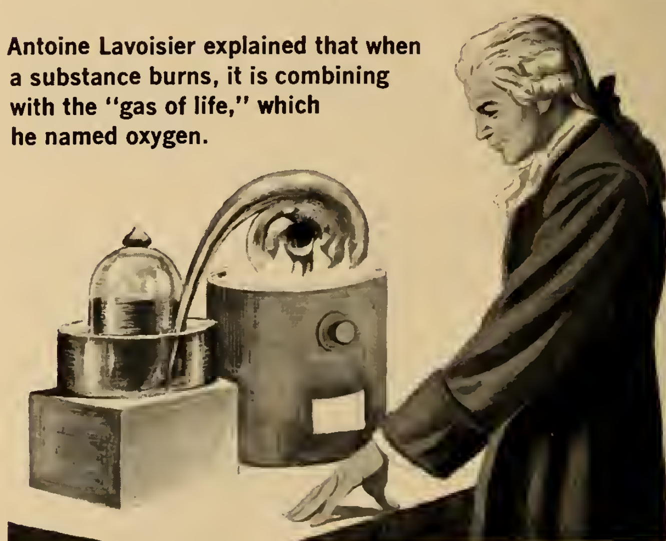
The great French chemist, Antoine Lavoisier, began studying the burning process in 1770. By 1772, he had discovered that certain substances increase in weight when burned in air. Yet according to the phlogiston theory, burned substances should lose weight by giving off phlogiston. Lavoisier realized he had hit upon something unusual and he began to doubt the phlogiston theory.

How Oxygen Got Its Name

In 1774, Priestley visited Paris, and Lavoisier heard him describe his experiments with the candle and smoldering wood. Lavoisier repeated Priestley's experiments and went on to make more elaborate ones of his own. He realized that this new gas behaved quite differently from ordinary air. By 1777, Lavoisier had decided that the new gas was only one of several gases that make up air, and that substances increase in weight when they are burned because this gas combines with them in the burning process.

It was this work of Lavoisier that led him to present the modern idea of the elements: They are the basic materials that form substances such as air, earth, and water. Lavoisier also proposed a name for the new gas—"oxygen." It is interesting to note that Lavoisier made an

Antoine Lavoisier explained that when a substance burns, it is combining with the "gas of life," which he named oxygen.



error here. The name was based on Greek words meaning "acid producer." Lavoisier mistakenly believed to the end of his life that this new gas was a part of all acids.

Like the discovery of oxygen, scientific discoveries are seldom as simple and as easy as they may seem when you read, for example, that "Oxygen was discovered by Joseph Priestley in 1774." For convenience, of course, we usually settle on one man and one date. But this story may make you think twice the next time someone asks you, "Who discovered . . . ?" ■

GRANDEST OF ALL CANYONS

"The ages have been at work on it and man can only mar it."
—Theodore Roosevelt

■ Ten million years ago, more or less, the Colorado River shifted its course. Instead of flowing south through what is now Arizona, the river turned west across the flat Kaibab Plateau *(see diagram)* and headed for the Gulf of California. This marked the birth of the Grand Canyon.

Today the canyon is a mile-deep gash in the earth, up to 18 miles wide and 217 miles long. It is one of the world's most famous sights, and many thousands of people visit it each year.

The Grand Canyon is a spectacular example of *erosion*—the wearing away of the land. We usually think of erosion as something "bad." It is harmful when valuable topsoil is washed away from croplands. Yet, erosion goes on to some extent all of the time, wherever wind or water wear away particles of soil and rock.

The Colorado River has always been a muddy stream. It carries eroded soil, rocks, and even boulders. Its waters are "too thick to drink and too thin to plow." The soil and rocks in the river's waters are its cutting tools. They scour and scrape along the stream bed, wearing away layer after layer of rock. Scientists estimate that the river has worn away a foot of rock in the canyon every 2,150 years.

The river has now cut a mile down into the Kaibab Plateau. As it cut deeper and deeper into the rocks, rainwater and small streams began wearing away the surrounding country, making side canyons and widening the main canyon.

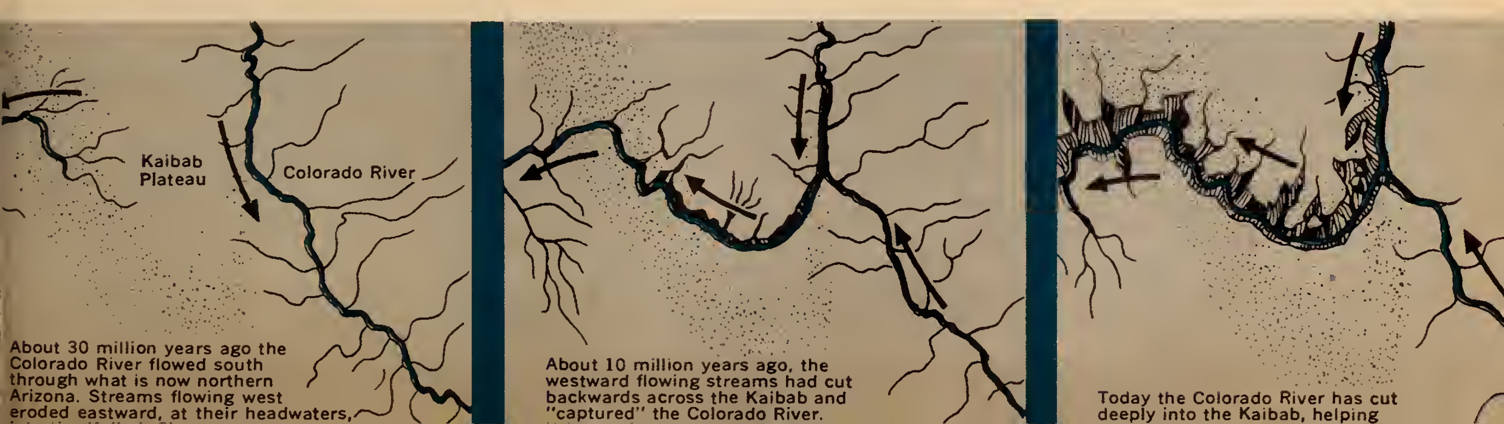
Grand Canyon has been carved in the earth during the past 10 million years, but the rocks of the canyon walls are much older than that. At the bottom of the canyon, where the river flows, the rocks are about two *billion* years old. These rocks once were part of a towering mountain range. The tops of the mountains eroded away after millions of years. Now all that can be seen of the mountains are their "roots"—layers of dark-colored rock deep in the canyon.

Above the dark rocks at the canyon's bottom lie many layers of younger rocks. By examining the different layers, *geologists* (scientists who study the history of the earth) can learn how and when the rocks were formed.

The rocks of the canyon's rims, for example, are white limestone that is about 225 million years old. This 300-foot layer of rock was formed from the shells of sea animals that settled to the bottom of a shallow sea that then covered the area. (Since then, shifts in the earth's crust have raised southwestern North America far above sea level.) The limestone contains many fossils of animals—corals, sponges, sharks—that lived in the sea.

For scientists who study the history of living things on earth, the Grand Canyon is much more than an outstanding example of erosion. The layers of rocks—and the fossils preserved in them—reveal many clues to the past life on earth and how it has changed *(see pages 8 and 9)*.

(Continued on page 10)



About 30 million years ago the Colorado River flowed south through what is now northern Arizona. Streams flowing west eroded eastward, at their headwaters,

About 10 million years ago, the westward flowing streams had cut backwards across the Kaibab and "captured" the Colorado River.

Today the Colorado River has cut deeply into the Kaibab, helping

Nove

The Rocks of Grand Canyon and How They Formed

Warm shallow seas covered the area until about 225 million years ago. Shells of sea animals settled at the bottom and eventually became rock such as Kaibab Limestone, the canyon's rimrock today.

Desert dunes covered the area about 240 million years ago. The desert sand was later pressed into Coconino Sandstone.

Mud and clay carried by freshwater streams were deposited in this area. Later the sediments were pressed into layers of rock 300 feet thick, called Hermit Shale.

The Supai Formation, formed about 275 million years ago, is 1,000 feet thick. Layers of shale formed when the area was covered by a shallow sea; the upper sandstone rocks were formed of sand that was deposited by rivers.

After the rocks called Muav Limestone were formed, the land lifted above the sea for a time and was eroded. Then the seas closed in again. The valleys and gullies worn in the Muav Limestone were filled with sediments that slowly became the lavender-colored Temple Butte Limestone.

REDWALL LIMESTONE

MUAV LIMESTONE

BRIGHT ANGEL SHALE

About 200 feet thick, this layer is called Tapeats Sandstone. Ripple marks preserved as fossils in the rocks show that they were formed along the edge of a sea.

Thick layers of sediments, such as mud and the remains of simple plants, were pressed together to form these layers of limestone and shale, once perhaps about 12,000 feet thick. Later, the giant layers cracked and tilted, forming "fault block" mountains. But by 600 million years ago, the mountains had been worn away and only tilted wedges like this remained.

This section of rock is all that remains of an ancient mountain range of two billion years ago. The rocks are mostly granite and schist and probably extend thousands of feet below the present river bed. By about 1.2 billion years ago, the mountains had been worn down to a flat plain.

Color

HISTORY IN

■ You might think that a history
heavy reading. But the Gran
pages are full of exciting even
Colorado River began flowing
cut through layer after layer
canyon's bottom. The younges
volcanoes that erupted only
of the hot, liquid rock *(lava)* f
the canyon. Today some of th
canyon's rapids. The next young
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rocks used to cover them, inclu
dinosaurs and early mammals
least 4,000 feet thick, were
Colorado River began carving
walls, each layer of rock was
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Grand Canyo

THE ROCKS

Fossils of Plants a
Animals Discover
in the Rocks
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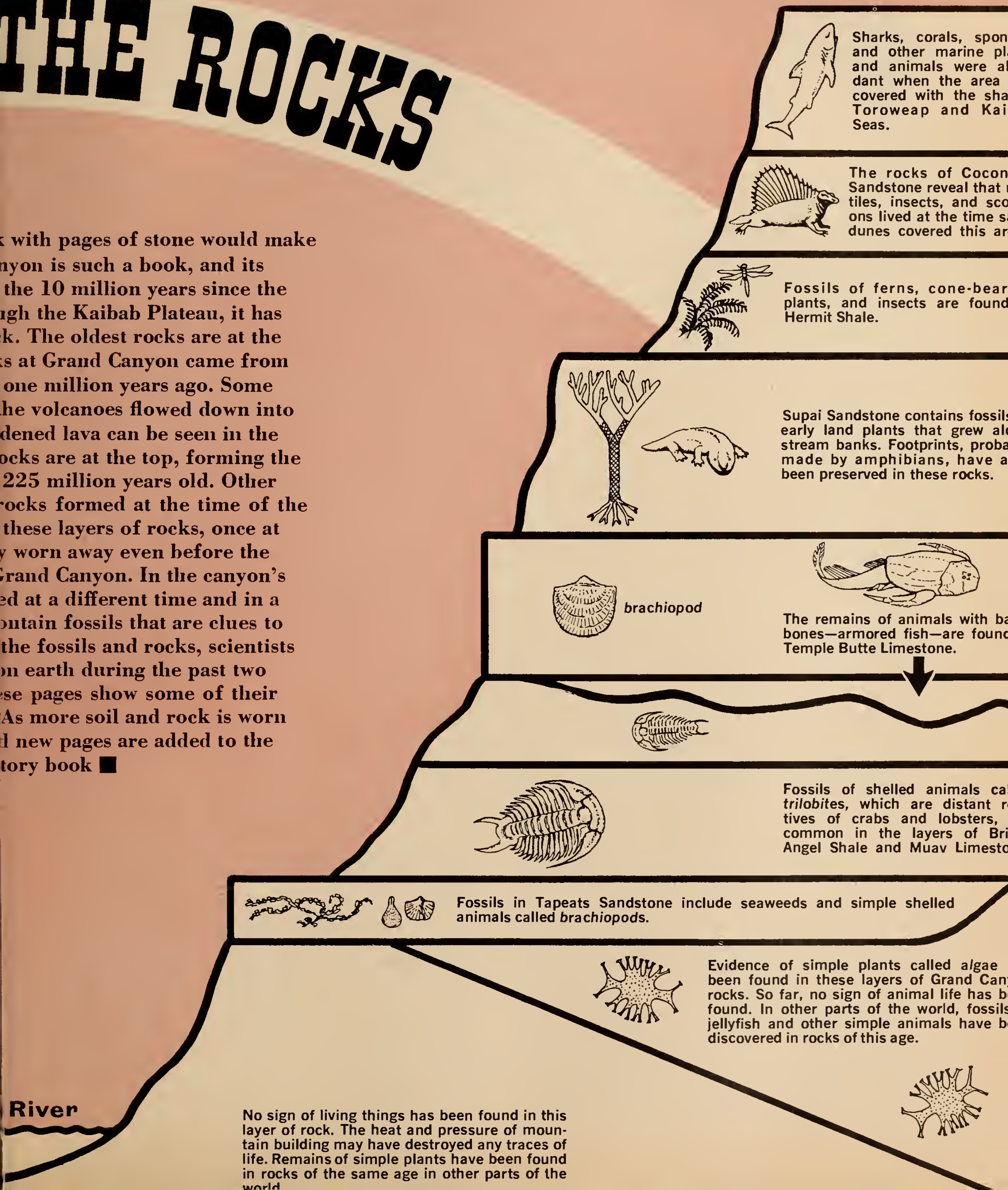


ABERT SQUIRREL, south rim

KAIBAB SQUIRREL, north rim

Long ago, only one kind of tree squirrel lived on the Kaibab Plateau. Then the Grand Canyon formed a barrier that squirrels could not cross. As a result, the squirrels on opposite sides of the canyon have evolved in different ways.

Grandest of All Canyons (continued)

When former President Theodore Roosevelt first saw the Grand Canyon, he said, "Do nothing to mar its grandeur. . . . Keep it for your children, your children's children, and all who come after you, as the one great sight which every American should see."

Part of the canyon is protected by a National Park and a National Monument *(see map)*. To the casual visitor, the vast canyon seems undisturbed by man. But the Glen Canyon Dam *(see map),* built upstream from the Grand Canyon in 1963, has affected the Colorado River. Most of the soil, pebbles, and other *sediments* carried by the river are trapped behind the dam. (Eventually, the lake formed by the dam will completely fill with sediments carried by the river.)

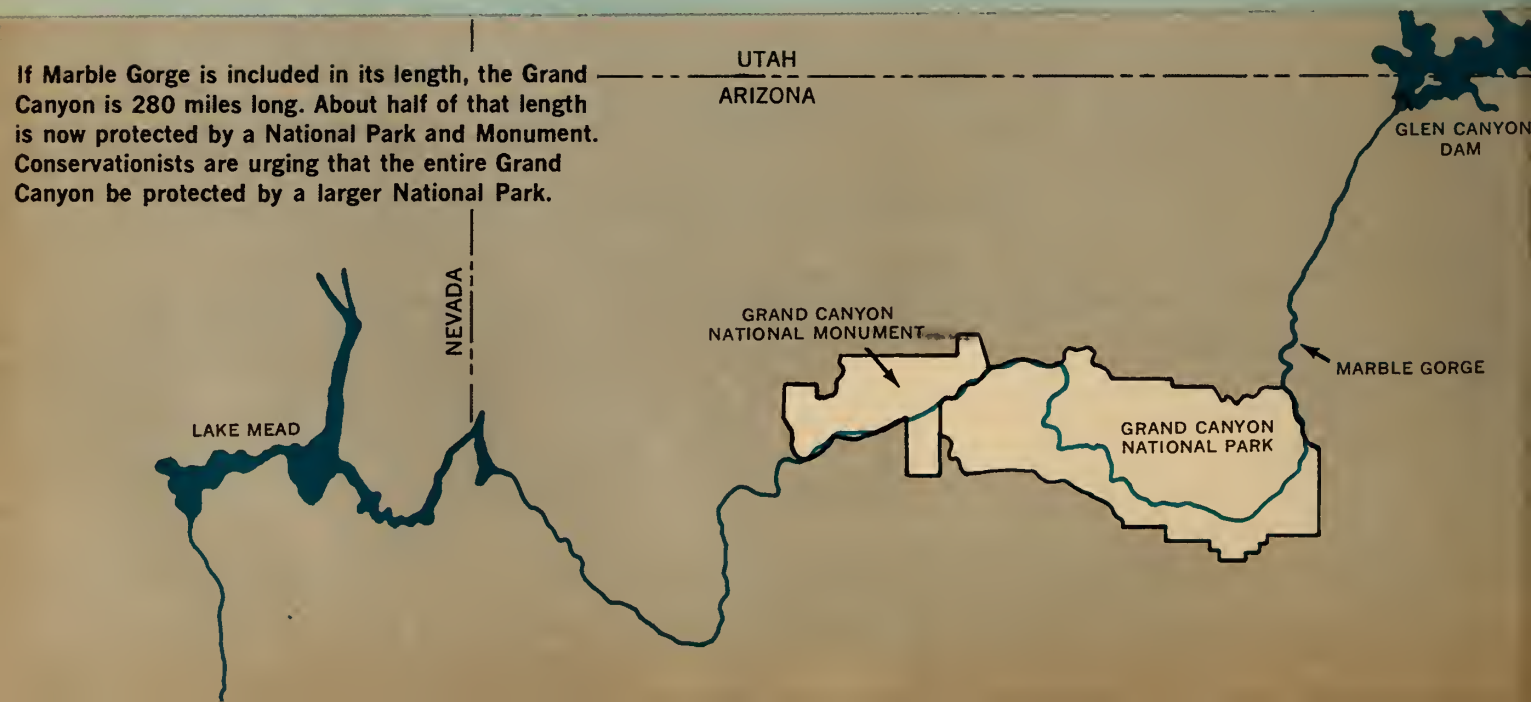
As the Colorado River leaves Glen Canyon Dam, it now carries only about one-sixth as much sediment as it used to carry. This means that the river is wearing away the rock more slowly.

Looking into the future, geologists predict that the Colorado will cut another half-mile deeper into the Kaibab Plateau. Then, flowing more slowly, the Colorado will begin side-cutting, eroding away every pinnacle, mesa, and butte that now stands in the canyon. Erosion from rainfall and small streams will continue to wear away the sides of the canyon. Millions of years from now, if man leaves the Grand Canyon alone, the bottom of the canyon will have changed to a 50-mile-wide plain. There the Colorado River will gently flow and meander, its great work done.

—LAURENCE PRINGLE

For a detailed story of Grand Canyon, illustrated with many photographs, look in a library for **Time and The River Flowing: Grand Canyon,** by Francois Leydet, Sierra Club, San Francisco, California, 1964, $25. An excellent small book, also illustrated with many photos, is **Grand Canyon, the Story Behind the Scenery,** by Merrill D. Beal, KC Publications, 2115 N. Talkington Drive, Flagstaff, Arizona, 1967, $1 (paper).

If Marble Gorge is included in its length, the Grand Canyon is 280 miles long. About half of that length is now protected by a National Park and Monument. Conservationists are urging that the entire Grand Canyon be protected by a larger National Park.



Brain Boosters

prepared by **DAVID WEBSTER**

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   ME
 x WE
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  SSS
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FUN WITH NUMBERS AND SHAPES

Each different capital letter stands for a different numeral. Change the letters into numbers so the multiplication problem is correct.

Submitted by Robert Handel, Rye, New York

WHAT WOULD HAPPEN IF . . .

. . . you mounted a candle as shown (with the paper clip not quite at the center of the candle) and then lighted it at both ends? Would the candle stay tilted the same way as it burned? (Ask an adult to help you try this.)

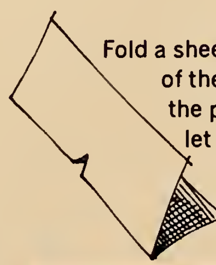
MYSTERY PHOTO

Which piece of wood was cut closest to the center of the log?

CAN YOU DO IT?

The drawing shows how to measure the amount of air that you blow out in one breath. Can you blow out more than a quart?

FOR SCIENCE EXPERTS ONLY



Fold a sheet of paper in half and cut a tiny triangle out of the folded edge (see *diagram*). When you open the paper, you will have a square hole. But if you let the sun shine through the hole onto another sheet of paper, the spot of light you see will be round. Can you explain why?

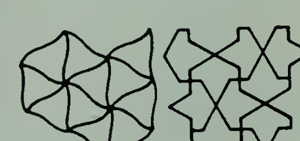
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The skull with the elongated incisor tooth probably came from a woodchuck whose lower incisor had been broken off. The upper and lower incisors of rodents grow continually, and are kept at the proper length by rubbing against one another. If a lower incisor were broken, the upper incisor would continue to grow unchecked.

What will happen if? A wet washcloth can move a door more than a ball of equal weight when both strike the door with the same force.

Can you do it? To throw a ball and make it come back without hitting something, throw it straight up into the air.

Fun with numbers and shapes: Here are two kinds of odd shapes that can be fitted together.



For science experts only: Bulbs A and B will be brightest. Which battery would last longest?

WHAT'S NEW

Ivory-billed woodpeckers *(see drawing)* have been seen so seldom in late years that scientists thought they were nearly extinct. But now John V. Dennis, an expert on woodpeckers, has seen three pairs of the birds in the Big Thicket country of eastern Texas. Mr. Dennis believes that there may be as many as five to 10 pairs of the ivory-bills in the area. The last ivory-bill had been seen in Florida, in 1950.

IVORY-BILLED WOODPECKER

The huge woodpeckers are about the size of crows, but are colored black and white. The male ivory-bill has a bright red crest, and the female has a black crest. The ivory-bills look a lot like the slightly smaller pileated woodpeckers that are fairly common in eastern woods.

Rats that solve problems may grow larger brains than rats that don't. Scientists at the University of California at Berkeley separated rats or mice born in the same litter into two groups soon after they were born. Each animal of one group was raised alone and was given no special opportunity to use its brain. Those in the other group lived together and were constantly given problems to solve, such as finding their food at the end of a tricky passageway with many "wrong turns."

The brains of the animals that had to solve problems grew larger than those of the animals that didn't have any problems to solve. The scientists believe that the problem-solving animals also developed more "brain-power" than the others, even though their brains returned to normal size after a while. The scientists believe that the human brain may also increase its size and its powers through use.

Sharp-eyed girl scouts made an important discovery along the shore of Lake Michigan, according to a recent report from Cornell University, in Ithaca, New York. The girls found a dead herring gull with a numbered band on its leg. They mailed the band, as requested, to the Biological Survey in Washington, D.C.

Exciting news came back. The gull, banded shortly after its birth, was 36 years old when it died. This is believed to be a world record for length of life in a wild bird. Previous record holder, as far as Cornell knows, was a herring gull that lived 31 years and 11 months. Captive birds have lived much longer than these wild ones.

Food won't be fancy aboard the Apollo spacecraft during its expected flight to the moon sometime before 1970. A typical meal, according to the National Aeronautics and Space Administration, may start with freeze-dried chicken à la king in a sealed plastic bag. Fitting a water nozzle into a valve in the bag, an astronaut will add hot water to make the contents warm and creamy. He'll squeeze a little into his mouth, and chew it with his mouth closed. If the food escaped while the craft and everything in it were "weightless" the food would float around in the spacecraft.

For dessert the astronaut may eat cookies—*and* the package they come in. Making packages edible is the best way to get rid of them. Tossing them overboard would be no solution, for it would produce a trail of litter coasting along after the spacecraft.

Crash! As the car slams into a tree, its front end collapses like an accordion. Unsafe to ride in? It may be safer than your family car. As the front end collapses, it absorbs some of the force of the collision. Cars with collapsible front ends are being tested at the Cornell Aeronautical Laboratory to see whether they can save lives and reduce injuries in auto accidents.

Cornell scientists are also testing a seat that will slide a few inches forward or backward in a collision. The rider will be held in the seat by a seat belt, and shock absorbers will bring the seat to a gradual stop. A new design for the seat itself is also being investigated. The new seat will "wrap around" the rider to protect him against injury from the sides.

A cushion of air enables this plane to take off and land without wheels. Air forced into the "hole" of the large, doughnut-shaped balloon pushes downward to lift the plane up or let it down gently. Many types of planes could use the air-cushion device, developed by the Bell Aerosystems Company in Buffalo, New York. They could then come down or take off on land, water, ice, snow, sand, or swamp.

These boys and girls in Riverdale, New York, are trying to tip over the blocks with their noses without tipping over themselves. Can you do it?

Where's your Balancing Point?

by Laurence B. White, Jr.

Is it the same for girls as for boys? Here is a way to find out.

■ You can balance a ruler on your fingertip at least four different ways: with a flat side, an edge, an end, or a corner resting on your finger. It will only balance, though, as long as your fingertip is under the center of the ruler.

Every object—a car, an elephant, a feather, for example —has a *balancing point*. But such objects are not as evenly shaped as a ruler, and they are made of many different materials, so it is harder to find their balancing points. Balance a curved banana or a small, curved tree branch on your fingertip. Try balancing it on its end as well as on its side. Where do you think its balance point is?

The balance point of an object is called its *center of mass*. The *mass* of an object is the total amount of material it is made of. If the object is made of all the same kind of material and is evenly shaped—like a ruler or a solid rubber ball—its center of mass is at the middle of the object. But for an unevenly shaped object made of different kinds of materials—like a car, banana, or feather — the center of mass is not likely to be in the exact middle of the object. As long as the center of mass of an object is resting over whatever is holding the object up, the object will remain balanced.

You have a center of mass too. When you are standing it is somewhere in your middle, between your hips and your waist. Just exactly where it is depends upon how much you weigh, how long your legs are, how large your bones are, and how your mass is spread around. When you are standing up straight, your center of mass is right over your feet. As long as it stays there, you will remain standing. You are properly balanced. If you bend over or lean so that your center of mass is no longer over your feet, you will fall off balance. This rarely happens, because your brain tells you that you are falling and you automatically move your feet to a place where they will again be under your center of mass.

Make Your Friends Fall for You

Here is a way to find out what happens when you move your center of mass without moving your feet.

Have a friend stand with his back against the wall. His heels should be touching the baseboard. Drop a handkerchief on the floor, just in front of his toes. Ask him to pick up the handkerchief—*but he must not move his feet or*

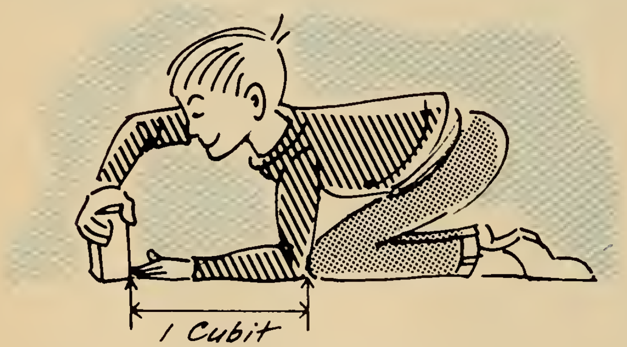
(Continued on the next page)

bend his knees! What happens to your friend? What happened to his center of mass? Where did it move?

Since a girl's mass is usually arranged differently from a boy's, do you think their centers of mass are usually in different places? You can make some tests to find out. The only equipment you will need is a small block of wood about 3 inches long. Try the experiment on yourself first. Afterwards you can ask a friend to try it, or better still, ask your teacher to conduct the experiment in a class with lots of boys and girls.

Get down on the floor on your knees *(see diagram)* and measure off one *cubit,* straight out from one of your knees. (A "cubit" is an old Egyptian measure. It is the length of your arm from the elbow to the tip of your middle finger.) Stand the block on end at the tip of your finger while your elbow is pressed against your knee.

Now, hold your hands behind your back, then slowly bend forward and try to knock the block over with your

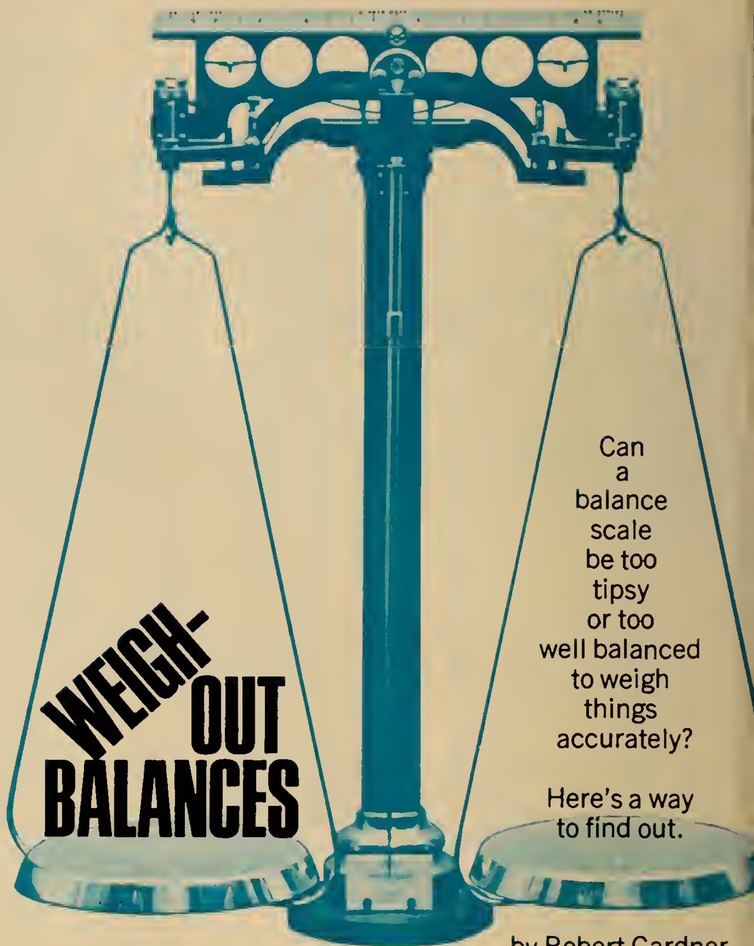


nose. Did you do it? Some people can, others cannot. It has nothing to do with how clever you are. It depends on how you are built.

As you tip forward, your center of mass also moves forward. If it moves over your support (your knees), you will fall. If it doesn't, you will succeed in knocking the block over. Try it several times, then try it on each member of your class. (Each person should use his own cubit to set up the block.) Let each person try it three times. Form teams—boys against girls. Who are the winners? Someone should record the numbers of boys and girls who succeed without falling ■

A QUICK QUIZ FOR YOUR BALANCE SENSE

1. Why should a person not stand up in a tippy boat?
2. What problem does a person have riding on a surfboard?
3. Why is it hard to walk a tightrope?
4. Why may it be dangerous to pull a chair out from under someone who is about to sit down?



WEIGH-OUT BALANCES

Can a balance scale be too tipsy or too well balanced to weigh things accurately?

Here's a way to find out.

by Robert Gardner

■ A balance scale is one of the most valuable tools in a scientist's laboratory. An expensive balance like the one shown here will weigh an object to the nearest 1/10,000th of a gram (a gram is about 1/28th of an ounce). Other balances may be accurate to only one gram.

You can make a simple balance *(see directions on the next page),* find out how it works, and investigate ways to make it more or less sensitive to weight.

Finding a Rule for Balancing

When your balance is made, get a dozen or so steel washers that are identical and at least one inch in diameter. Hang one washer on one of the number 5 clips. Where should you hang a second washer to make the beam level again? Where should you place two washers on the left side of the beam to balance one washer at the number 4 position on the right side?

Try to find combinations that balance. Record the number of washers at each position on the left and right side of the beam for each combination that balances. Experiment with the washers and see if you can fill in the missing numbers in the table below. Can you find a rule that always enables you to balance the beam?

	LEFT SIDE OF BEAM		RIGHT SIDE OF BEAM	
TRIAL	WASHERS	POSITION	WASHERS	POSITION
A	1 at	3	1 at	3
B	2 at	4	— at	2
C	3 at	5	5 at	—
D	2 at	—	— at	—
E	2 at 3 at	3 and 4	6 at	—
F	1 at 3 at	5 and 3	— at 2 at	2 and 4

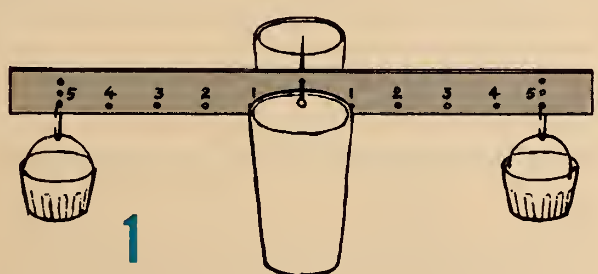
You can see that the distance of the washers from the center support is as important in balancing the beam as the number of washers on each side. Can you find a way to make the *number* of washers and the *number* of inches they are from the center on the left side of the beam equal the *number* of washers and the *number* of inches they are from the center on the right side? Try adding, dividing, or multiplying the numbers of washers and inches on each side of the beam when it is balanced.

PLAY THE BALANCE GAME

Hang some washers on the left side of the beam and give a friend some washers. Challenge him to make the beam balance without moving washers once they have been placed on the hooks. Then let him challenge you.

Do you think it makes any difference where the nail that supports the beam is located on the center line?

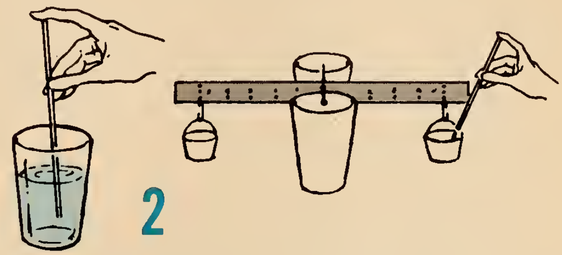
To find out, remove all the paper clips except the two in the number 5 holes. Make two "pans" of small paper cups with paper clip handles and hang them on these two hooks *(see Diagram 1)*. If the beam is not level, trim a little



cardboard from the heavy end.

Will a washer in one of the cups balance a washer in the other cup? Which weighs more, a penny or two dimes? How many paper clips does one washer weigh? Try weighing some other things such as erasers, pencils, coins, paper, and so on. How many paper clips does each of the things weigh? Can you weigh something that weighs less than one paper clip? How?

To find out what happens when you change the position of the center nail, you will have to use water drops, instead of paper clips, as weights. Place a drinking straw in a glass of water, then cover the top end of the straw with your index finger *(see Diagram 2)*. Some water will remain in



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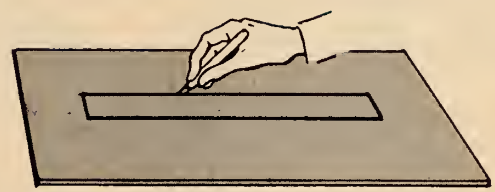
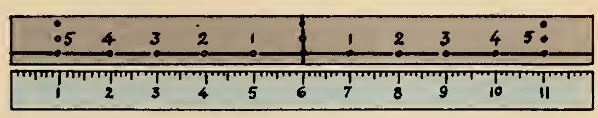
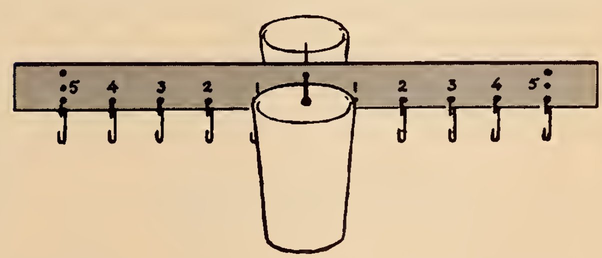
HOW TO MAKE A BALANCE



Place a 1-foot ruler on a piece of stiff cardboard, and draw an outline of the ruler with a pencil. Have an adult help you use a sharp knife to cut out the section of cardboard you have outlined.



Draw a line across the exact center of the cardboard and another line ¼ inch from one side. Use a nail to punch holes at the positions shown here. Number the holes.

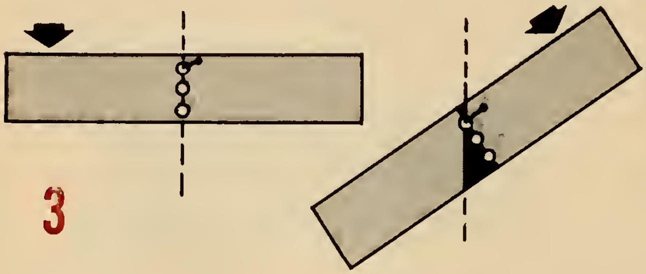


Push the nail through the top center hole, and support the ends of the nail between two large cans, glasses, or books. Unfold 10 paper clips and suspend them from the holes along the base of the cardboard beam. If the beam is not level, trim a little cardboard off the heavy end with scissors.

the straw when you lift it out of the glass. (Can you explain why?) By lifting your finger from the top of the straw for an instant, you can let a single drop of water fall out and into the balance pan.

With the nail in the upper center hole, how many drops of water must you add to one of the pans before it touches the table? Now place the nail in the *middle* center hole. How many drops of water are needed to make the pan touch the table? What happens when you put the nail in the *lower* center hole?

When the nail is in the top hole, tipping the beam to the left moves some of the weight of the beam to the right side of the nail, and this extra weight tends to make the beam swing back to a level position *(see Diagram 3).*



3

The beam is very *stable,* or well balanced, in this position. But it is not very *sensitive*—that is, it doesn't move very far when just a little bit of weight is added to one side.

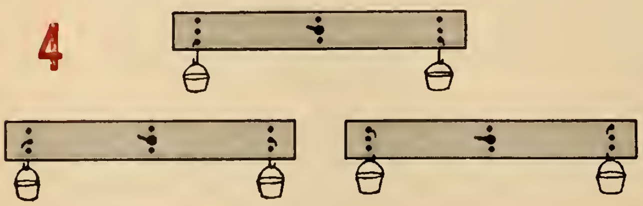
When the nail is in the bottom hole, tipping the beam to the left moves some of its weight to the left side, making it tip even farther to the left. Such a balance is so sensitive and unstable that it is useless.

Can you explain what happens when the nail is in the exact center of the beam? Which position should the nail be in to weigh things as accurately as possible?

A Look at the Ends of the Beam

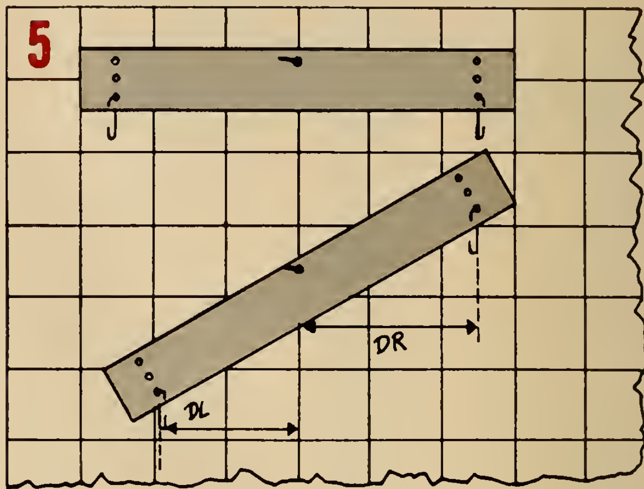
Does it make any difference where you hang the paper clip hooks that support the pans at the ends of the beam? Try three different arrangements shown in Diagram 4.

4



How many drops of water do you have to add to one of the pans before it will touch the table? Which arrangement is unstable? Which is least sensitive?

You can see what happens in each case by drawing a picture of the beam on a sheet of graph paper *(see Diagram 5).* If the pan is suspended from a point *below* the center

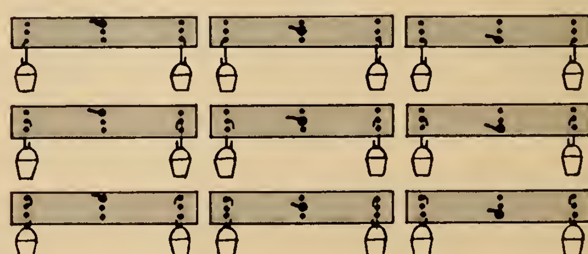


support, as the beam swings down on the left the distance (DR) from the center line to the point where the pan pulls on the beam on the right side becomes greater than the distance (DL) on the left side. This will make the beam tend to swing back toward its level position.

What will happen if the pans are supported from points *above* the level of the center nail? What if the pans are supported from points on the *same level* as the nail? ■

MORE INVESTIGATIONS

1. If you move the pans closer to the center of the beam, will it make the balance more or less sensitive? Does placing several washers in each pan make the balance more or less sensitive than when the pans are empty?
2. Which of the balances shown below would be unstable? Which would be most sensitive <u>and</u> useful? Which would be the least sensitive?
3. Which of the balances shown below would you use to weigh chemicals in a pharmacy? Which balance would you use to weigh bananas in a grocery store?
4. What problems would you find if you tried to weigh heavy objects on your balance?
5. What could you do to improve your balance? Can you build a better one?



Using This Issue . . .
(continued from page 2T)

cause the pull of gravity is weaker the farther the object is from the earth's center of mass.

However, for objects at the same distance from the earth's center of mass, the weight of the object depends on its mass, so mass is usually measured in terms of weight.

• *Why does this article refer to an object's balancing point as its* center of mass, *rather than its* center of gravity? Gravity is not the only force that acts on an object as if all of its mass were concentrated at one point. For example, if you throw a banana, it will travel in the direction your throw pushes the banana's center of mass. (This is true even if you hold the banana at one end as you throw it. In that case, though, some of the push you give the end of the banana makes it spin end for end around its center of mass as it travels through the air.)

Most scientists use the term center of mass instead of center of gravity because the location of that point depends on the arrangement of material in the object, not on the particular force that is acting on it.

Activities

• *Have your pupils try to balance a wire coathanger at various points and guess where its center of mass is located.* They will have trouble balancing the hanger by standing it on a finger, but suggest *suspending* the hanger from a finger—or, better, a nail or hook. When the coathanger comes to rest, it is balanced, because its center of mass is supported by the nail.

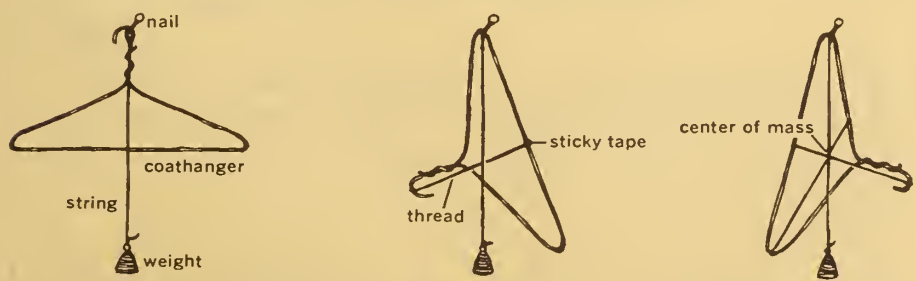
To locate the center of mass, suspend a plumb line (string with a weight tied to one end) from the nail *(see diagram)*. Since gravity pulls the centers of mass of the plumb line and the hanger in the same direction, the hanger's center of mass must be someplace along the plumb line, in the hanger. When the plumb line comes to rest, stretch a piece of thread between the top and bottom points where the string crosses the hanger, and attach the ends of the thread to the hanger with small bits of sticky tape. Then balance the hanger from each end of its large loop, attaching a thread to mark the points where the plumb line crosses the hanger in each balancing position. The point where the threads intersect is the hanger's center of mass.

• *Have your pupils think of some other objects whose center of mass is not in the material the objects are made of* (bottle, hoop, boomerang, etc.).

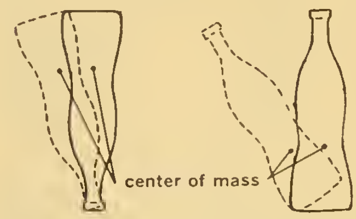
• *What happens to an object's center of mass when the shape of the object is changed?* Push the ends of another wire coathanger together to form a V, then use a plumb line to find its center of mass. Balance both hangers by their hooks from the same nail and your pupils can see that changing the arrangement of the material in an object moves its center of mass. Have them try to figure out what happens to the center of mass of their bodies when they bend over, stoop, sit, or lie down.

• *Have your pupils try to figure out why an empty pop bottle is easier to tip off balance when it is standing on its top (upside down) than when it is standing on its bottom.* The center of mass is centered between the sides of the bottle, but nearer the bottom than the top. Also, the bottom is much wider than the top. To tip the bottle off balance, you have to tip it so the center of mass is no longer over the part of the bottle that is supporting it. This distance is shorter when the bottle is balanced on its top than when it is balanced on its bottom *(see diagram)*.

FINDING THE CENTER OF MASS OF A COATHANGER



TIPPING A BOTTLE



Weigh-Out Balances

Have your pupils investigate balancing points *(see above)* before beginning this SCIENCE WORKSHOP on the use and characteristics of balance scales. For this workshop, you might divide the class into groups of three or four to make and investigate balances.

You will need a supply of stiff cardboard for balance beams, some 12-inch rulers, nails for beam supports, small paper clips, metal washers (identical), small paper cups, and drinking straws for water droppers.

Help your pupils to see that adding material (hooks, cups, washers, water —anything) to one side of the balance beam rearranges the mass of the beam and shifts the center of mass to that side of the nail supporting the beam. The farther the added mass is from the nail, the farther the beam's center of mass is shifted.

Your pupils should be able to discover this rule for balancing the beam: The number of washers on one side of the beam multiplied by the number of inches from the support must equal the number of washers on the other side multiplied by their distance in inches from the support. If there are washers at two or more places on one side of the support, the number x distance of washers at each point must be added together to get the "balancing number."

A balance enables you to measure the mass of an object or material in terms of another mass. If you know the *weight* of one of the objects *(see "Balancing Point" above)*, you can also measure the weight of the second object. *(Continued on page 4T)*

Using This Issue . . .
(continued from page 3T)

Brain-Boosters

Mystery Photo. Have your students examine the end grain of wood. They might be able to find different kinds of grain on the furniture or shelves in the schoolroom. You could also bring in some scraps from a woodworking shop. The piece of wood lettered "B" was cut closest to the center of the log. The rings on this piece are curved the most. Boards cut from the outside of a thick log have rings that are practically straight. You might clarify this by drawing a series of concentric circles to represent the end of a log.

What would happen if? Demonstrate this experiment to your class. As the candle burns, the wax from the lower end will melt faster, and soon the candle will be balanced in a level position. After this, it will wobble back and forth like a little seesaw. Eventually, it may reach equilibrium again.

Can you do it? Assemble the materials required to measure the volume of one's exhaled breath. (Drinking straws may be substituted for the rubber tubing for sanitation.) Place a piece of masking tape along the side of the jar and mark it to show each half-quart. Then let small groups of children determine how much air each one can blow out in one breath, and record the results on a chart. The water will probably get a little messy, so cleanup supplies should be available. Most children can blow out at least a quart of air, while some adults are able to exhale as much as a gallon. After all the students have had a chance, see if you can beat the record.

Fun with numbers and shapes. Let the children attempt to solve this problem before you give them the answer.

```
  M E       3 7
x W E     x 2 7
-----     -----
S S S     9 9 9
```

For science experts only. Let the students take their square holes outside in the sun. If the spots of light they cast are square, try cutting smaller holes. A square hole acts like a lens to focus an image of the round sun on a piece of paper. If the sun were square, either a round or square hole would make a square spot of light.

nature and science
TEACHER'S EDITION
VOL. 5 NO. 6 / DECEMBER 4, 1967 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Recent Life Science Books for Your Pupils

by Barbara Neill

Lives of famous people usually make good reading, and when people have become famous through great scientific works and discoveries, their stories may be inspiring as well. Many children will say that they prefer reading biographies above any other type of book.

Louis Pasteur, by John Mann (Macmillan, 40 pp., $2.95) and **Charles Darwin,** by George Allen Cooper (Macmillan, 40 pp., $2.95). These two slim volumes are part of Macmillan's Science Story Library series. Both are suitable for 8 to 10 year olds, although the book on Pasteur is a little easier reading. Clear explanations of Pasteur's discovery that heat will kill the "little animals" that spoil wine, and of his discovery of the abundance of these microbes everywhere, help children understand his later work in finding protections against chicken cholera, anthrax, and rabies.

The highlights of the voyage of *H.M.S. Beagle* around the world from 1831 to 1836 are recounted in the book on Darwin. It is shown that his significant findings of shells in the Andes and the finches with their variety of bills were part of new raw material which enabled him, years later, to write the *Origin of Species.*

Both books devote several pages to the boyhoods of these men. Some children may be rather pleased to note that neither boy was overly fond of school. However, it is made clear that both worked enormously hard and with great patience in their chosen fields.

Wizard of Tuskegee, by David Manber (Crowell-Collier Press, 168 pp., $2.95). This biography of George Washington Carver reads like a good novel. Born into slavery in 1861, Carver had to fight prejudice, lack of money, and indifference nearly all his life. Although a few people recognized his genius early and were able to help him get an education, his formidable accomplishments were due mainly to his own incredible energy and strength of character.

Like some other men of great ability, Carver was many-faceted. He was an artist of great promise when he decided to devote his life instead to agricultural science. The list of his discoveries is nearly endless: wallboard from pine cones, paper from yucca, and everything from bleach to linoleum from peanuts. So many products emerged regularly from his laboratories that he might be called the father of synthetics.

The author has succeeded in bringing to life this remarkable man, revealing his warm personality as well as his talents. Highly recommended for upper elementary grades and older.

The Heart Explorers, by Tony Si-

(Continued on page 3T)

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York.

IN THIS ISSUE

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

Shooting Stars
How your pupils can watch, photograph, and map meteors in showers that peak December 13 and 22.

● **How Did People Get Different Colored Skin?**
A new theory suggests how skin color may have become differentiated through natural selection.

● **Brain-Boosters**

● **Travel Guide to the Sun and Its Planets**
Gives your pupils up-to-date information and estimates of conditions on the planets.

How Good Is Your Sense of Touch?
Using common objects, your pupils can test and compare their tactile sensitivities.

What Happened to the Mayas?
Part 2 of The Mystery of the Mayas evaluates current theories about why the Mayas abandoned their cities.

● **How To Be a Twig Detective**
By studying twigs from a tree, your pupils can find out some things about the tree's past.

● **Playing 'Possum**
How scientists found out whether opossums feign death or actually lose consciousness when attacked.

IN THE NEXT ISSUE

The bats of Carlsbad Caverns . . . How animals are adapted for life in caves, a WALL CHART . . . SCIENCE WORKSHOP: measuring the strength of an egg's shell.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Skin Color

Dr. Loomis's theory about how the skin color of humans came to be differentiated is based on the process of *natural selection*, which produces changes in a species of animals or plants, usually over long periods of time. In all species, those individuals that are best adapted to their environment have the best chance of surviving and reproducing. Their genetic qualities are passed along to their offspring. Individuals that are not so well adapted to their environment tend to die out *(see* WALL CHART, N&S, *November 14, 1966).*

Point out to your pupils that Dr. Loomis's theory may be correct and still not be the *only* explanation of varied skin color in humans.

Topics for Class Discussion

- *If Dr. Loomis's theory is correct, how can people with dark skins live in northern areas and people with light skins live near the equator without shortening their lives?* Man has learned to clothe and feed himself so that sunlight is no longer a matter of life and death. His *cultural* adaptations—food and clothing—have at least lessened the need for further *biological* adaptation—melanization or demelanization of the skin.
- *Since dark skin absorbs more heat from the sun than light skin, why didn't natural selection tend to lighten the skin of peoples living near the equator and darken the skin of those living in areas where the sunlight is weaker?* Apparently the protection dark skin gives against an overdose of vitamin D—and light skin against too little vitamin D—was a more powerful influence in helping people survive than the ability of their skin to absorb or reflect heat.

You might point out that suntanning is a temporary biological adjustment to strong sunlight. A light-skinned person who has a deep tan all his life will have light-skinned offspring. The *ability* to tan is an inherited trait, however, and it probably helped early men with light skins to survive in areas where the strength of the sunlight changes greatly from one time of year to another.

Sun and Its Planets

The WALL CHART on pages 8 and 9 shows the relative sizes of the planets but it does not show the planets' relative distances from the sun or from each other. As a result, it cannot give any feeling for the size of the solar system.

A scale that permits us to show the relative sizes of the planets is too large to show distances. If we revise the scale so that the distances of the planets are shown well, then the scale is too small to show planetary sizes. A dilemma? Not if you have enough room.

You and your pupils can have a lot of fun with this idea. The problem is to come up with a single scale that shows planetary sizes *and* distances. Lead your pupils into this idea, and with your guidance let them work out scales of their own.

You might begin with your classroom. Is it big enough to house a model of the solar system in which the planets are larger than pin heads? Some pupils should make a list of the distances of the planets from the sun, rounding them off to the nearest million miles. Another group can list the planets' diameters, rounding each off to the nearest thousand miles.

Suggest a scale to your pupils. For instance, if you let five inches represent 100 million miles, the earth would be about five inches from the sun, but it would be only 1/2,000 inch in diameter. Obviously this scale is not a good one.

What about a football field? If you let one inch represent 160,000 miles, the earth is 1/20 inch in diameter and 50 feet from the sun (0-yard line). On this scale Pluto would be about 1/40 inch in diameter and nearly a half mile away. Here is where the fun begins. Suggest a scale of 1:80,000. If your pupils still feel that the planets are "too small," have them work out how many miles of highway they would need in order to make their model planets big enough.

You might use a map of your city, or of your state. What if you made the sun a sphere two feet in diameter and placed it on the roof of City Hall? How far away would the earth be? How large would it be? How far away would Pluto be? Would it still be in your state?

When you and your pupils have worked out a scale model of the solar system to your liking, ask if they think that the solar system is a very crowded place?

Twig Detective

This SCIENCE WORKSHOP, first published four years ago in *N&S*, provides several opportunities for winter botany activities. Along with the investigations at the end of the article, you might consider having a twig-collecting field trip, or have each pupil bring in a twig from a tree near his home. The

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

nature and science

VOL. 5 NO. 6 / DECEMBER 4, 1967

To watch this month's two big meteor showers, see . . .
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PICTURE CREDITS: Cover, middle photo from Frederic Lewis, others from Annan Photo Features; pp. 2-11, 14-15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, UNICEF photo; p. 7, photo by Joan Hamblin; pp. 12-14, photos from W. R. Coe, The University Museum, Philadelphia, except for right photo, p. 13, from Nicholas Hellmuth; p. 16, photo by Don Wooldridge.

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

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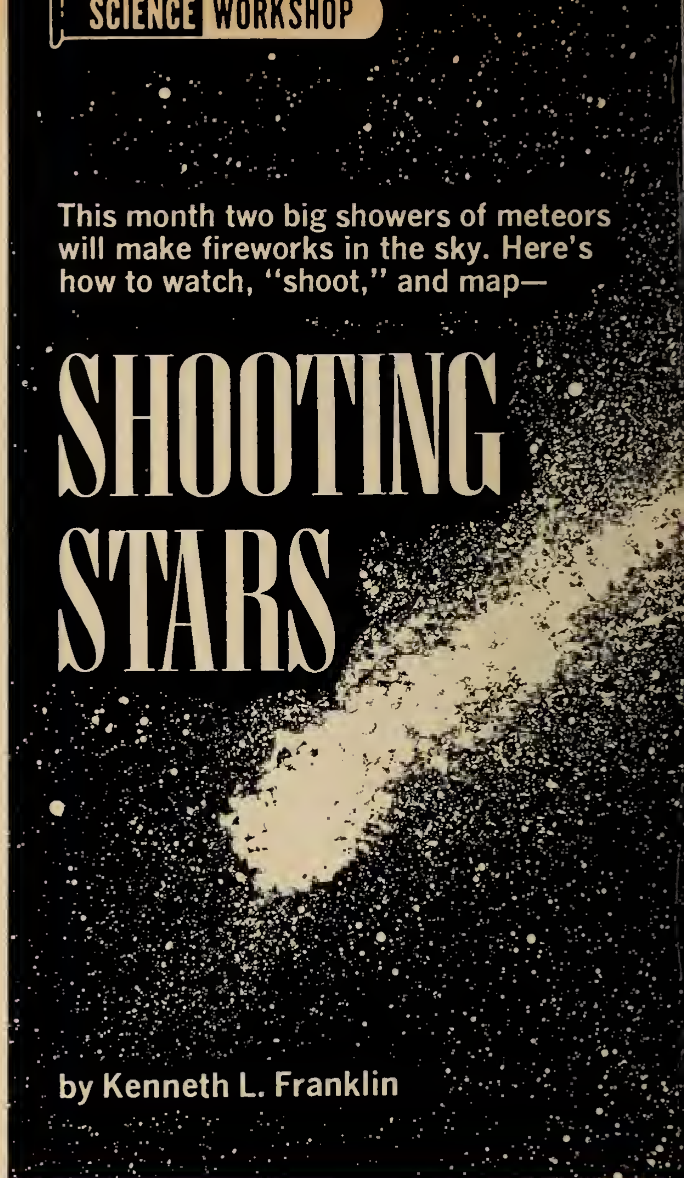


This month two big showers of meteors will make fireworks in the sky. Here's how to watch, "shoot," and map—

SHOOTING STARS

by Kenneth L. Franklin

■ You have probably seen meteors, or "shooting stars," in the night sky. These glowing streaks are made by small pieces of metal, rock, or ash from space that heat up and glow as they speed through the earth's air.

Twice this month the number of meteors that you can see will be unusually high. A six-day meteor shower will reach its peak on December 13, and a two-day shower on December 22. You might ask your parents to let you stay up for an hour or two after midnight on a few nights before and after those dates.

To "catch" the most meteors, face in the direction that lets you see the most sky with no bright lights nearby. Look high into the sky and keep your eyes moving.

When a meteor flashes by, trace its path backwards, past its beginning. Notice which star groups it passed. Meteors that are part of the shower will come from one part of the

Dr. Kenneth L. Franklin is an Astronomer at The American Museum-Hayden Planetarium in New York City.

Mapping Meteors

You can make a map of a meteor shower. When you begin watching, hold this star map overhead and find where the stars on it are located in the sky. If you are facing south, hold the map so that the "south" part is at the bottom. Stars in the middle of the map are directly overhead.

Mark the beginning and end of each meteor's streak on the map and number the meteor. Mark down the time to the nearest five seconds. You can use a flashlight when you are writing, but cover its lens with red cellophane or red ink. Red light does not spoil your night vision; white light does.

See if you can measure the lengths of meteor trains in degrees. (The two stars that form the edge of the Big Dipper star group and "point" to the North Star—Polaris—are five degrees apart; the moon is one-half degree across.)

On the map, the bigger dots are for the stars that look brighter in the sky. Which of these dots would best show the brightness of the meteors you see?

sky called the *radiant* of the shower. Can you find it? How many meteors do you see that are not part of the shower?

Does each meteor have a "train"—glowing pieces that follow it like a tail? If the train keeps shining after the meteor goes out it is called a "trail." How long does a trail glow? What color is it?

Does each meteor get brighter as you watch it? Do any fade out, then brighten again?

Taking Pictures of Meteors

You can photograph meteors with an ordinary camera that can be set for a long time exposure. Use the "fastest," or most sensitive, film you can get. Put the camera on a sturdy tripod, table, or other firm support.

City lights or a bright moon will fog the film after a few minutes; a dark night may let you expose film for an hour or more without fogging. Experiment for a few nights. Then try photographing a meteor shower.

Point the camera straight up, with the focus set for infinity and the lens opened to its widest. Hold a card over the lens, open the shutter, and leave it open. Then remove the card and write down the time. (The card is to keep any jiggling as you open the shutter from affecting your picture.)

Look up at the part of the sky your camera "sees." After you have counted five or so meteors, replace the card and close the shutter. Record the time. Later you can count the number of meteors in this picture to see if your camera "saw" them as well as you did.

Try to aim the camera so that the radiant will be in one corner of the picture. If you aim directly at the radiant you will miss most of the meteors.

Your developed pictures should show straight streaks caused by the meteors, and some curved streaks. What made the curved streaks? Did the radiant stay in the same part of the sky all the time? Did the number of meteor sightings per hour rise and fall sharply, or was the change gradual? ■

How Did People Get Different Colored Skin?

Most of the reasons suggested over the centuries were not very scientific. Now the findings of modern scientists have been put together in an explanation that fits what we know about how animals change over thousands of years.

by Steven W. Morris

■ Most people who have dark colored skin live near the equator, where the sun shines strongest all year round. If you traveled north or south from the equator, you would notice that the farther people live from the equator, the lighter their skin color is likely to be *(see map).*

For thousands of years men have made up stories to explain the mystery of why people have different colored skins. One story said black skin showed that the person who had it was being "punished." Another said black skin had a mysterious substance in it that no other skin had. Recent findings by scientists may have led to the correct explanation.

Black Skin, Yellow Skin, White Skin

Our skin has several layers. The tough outside, called the "horny layer," is made up of dead cells. Layers under it contain living cells that make light or colorless *keratin* and a brown or black substance called *melanin.*

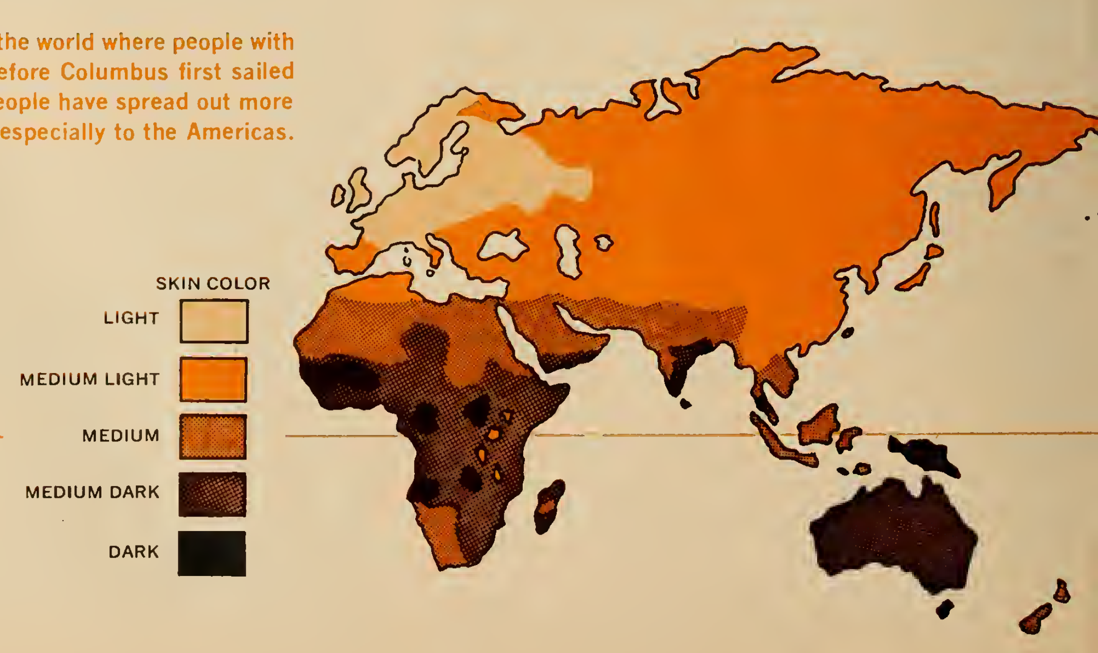
You have about the same number of cells that make keratin and melanin as anyone else of your size in the world. If your cells produce a lot of melanin your skin is dark brown or black. A person with less melanin has light brown or yellowish skin. Skin that has very few melanin grains in it looks pink, because you can see a person's blood through his skin. Except for *albinos*—the few people whose cells cannot make melanin—all humans have both melanin and keratin in their skin.

The skin of people who live near the equator produces more melanin than the skin of people living farther north or south. Dr. W. Farnsworth Loomis, Professor of Biochemistry at Brandeis University in Waltham, Massachusetts, says he has figured out why. One clue that helped him was discovered about 45 years ago.

Sunlight and Sickness

Dr. Alfred F. Hess, a New York physician, was trying to find why sunlight seemed to help cure a disease called *rickets* that causes children to grow up with crooked legs

This map shows the areas of the world where people with different skin colors lived before Columbus first sailed to the Americas. Since then, people have spread out more over the world, especially to the Americas.



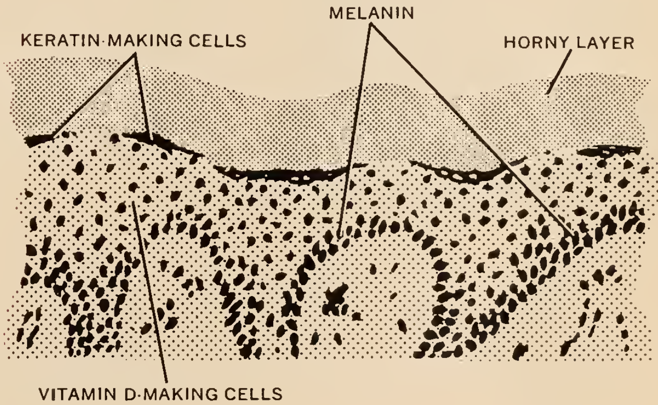
Rickets—a disease caused by a lack of vitamin D—made this Indonesian girl's legs grow crooked. Before scientists learned how to cure this disease, it lessened a child's chances of growing up and becoming a parent.

and twisted backbones *(see photo).* In grownups, a form of the disease causes softened bones. Many people in northern cities used to get the disease, and so did women in India whose customs made them stay indoors, out of the sun, almost all the time.

Dr. Hess put six black rats in one cage and six white rats in another cage, and fed the rats in both cages the same kind of food. He shined *ultraviolet radiation*—a kind of light we can't see—onto the rats. All the white rats stayed healthy, and all the black rats got rickets. Dr. Hess decided that the coloring matter in the black rats kept the ultraviolet radiation from getting into their bodies where it could help prevent the disease.

Other scientists found that eating vitamin D, a substance found in cod liver oil, also helps to cure rickets and to keep people from getting the disease. They also found that a person with no vitamin D in his body is sure to get rickets. Yet many people who do not eat cod liver oil do not get rickets. The reason they don't is suggested by Dr. Hess's experiment with white and black rats: The ultraviolet radiation in sunlight makes substances under our skin *produce* vitamin D (*see diagram).*

About 10 years ago a scientist measured the amount of vitamin D that was made when he shined ultraviolet light on pieces of skin taken from humans. His results showed that if the face of a light-skinned baby was exposed to sunlight for three hours a day, the cells in its skin would make enough vitamin D to keep the baby from getting rickets. But in northern European cities where the sunlight is weak, many light-skinned people do not get enough ultraviolet light to prevent this disease.



Keratin and melanin in upper layers of our skin block part of the sunlight from reaching cells that make vitamin D.

Too Much Vitamin D

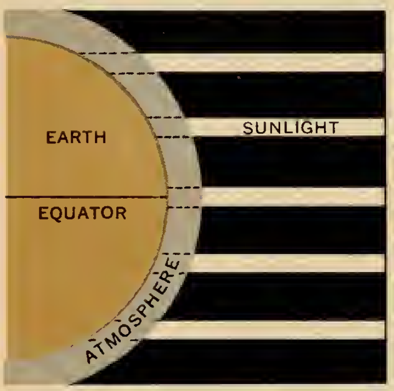
The milk you drink usually contains vitamin D that was made in a laboratory and added to the milk. The vitamin is also put into pills. As these forms of vitamin D have come to be used more and more, rickets has been almost wiped out in some northern areas where it used to be common.

But something unexpected has happened. Drinking milk with vitamin D in it is perfectly safe, but scientists have found that giving very large doses of pure vitamin D to people can be dangerous. This sometimes makes lumps of bone-building minerals form in the wrong places in a person's body, and a few people have died from an "over-

(Continued on the next page)

dose" of vitamin D. Scientists think the same thing can happen to a person whose skin manufactures too much of this vitamin.

Many of the people who live in hot areas near the equator wear little or no clothing. Since these people are exposed to strong sunlight much of the time, some scientists wondered why they don't get overdoses of vitamin D. When the scientists tested pieces of skin from dark-skinned Africans, they found that the melanin and keratin grains in the skin blocked most of the ultraviolet light from reaching the vitamin-making cells. Enough ultraviolet gets through to prevent rickets. Less coloring material in the skin would have let enough ultraviolet light through to make a killing dose of vitamin D.



Sunlight travels through more of the earth's atmosphere to reach the northern and southern areas of the earth than to reach the areas near the equator. The farther sunlight goes through the atmosphere, the more of its ultraviolet radiation is lost to the atmosphere.

Near the equator, dark skin is a needed shield against the strong sunlight. But in the weaker sunlight of, say, Scandinavia, dark skin blocks out the ultraviolet light a person needs to keep from getting rickets.

From these and other clues, Dr. Loomis believes that people's skin colors became different through *evolution*.

The Right Color for Survival

Dr. Loomis explains his theory something like this: The earliest men on the earth lived near the equator and had dark skins. Over thousands of years, some of them moved north to areas where the sunlight is weaker. In these new lands, persons with the darkest skins probably tended to develop rickets. The disease crippled these people or made them too sick to work and get food. Many of them died without having children.

Persons with lighter skins that let more sunlight through got rickets less often. They were healthier and tended to have more children. The children with the lightest skins had the best chance of staying healthy and growing up to have children of their own—most of whom would also have light skins like their parents. After many thousands and thousands of years, there were no more dark-skinned people in many areas where the sunlight is weak.

Dr. Loomis thinks that early men living in Western Europe lost most of their dark skin color by about half a million years ago. Scientists who study the history of man believe that people did not live in the cold northern part of Europe, including Scandinavia, until much later. By that time people were wearing animal skins as clothing. This cut down the amount of their own skin that was exposed to the sun. Gradually, over thousands of years, the people in northern Europe probably came to have even lighter skin, which lets in more ultraviolet light. People who live in some parts of Scandinavia have the lightest colored skin in the world.

What about Indians and Eskimos?

Twenty thousand years ago, people from Asia who had light yellowish skins crossed over the Bering Straits into what is now Alaska *(see map on page 4)*. They gradually spread southward into areas of North and South America where the sunlight is stronger than it is in northern Asia.

These people had a lot of keratin in their skins, but keratin is not as good a shield against sunlight as melanin. Those of their children who had darker skins tended to be healthier and produce more children than those with lighter skins. Today many South American Indians have much darker skins than their Asiatic ancestors had.

The Eskimos settled farthest north of all people, in the lands around the cold Arctic seas. In these areas, the sun can't be seen for months at a time and when it does appear, its light is weak. Yet Eskimos' skins are darker than Scandinavians' skin—and they don't get rickets.

More than 30 years ago a scientist studying Eskimo food found that an Eskimo eats enough fish to give him all the vitamin D he needs to prevent rickets. In this way, the Eskimos were protected against the disease that probably caused the skin of other peoples to gradually become lighter in color as they moved northward over thousands of years■

SUNBURN—A WARNING

Every summer, many light-skinned people get painful *sunburn*—a warning that they are receiving too-large doses of ultraviolet light. A way to avoid this is to stay in the sun for only a short while each day. Gradually these people get a *suntan*—their skin darkens as cells increase production of melanin and keratin. Once the shield of color grains is strong enough, these people can remain in the sun for long times without being "burned." When summer is over the sunlight becomes weaker and people cover more of their body with clothes. Their cells make less melanin and keratin and their skin becomes lighter-colored again.

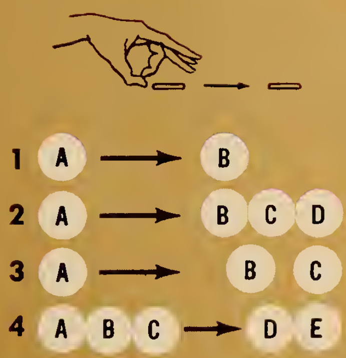
prepared by DAVID WEBSTER

Brain Boosters

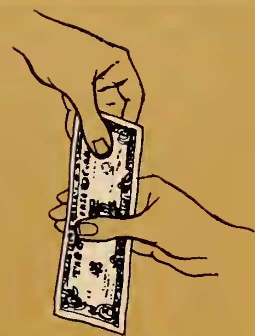
Mystery Photo
What is it?

What will happen when...

...you shoot the penny on the left against the pennies on the right in each of these four arrangements?



Just for fun



Have someone hold a dollar bill so that the picture of George Washington is between your fingers. Can you catch it when he lets go?

For science experts only

Here are two tricky astronomy questions:

What is the name of the first satellite to circle the earth?
Can you see any stars in the daytime?

Can you do it?

Place a raw egg in your hands as shown. Be sure that the egg is held the long way. Can you break the egg by squeezing your hands together? *Submitted by Pat Lavin, St. Louis, Missouri*

Fun with numbers and shapes

Can you figure out what these letters represent?

O T T F F S S E N T

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The piece of wood lettered "B" was cut closest to the center of the log. The rings on this piece are curved the most.

What would happen if? As the candle burns, the wax from the lower end will melt faster. Soon the candle will be balanced straight across. After this, it will wobble back and forth like a little see-saw. After a while, it may balance again.

Can you do it? Most children are able to blow out a quart of air in one breath; adults can exhale as much as a whole gallon.

Fun with numbers and shapes:

$$\begin{array}{r} ME \\ \times\ WE \\ \hline SSS \end{array} \rightarrow \begin{array}{r} 37 \\ \times\ 27 \\ \hline 999 \end{array}$$

For science experts only: A square hole acts like a lens to focus an image of the round sun on the piece of paper. If the sun were square, would it make a square spot of light?

TRAVEL GUIDE TO THE SUN AND ITS P

In years to come, men from earth may be visiting other planets. When they do, they will face conditions very different from those on earth. Their bodies will feel either heavier or lighter than they do on earth, for example. And they will find temperatures that will be boiling hot or freezing cold.

But scientists can't be sure of exactly what conditions men will find on each planet. Since no one has been to any of the other planets as yet, our information about them is uncertain. That's why some of the lines on this WALL CHART end with question marks. Also, some of the numbers on the chart are averages. This is so because a planet's distance from the sun, for examp changes as the planet moves along its orbit. And b cause the planets are not perfectly round, the diamet of each one is not the same at all points along surface.

The time it takes for a planet to complete one tr around the sun (Period of Revolution) and to co plete one turn about its axis (Period of Rotation) given in earth time. The drawings on this chart sh about how big each planet is compared to the othe But a chart like this can't give you an idea of how f each planet is from the sun. Can you guess why?

HOW MUCH WOULD YOU WEIGH ON...

You can figure out how much you would weigh on planet by multiplying your weight on earth by the Surface Gravity number. For example, if you wei pounds on earth, your weight on Venus would be 89 (100 x .89 = 89).

On which planet do you think you could jump the On which planet would you least like to have a frien in your lap?

SUN

SURFACE TEMPERATURE 10,000°F
TEMPERATURE AT CENTER about 20,000,000°F
DIAMETER 864,000 mi.
SURFACE GRAVITY 28

To us, the sun seems like the largest thing in the sky, but it is just a medium-size star. Unlike the planets, which all seem to be made of solid material, the sun is a mixture of gases. The equator of the sun turns around its axis once in about 26 earth days; the polar regions turn once in 29 days.

ASTEROIDS

DISTANCE between 200,000,000 and 400,000
DIAMETERS up to 500 mi.
PERIODS OF REVOLUTION between 3.3 and 6

Asteroids are miniature planets made of rock low orbits around the sun between Mars an have figured out the orbits of about 3,000 of t

MERCURY

DISTANCE 36,000,000 mi.
DIAMETER 3,000 mi.
SATELLITES none
SPEED AROUND SUN 107,000 mph
PERIOD OF REVOLUTION 88 days
PERIOD OF ROTATION 59 days
SURFACE GRAVITY 0.37
SURFACE TEMPERATURE 640°F (sunlit side)

The smallest planet, Mercury is also the hottest, because it is so close to the sun and because its surface holds more of the heat it receives from the sun than the surfaces of the other planets hold.

VENUS

DISTANCE 67,200,000 mi.
DIAMETER 7,600 mi.
SATELLITES none
SPEED AROUND SUN 78,000 mph
PERIOD OF REVOLUTION 225 days
PERIOD OF ROTATION 243 days
SURFACE GRAVITY 0.89
TEMPERATURE 104°F (tops of clouds) to 536°F (surface)

Venus may have an atmosphere more than 15 times denser than earth's, made up mostly of carbon dioxide. The clouds that cover the planet may be made of dust particles.

EARTH

DISTANCE 92,900,000 mi.
DIAMETER 7,918 mi.
SATELLITES 1
SPEED AROUND SUN 66,500 mp
PERIOD OF REVOLUTION 365.24
PERIOD OF ROTATION 23 hrs. 5
SURFACE GRAVITY 1
SURFACE TEMPERATURE -125°F to 136°F

Earth seems to be the only planet with oxygen in its atmosphere. It may be the only planet capable of supporting life as we know it.

ANETS

PLUTO

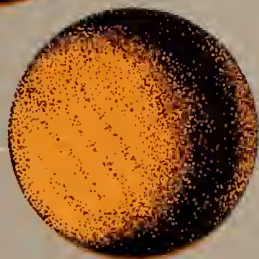
DISTANCE 3,671,000,000 mi.
DIAMETER 3,700 mi. (?)
SATELLITES (?)
SPEED AROUND SUN 10,500 mph
PERIOD OF REVOLUTION 248.4 yrs.
PERIOD OF ROTATION 6.4 days (?)
SURFACE GRAVITY 4 (?)
TEMPERATURE −375°F(?)

Pluto is so far away and so small that it was detected only about 40 years ago. Pluto's orbit is less circular than any other planet's: It will bring Pluto closer to the sun than Neptune in 1969, leaving Neptune the "far-out" planet for about 40 years.

NEPTUNE

DISTANCE 2,794,000,000 mi.
DIAMETER 27,600 mi.
SATELLITES 2
SPEED AROUND SUN 12,150 mph
PERIOD OF REVOLUTION 164.8 yrs.
PERIOD OF ROTATION 15 hrs. 50 mins.
SURFACE GRAVITY 1.54
TEMPERATURE −260°F at tops of clouds

Only Venus follows a path around the sun that is more nearly a perfect circle than Neptune's path.



URANUS

DISTANCE 1,782,000,000 mi.
DIAMETER 29,500 mi.
SATELLITES 5
SPEED AROUND SUN 15,200 mph
PERIOD OF REVOLUTION 84.0 yrs.
PERIOD OF ROTATION 10 hrs. 49 mins.
SURFACE GRAVITY 0.97
TEMPERATURE −290°F at tops of clouds

The planets from Mercury to Saturn were all known in ancient times. Uranus was the first to be "discovered" by astronomers, in 1781.

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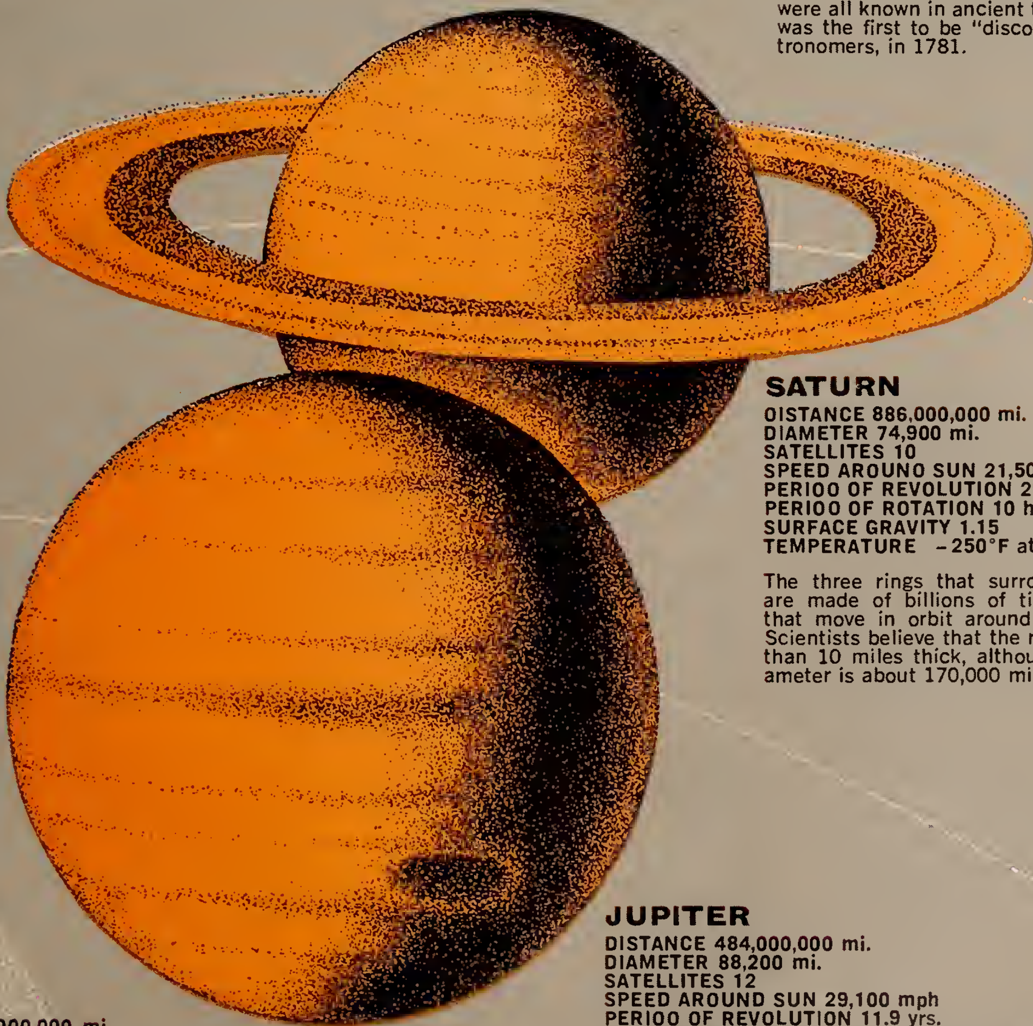

SATURN

DISTANCE 886,000,000 mi.
DIAMETER 74,900 mi.
SATELLITES 10
SPEED AROUND SUN 21,500 mph
PERIOD OF REVOLUTION 29.5 yrs.
PERIOD OF ROTATION 10 hrs. 38 mins. (average)
SURFACE GRAVITY 1.15
TEMPERATURE −250°F at tops of clouds

The three rings that surround Saturn are made of billions of tiny particles that move in orbit around the planet. Scientists believe that the rings are less than 10 miles thick, although their diameter is about 170,000 miles.

ni.

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metal that fol-
ter. Scientists

JUPITER

DISTANCE 484,000,000 mi.
DIAMETER 88,200 mi.
SATELLITES 12
SPEED AROUND SUN 29,100 mph
PERIOD OF REVOLUTION 11.9 yrs.
PERIOD OF ROTATION 9 hrs. 55 mins. (average)
SURFACE GRAVITY 2.67
TEMPERATURE −225°F at tops of clouds

The largest of the planets, Jupiter has a force of gravity strong enough to "hold onto" 12 satellites—one of which is slightly larger than Mercury.

s.

MARS

DISTANCE 142,000,000 mi.
DIAMETER 4,200 mi.
SATELLITES 2
SPEED AROUND SUN 54,000 mph
PERIOD OF REVOLUTION 687 days
PERIOD OF ROTATION 24 hrs. 37 mins.
SURFACE GRAVITY 0.39
SURFACE TEMPERATURE −150°F to 80°F

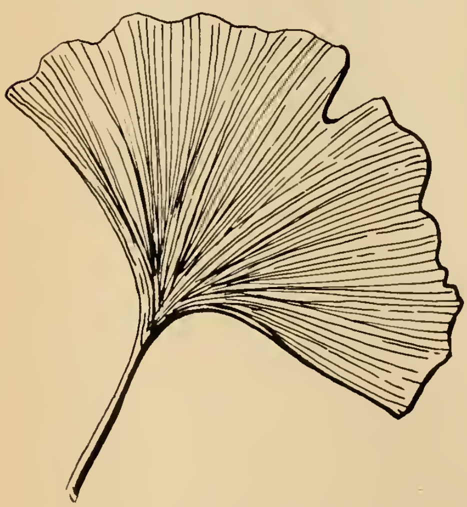
Much of the surface of Mars has a bright, reddish look, giving Mars its nickname, "the red planet." A few scientists believe there could be a simple form of plant life on Mars.

WHAT'S NEW

"Flying saucers" are definitely not from another planet, says Dr. William Markowitz, professor of physics at Marquette University, in Milwaukee, Wisconsin. Writing in *Science,* Dr. Markowitz agrees that UFOs (unidentified flying objects) exist. But, he says, the laws of physics rule out the possibility of their coming from another planet and flying about here in the way they've been reported to do.

Some persons believe that an advanced people from another solar system could have discovered ways of propelling spacecraft that are beyond the laws of physics. Anyone is free to believe such "magic," says Dr. Markowitz, but *he* does not. *(See "The Case of the UFOs,"* N&S, *October 2, 1967.)*

The most ancient living tree is probably the ginkgo, also known as the maidenhair. This tree, with its fan-shaped leaves *(see drawing),* is a familiar



sight along many city streets. Called a "living fossil" by famed biologist Charles Darwin, the ginkgo has existed for perhaps 200 million years. During this time, while other ancient trees died off or gradually changed, the ginkgo changed hardly at all. How did it survive so successfully?

Studies at the University of Virginia, in Charlottesville, and elsewhere supply part of the answer, reports Virginia chemist Randolph T. Major in the journal *Science.* The ginkgo's roots, trunk, and leaves are to some degree poisonous to various insects, bacteria, viruses, and fungi that harm other trees.

Nothing can be colder than —273.16 degrees Centigrade (—459.69 degrees Fahrenheit). That's *absolute zero*—the complete absence of heat. With special techniques involving powerful magnets, researchers have been producing temperatures closer and closer to absolute zero. Now, scientists at the Naval Research Laboratory in Washington, D.C., have reached the coldest temperature yet—lower than one millionth of a degree (Centigrade) above absolute zero.

Letting forest fires burn is sometimes wise. Putting out *all* forest fires could "destroy rather than protect our wilderness areas," says Arthur Brackebusch, chief of the United States Forest Service's Northern Forest Fire Laboratory at Missoula, Montana. The scientists there are trying not only to find better means of preventing, detecting, and controlling forest fires, but also to determine which fires to put out and which ones to let burn. As Forester Brackebusch notes: "Fire has played an important role in building our beautiful wilderness areas. It has come through the forests, destroying old stands and making way for new ones."

Strange as it seems, we now know more about the moon's topography (surface pattern) than about the earth's. British astronomer Zdenek Kopal pointed this out recently. Photographs made by United States and Russian spacecraft clearly show almost all of the moon's surface features. In contrast, many of the earth's surface features are hidden by water or are camouflaged by vegetation in wilderness areas.

Our national bird, the bald eagle, is being shot out of existence, says the National Audubon Society. Though it's against the law to shoot bald eagles anywhere in the United States, gunshot is the most common cause of their death. Why do hunters shoot these magnificent birds?

Many probably mistake young eagles for adult hawks. The young bald eagles are brown all over. Not until they are about four years old do they develop the

"Stop worrying about him. He'll get bald as he gets older."

white head and tail that make adult eagles so easy to recognize.

Hunters should not be shooting hawks anyway. In most states most kinds of hawks are protected by law. And, the Society points out, "Hawks in general do man much more good than harm. They eat far more farm pests, such as rats, than chickens and game birds."

Grass that grows where it "shouldn't" is fascinating botanists at the University College of North Wales in Great Britain. Common bentgrass is growing near a copper mine in soil that has 20 times more copper than ordinary soil has. This is usually enough copper to kill any plants.

The scientists believe that a few of the bentgrass seeds blown to the area were somehow able to grow in the copper-rich soil. These few survived and produced a healthy young crop that could also live there. The ability to grow in coppery soil is being passed from one generation to the next. It may be the first known example of "quick evolution" in plants. The grass that can live with copper may eventually change so much that it will become an entirely new kind *(species)* of grass.

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 ■

WHAT HAPPENED TO THE MAYAS?

by Diane Sherman

Part 1 ("The Mystery of the Mayas," N&S, November 13, 1967) described the amazing achievements of these people, who built cities in the forests of Central America for about 1,000 years. Then, around 800 A.D., something mysterious happened to the Mayan civilization. Activity stopped in city after city. No more monuments or temples were built. Walls and foundations for new buildings were left unfinished. To modern archeologists it looked as if the cities had been abandoned.

■ Over the years, many different theories have been suggested to explain why the Mayas left their cities. One theory is that their food supply failed. Could the people have been driven out by famine?

The Mayas' main food was corn. They grew it in fields that were cleared by cutting down trees and burning the stumps and other vegetation. But the tropical soil is not very deep and it contains little of the minerals that plants need to grow. Decaying trees and leaves return their minerals to the soil, but corn plants take the minerals from the soil and do not return them. Because of this, the Mayas had to clear new land for corn fields every few years, and they could not use an abandoned field for 10 years or so, until the field had received enough minerals from decaying vegetation.

This is the only way corn can be grown in such thin soil—by moving from field to field. Perhaps as the population increased there wasn't enough land around the cities to grow all the corn that was needed. Perhaps people left the cities to look for more fertile soil.

There is one trouble with this theory. If it were true, we would expect that the cities with the best soil would have lasted the longest. Yet around the city of Quirigua, the soil is rich and fertilized by frequent river floods. And if people started leaving a city at the same time they stopped putting up new monuments, Quirigua was one of the first cities the Mayas left.

Disease or Wars?

Could disease have killed off the Mayas? At first, this seemed possible, because today many Indians living in forests like those around the ruins of the Mayan cities get malaria. Did epidemics of malaria or yellow fever wipe out many of the early Mayas? Or did diseases perhaps weaken them so much that they moved away from the cities to look for healthier surroundings?

As modern scientists learned more about diseases, they realized that yellow fever and malaria were brought to America by people from Europe and Africa. They came in the 15th and 16th centuries, long after the end of Mayan civilization. Still, perhaps there were other tropical diseases that killed off the Mayas.

Another suggestion is that wars could have driven the Mayas away. In Mexico there were many highly advanced people living in cities at the same time as the Mayas. There is evidence of trade between the two peoples, and some Mayan monuments show Mexican gods.

We also know that the Mayas were not as warlike as the Mexicans. Among all the pictures and carvings that show the Mayas' life, there are very few battle scenes. Mayan cities, built on low, open ground, would have been hard to defend. Did invaders, perhaps from Mexico, cause the cities' downfall?

The trouble with this idea is that there is little evidence to support it. A few monuments have been found smashed, but the Mayan cities were not destroyed, as an invading army might do.

The Possibility of a Revolution

Another theory says that the Mayas may have revolted against their priests and rulers. To the common people the priests must have seemed in close contact with the gods. How else could the priests predict eclipses, or tell when the planet Venus would be seen in the sky? No wonder the people obeyed when the priests told them what to do!

The people believed the success of their crops depended on the gods. Mayan writings tell us this. People

This picture painted on pottery shows a Mayan ruler on a throne receiving gifts from important visitors. Scientists believe the Mayan people may have become angry at their rulers and revolted against them.

thought each day of the year was controlled by a different god, some good, some evil. The priests figured out which days were most favorable for burning, planting, or harvesting. They told the farmers when to make offerings, and which gods to make them to.

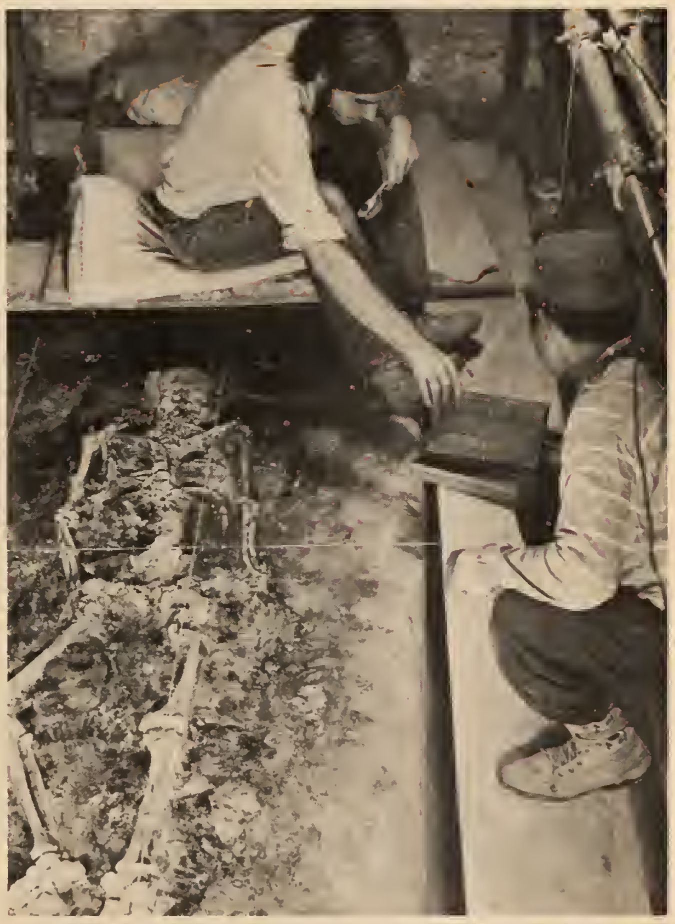
In return, the people gave up part of their crop to feed the priests and rulers. They also had to help in the construction of new temples and monuments. It seems that for a long time the priests and farmers must have been working together.

As the centuries passed, the priests' learning increased, and the later monuments show that the religion became more complicated. Since the Mayas believed everything was controlled by the gods, new knowledge meant new gods to worship. That meant more priests to explain what the new gods wanted. With more priests, the people had to provide more corn and build more temples.

In time, the people may have resented the increasing demands of the priests for food and labor. Most of the people probably cared little about complicated astronomical or mathematical calculations. All they wanted from the priests was guidance in growing their crops. It must have seemed that the priests weren't paying attention to their jobs. Did the people revolt at last, in city after city? Did they kill or drive out their rulers?

There is evidence to show that something like this

(Continued on the next page)



Nicholas Hellmuth—probably the youngest person ever to uncover an ancient Mayan tomb—used a spoon and other small tools to dig out this 1,200-year-old skeleton of a rich Maya. Hellmuth (*top*) was 16 when he began studying Mayan culture while on a vacation trip to Mexico. Five years later he uncovered this tomb while working with Dr. William R. Coe's expedition to the ancient city of Tikal, in Guatemala (described in Part 1 of this article).

Lines of stone monuments stand between two temples at Tikal, in Guatemala, where priests once led ceremonies. The Mayan people probably believed their hard work in building temples pleased the gods. This belief would have helped the priests control the people

This jaguar's head found in the tomb Nicholas Hellmuth uncovered at Tikal is the largest piece of carved jade ever discovered in the ruins of Mayan cities.

may have happened. The smashed monuments found here and there could very well be the work of peasants who were angry at their rulers. In one city a beautiful stone throne was destroyed. Even carvings of the gods were damaged—especially their noses.

About the time when the Mayas left their cities, other beautiful cities in what is now central Mexico were being destroyed by a tribe of warriors called the Toltecs. These cities had been ruled by priest-kings, as those of the Mayas were. It is possible that news of these conquests encouraged the Mayan peasants to overthrow their rulers.

Earlier archeologists assumed that because the old activities in the Mayan cities stopped, all the people must have left. Yet new evidence shows that some people went on living in the cities after their rulers were gone. The remains of pottery at Tikal show that people continued to live there for at least 100 more years. During this time, some of the monuments were moved to new positions, but the artists and craftsmen were gone, and the buildings were not kept in repair.

Gradually the temples began to collapse. People tried to shut off the fallen sections, but the walls they used were crude, nothing like the walls of the original buildings. Perhaps, in time, the people drifted back to the countryside. Long before the Spaniards came in the 1500s, all the Mayas had left the great cities they had built in what is now the northern part of Guatemala.

The Unanswered Question

Was this what happened to Maya civilization? Many archeologists think it is the best way to explain what has been found, but no one really knows what happened. There is still much work to be done. We may not have found all the cities yet, and only a few of the ones we know about have been dug into and studied by scientists. Perhaps the answer to the mystery is still lying in the forest, waiting for an archeologist's spade ■

how to

■ Sometimes being a scientist is like being a detective. In both jobs, you may have only a few clues to help you solve a problem.

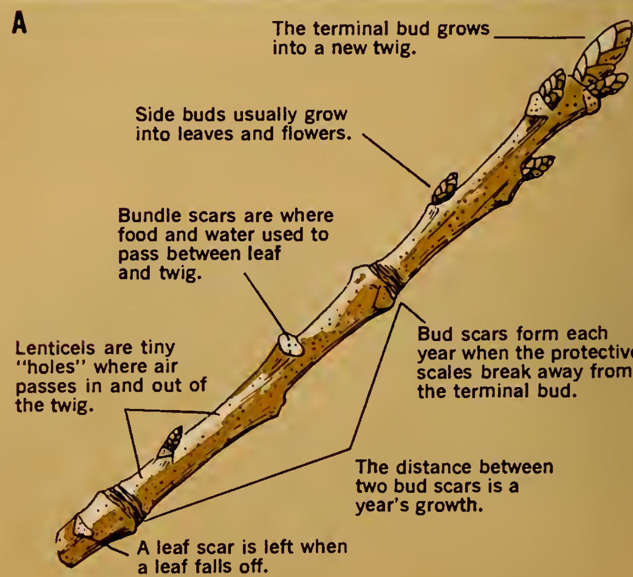
Imagine that you are a plant "detective." You are given a single clue: a twig from a tree. What can you discover about the twig?

To find out, you will need a twig. Cut one from a tree that has lost its leaves. Clip the twig off cleanly about six inches from its tip.

You will see all sorts of markings and bumps on your twig *(see Diagram A)*. Depending on the type of tree, the twig may feel sticky, or hairy, or have thorns. Botanists can identify many trees just by looking at twigs. Later you might cut twigs from several kinds of trees and see how they differ *(see Diagram B)*.

All of the strange-looking bumps and markings on a twig are important to the life of a tree. Most of a tree's growth takes place in the twigs. Leaves grow from twigs, and twigs also produce flowers from which seeds, fruits, or nuts develop. Eventually, twigs grow into branches.

The odd-shaped bumps on twigs are called *buds*. Some buds produce leaves, while new twigs and flowers grow from other buds. Nearly all twigs have a large bud or group of buds at their tip—called a *terminal* bud—which is the source of the next year's twig growth. The smaller buds that stick out along the side of a twig usually grow



be a twig detective

into leaves or flowers. Some other buds along the twig usually do not develop at all. They grow only if the terminal bud or some leaf or flower buds are injured.

Buds are usually covered by overlapping scales that protect them from cold temperatures, injury, and insects. If you carefully peel away these scales, you will see some tightly-packed green tissue inside the bud. If left alone, this tissue will grow into next spring's leaves or flowers.

Reading the Past

Buds are important to the future of a tree, but you can also learn something about the past of a tree from its twigs. Look at the base of the buds on your twig. Below some buds you will see a scar which is the place where a leaf grew during the past summer.

When a leaf dies, a corky layer grows between the stem of the leaf and its twig. This corky layer—called a *leaf scar* —is left when the leaf falls off. How many leaf scars can you find on your twig?

If you look closely at a leaf scar (a magnifying glass will help), you will see some dots on its surface. These dots—called *bundle scars*—are the remains of tiny "pipelines" through which food and water flowed between the twig and the leaf. Count the number of bundle scars on several leaf scars of your twig. Did each leaf have the same number of "pipeline" holes?

Twigs have another type of scar, called a *bud* scar. These scars are rings of small, narrow marks left by bud scales when they fall away from the base of an opening bud. The most noticeable bud scars are left by the terminal buds. Each bud scar marks the place where a terminal bud began growing into a new section of twig. A twig gets one of these ring-like scars each year. How many of these scars can you find on your twig?

The distance between bud scars is the length that the twig grew in a particular year *(see Diagram A)*. You can find out how much your twig grew in the past year by measuring the distance from the twig's tip to the nearest bud scar. (This new growth is often easy to see because its color is usually lighter than the older parts of a twig.)

Measure the distance between the other bud scars on your twig. Are they the same for each year? The growth of a twig varies from year to year, depending on the amount of sunlight, water, minerals, and gases it gets. Compare twigs from several places on the same tree. Did they all grow the same distance during the past year?

Besides buds and scars, you may see some small speckles scattered along your twig. These speckles are called *lenticels*, and air goes into and out of the twig through them. Lenticels are easy to see on some twigs—such as cherry and peach—because their light color stands out against the dark twig.—HAROLD HUNGERFORD

Many trees can be identified by their twigs. These drawings show how the twigs of five different kinds of trees differ in size, shape, and markings.

INVESTIGATIONS

You can bring certain kinds of twigs indoors and "force" them to leaf out or to flower. (There has to be a period of four to six weeks with temperatures below 37°F before forcing is successful.) First cut some twigs from several kinds of trees or shrubs. (To keep from injuring a plant, do not cut more than a couple of twigs from it.) Then put them in a vase or jar that is partly filled with water. Set the jar near a window, and then examine the twigs each day for a week or two.

Notice which buds open first. Are there any buds that do not open at all?

Cut two twigs from the same tree, remove the terminal bud from one, and then set them both in water. Notice the buds which open on each twig. Does the removal of the terminal bud have any effect on the rest of the buds?

Take another twig and cut a slit halfway around it, just above one of the side buds. This will stop the flow of some minerals and water from going up the twig beyond the bud. Then notice if this bud grows faster or slower than others.

playing 'possum

■ In September 1965, two men rounded a corner in a trail at Glacier National Park in Montana, and surprised a female grizzly bear and her cubs. Defending her young, the bear charged. The men ran. When they saw that they could not escape, they fell to the ground and pretended to be dead. The bear grabbed one of the men, injuring him slightly, but then hurried back to her cubs.

The men survived by pretending to be dead, or "playing 'possum." The same trick helps the opossum to survive. This animal, the only native *marsupial* (mammal with a pouch for its young) in North America, is famous for its way of "playing" dead when threatened by a dog or other enemy. Once the opossum is "dead," many animals, especially dogs, lose interest and go away.

When the opossum is threatened, it may snarl, snap, and growl at first. Then it falls down on one side, body partly curled, mouth open, tongue sticking out *(see photo)*. The animal doesn't seem to be breathing, and its heartbeat slows. The opossum doesn't move, even if you pull its whiskers, bend its toes, or touch its eyes.

If left alone, the opossum usually begins to "wake up" in a few minutes. First it raises its head, listening, looking, and sniffing for danger. Soon, if all is safe, the opossum hurries away.

Is the 'Possum Really "Playing"?

For some time, biologists have wondered exactly *how* opossums "play 'possum." For instance, does an opossum go into a kind of trance, or lose consciousness, when it is attacked? Or is the animal fully awake?

A team of biologists in California decided to find out by using a device called an *electroencephalograph*, or EEG for short. An EEG machine detects the activity of an animal's brain through wires attached to its head and makes a tracing on paper of the brain's activity.

The men caught several opossums and took them to their lab. The wires from the EEG machine were attached to each opossum's head and the biologists took EEG tracings of the animal during its normal sleeping and waking.

Then each animal was suddenly "attacked." From a loudspeaker came a recording of a dog barking. Artificial dog jaws (really a big pair of pliers) grabbed the opossum by the neck and shook it. The opossum hissed, tried to fight, then "played 'possum."

The EEG tracings showed little change—before, during, or after the animals "played 'possum." To make sure of their findings, the biologists decided to take EEG tracings while opossums were attacked by a *real* dog. A fresh group of opossums was captured and kept at the lab until they were used to their surroundings. Then each animal was attacked by a specially trained dog.

The dog would paw at the opossum, chase it into a corner, then pick it up by the neck and shake it. After this attack, the animals would "play 'possum" for up to five or six minutes—longer than they did when attacked by an "artificial" dog. Again, the EEG tracings showed no unusual brain activity while the animals "played 'possum." The opossums' brain activity was that of normal, awake, alert animals. From their findings, the biologists concluded that opossums do not lose consciousness when they are attacked; they really are just "playing 'possum."

—LAURENCE PRINGLE

■ Look in your library or bookstore for this book on the North American opossum: **The World of the Opossum**, by James F. Keefe, J. B. Lippincott Co., Philadelphia and New York, 1967, $4.95.

Using This Issue . . .
(continued from page 2T)

twigs can be identified and arranged in a bulletin-board display.

References

For help in identifying trees by their twigs, see *Trees and Their Twigs,* an Audubon Nature Bulletin available from the National Audubon Society, 1130 Fifth Avenue, New York, N.Y. 10028, and *Winter Botany: An Identification Guide to Native Trees and Shrubs,* by William Trelease, Dover Publications, Inc., New York, 1967, $2 (paper).

Playing 'Possum

Pogo, the cartoon character, is a 'possum, but bears little resemblance to the marsupial that occurs in about half of the United States and in southern Ontario, Canada. This mammal often lives in suburban areas where, harassed by dogs, it has many opportunities for "playing 'possum."

The opossum lacks the natural defenses of such mammals as raccoons, porcupines, and skunks. Its ability to "play 'possum" probably helps the species to survive, though how this behavioral trait evolved is a puzzle.

Brain-Boosters

Mystery Photo. See if anyone can recognize the Mystery Photo as a picture of the inner stalks from a large bunch of celery.

What will happen when? Declare a Penny-Shooting Day, and ask each child to bring in five or six pennies. Have a supply of extra pennies for those who forget. Let everyone do the experiments on his desk. You could suggest additional things to try, such as using more pennies or substituting a heavier coin for one of the pennies.

Can you do it? Bring in an egg, and see if anyone can break it by squeezing as shown. It is almost impossible to do. For safety, you might enclose the hands squeezing the egg in a plastic bag.

Fun with numbers and shapes. This is a difficult question. The 10 letters are the first letters of the numbers from *o*ne to *t*en.

For science experts only. Allow your pupils some time to think about the two astronomy questions before you give them the answers. The first satellite to circle the earth was the moon, and the sun is a star.

Just for fun. It is very difficult for someone to catch a dollar bill dropped between his fingers. A ruler can be used to measure a person's reaction time. Hold the ruler with the bottom end between the person's thumb and forefinger. As soon as the stick is released, the person being tested closes his fingers to stop it. The slower his reaction time, the farther the stick falls. Test some of your pupils in this way. Do all the children react with about the same speed?

N&S REVIEWS . . .
(continued from page 1T)

mon (Basic Books, 118 pp., $3.95). Heart surgery is often in the news; new techniques and discoveries make dramatic stories. The last chapter of this book reviews many of these innovations. But of equal interest are the stories of the early discoveries about the heart and the men who made them. The chapters about Galen, Vesalius, and Harvey are especially good. There are many photos and drawings, as well as diagrams to show how the heart works, what can go wrong, and how it can be repaired. Perhaps the writing is at times over-colorful and explanations over-simplified, but for a sixth-grader it may serve as an exciting introduction to the mystery of how a heart works and to the history of this branch of medicine.

Foxes in the Woodshed, by Lilo Hess (Charles Scribner's Sons, 48 pp., $3.25), is a picture-story of three baby red foxes from the time they were brought to the woodshed as tiny pups to the time they reached adulthood. Their adventures while growing up are recounted; one tried to hide in a drain pipe when frightened by an owl, and another broke a leg which was put in a splint by a farmer. General information about foxes is included throughout this story, which will probably be enjoyed by third and fourth graders. The many attractive photographs of the baby foxes and their antics as playful pups are delightful; they are bright-eyed and full of life. This is not true, unfortunately, of the photos of the adult fox.

Pigeons Everywhere, by Lilo Hess (Charles Scribner's Sons, 62 pp., $3.50). Pigeons are so common that they tend to be ignored by some who hardly regard them as true birds. Yet for many city children pigeons are the first, and sometimes the only, birds they know. With this book in hand children will learn a good deal about pigeons and perhaps expand their interest to the whole world of birds. Besides containing general knowledge of pigeons, there is information on raising pigeons and on some of the fancy breeds which have been developed.

Since pictures are an important part of this book, it is too bad they were not captioned. It is rather confusing to find photographs of ringed turtle doves interspersed among those of common pigeons. And we find the text about an adult mated pair finding a nest site accompanied by a photograph of two young birds with wisps of down still clinging to them.

Although the jacket suggests the book for 6 to 10 year olds, the average 6 or 7 year old would find the vocabulary beyond him; 8 to 12 is more realistic.

The Wonders of Prehistoric Life, by Donald Barr, Darlene Geis, and Martin L. Keen (Grosset and Dunlap, 160 pp., $3.95). This is a simplified yet comprehensive book covering the beginnings of life, from the simplest sea animals to dinosaurs—and the strange early mammals up to the beginnings of man and historic times.

Considering the magnitude of the subject, the authors have done well in condensing the material and presenting it in clear, simple language. Scientific words are explained and pronunciations given; there is an index, and the book is profusely illustrated. It is probably best suited for sixth grade and up, though younger dinosaur enthusiasts will probably

(Continued on page 4T)

(continued from page 3T)

enjoy parts of it.

When three different authors write three different parts of one book there is apt to be a difference in style and even a different interpretation of facts. This has happened here. On page 9 we are told that "about a billion years ago, the first living things appeared on earth," while on pages 116 and 117 an explanation is given of the possible formation of the first living cell, "two billion years ago."

Small Mammals Are Where You Find Them, by Helen Damrosch Tee-Van (Alfred A. Knopf, 148 pp. $3.50). This might be called a "child's field guide to small North American mammals." Designed for 8 to 12 year olds, it follows the format of most field guides, starting with a two-page introduction to mammals and an explanation of scientific classification. Then the main text describes each mammal in turn, beginning with opossum and ending with the Florida Key deer (a sub-species included because it is so small). With each entry there is a location map and a black and white drawing. There is an index. The text is excellent, written with a child's interests and reading abilities in mind. Unfortunately, many of the accompanying illustrations by the author are far less successful.

Islands of the Deep Sea, by Albert B. Carr and Robert S. Hopkins (John Day Co., 96 pp., $2.86). Islands appeal to nearly everyone, especially those far-away islands with romantic-sounding names. From reading this book, a great deal can be learned about those oceanic islands—how they were formed, what plants and animals live on them, how they were first settled, and what it is really like to live on an island in the deep sea.

The authors know their subject well and all of these topics are thoroughly explored. The writing is exceptionally clear and concise, making this a highly readable and informative book for sixth grade and up. Well illustrated with black and white photos, maps, and diagrams. Indexed.

nature and science
TEACHER'S EDITION
VOL. 5 NO. 7 / DECEMBER 18, 1967 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

New Books on Archeology and Anthropology for Your Pupils

By Shirley Gorenstein

Crete: Island of Mystery, by Leonard Cottrell; illustrated by W. T. Mars (Prentice-Hall, 72 pp. $3.50). We are always fortunate when an archeologist who is also a writer turns his hand to a book for children. The result, in this case, is an accurate, intelligently conceived work written in a cultivated style. The subject is the archeology of Crete. Cottrell begins with the legend of Crete, goes on to trace the work of Heinrich Schliemann at Troy, Mycenae, and Tiryns as the background to Sir Arthur Evans's investigation of Knossos. He concludes with a brief description of Minoan civilization. The production of the book is excellent, and affords the reader the rare pleasure of using a well-designed book.

Race Against Time: The Story of Salvage Archeology, by Gordon C. Baldwin (G. P. Putnam's Sons, 191 pp. $3.29). Salvage archeology came to the fore after World War II when the pace of construction in the United States was enormously increased. Dams, highways, and pipelines were being constructed all over the country. Dams that tapped the rivers were of particular concern to archeologists because the remains of prehistoric Indians were concentrated along their banks. The story of how archeologists rallied to save them is well-told in *Race Against Time*. The history and work of the Inter-Agency Archeological Program is discussed with special attention to the River Basin Surveys. The archeology is not neglected, and the reader is able to understand the worth of what is being salvaged.

Quest for Prehistory, by Geoffrey Palmer and Noel Lloyd; illustrated by Carol Baker (John Day, 128 pp. $3.29). This neatly written book with pleasant illustrations is somewhat wrong in its facts, somewhat wrong in its concepts, and somewhat wrong in its interpretations. Chipping on the edge is not the diagnostic trait of Paleolithic tools; transformism was not introduced by Charles Darwin; *Homo sapiens* should not be defined as a race of men who came out of Asia or Africa as Neanderthal man was dying out. To right all the many small and subtle wrongs in this book would be a tedious and useless task. It is far better to avoid it entirely. Let us not perpetuate these inaccuracies by saddling another generation with the same misconceptions of prehistory.

Life Long Ago: The First Farmers, written and illustrated by Leonard Weisgard (Coward-McCann, Inc., 64 pp. $3.95). Mr. Weisgard, with some sound advice from Edward Ochsenschlager, has turned out an absorbing little book on the Neolithic. Archeological data from recently dug sites such as Jarmo, Jericho, Çatal Hüyük,

(Continued on page 3T)

Dr. Shirley Gorenstein is a Lecturer in Anthropology at Columbia University, in New York City, and the author of Introduction to Archeology, *a college text.*

IN THIS ISSUE

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

● **Exploring Inside an Egg**
By examining an egg, your pupils can find out quite a bit about its biology, "assembly," and even some clues about the hen that laid it.

● **How Strong Is an Eggshell?**
Your pupils can measure how much weight it takes to break an eggshell when it is whole, empty, water-filled, and in other conditions.

● **The Bats of Carlsbad Caverns**
A Park Naturalist takes your pupils into Bat Cave to study the ecology of these flying mammals.

● **Life in a Cave**
This WALL CHART emphasizes the adaptations that enable different kinds of animals to live in the various microclimates of a cave.

Case of the Vanishing Beach
This article shows your pupils how man-made structures such as dams and jetties can starve a beach for sand and make it disappear.

The Moon and the Weather
An old saying has it that they change together. Scientists are trying to find out if they really do.

IN THE NEXT ISSUE

Man's changing ways of measuring a year . . . Visit to a biological research station . . . Can you make a better paper airplane? . . . Measuring your own horsepower . . . Does water attract plant roots? . . . How scientists are attacking tooth decay.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Inside an Egg

By exploring the parts of a hen's egg, your pupils may be reminded that an egg is designed for something more than food. When fertilized by a sex cell (sperm) of a male chicken, an egg develops into a new chicken, with the embryo chick getting its food from the egg yolk.

Over the years, poultry breeders have deliberately bred chickens that produce many eggs, and have eliminated those individuals that are not good producers. In nature, different species of birds have evolved different ways of insuring that enough eggs are laid for the species to survive. Some birds are "determinate" layers; they lay just four eggs, say, and then begin to incubate them. The act of laying the "correct" *clutch* (number of eggs per nest) for the species seems to trigger the start of the bird's incubation.

Other birds (including chickens) are "indeterminate" layers; the trigger for incubation seems to be the feel of the correct clutch size beneath the female on the nest. As long as the clutch stays incomplete, the bird keeps laying eggs to complete it.

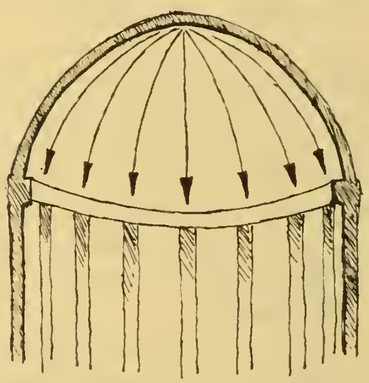
Eggshell Strength

Whether your pupils do this Science Workshop at home or in the classroom, and whether many or few do it, first have everyone try to guess how much weight an eggshell will hold without breaking. Record the guesses, and compare them with the findings of the egg-testers.

If you, or your pupils' parents, are averse to wasting eggs, your pupils could use half eggshells for the measuring tests (and save the insides for frying, poaching, or scrambling). Half-shell "table" legs should have fairly even edges so they rest solidly on the open end. Use clay on top to bring them all to the same height.

At least one test should be made to compare the strength of whole eggshells with that of half shells from the same carton of eggs. Comparing the strength of half shells with that of whole eggs and of blown-out eggshells will give your pupils an idea about whether the difference in strength between a whole and a half shell is due more to the contents of the whole shell or to its fully rounded shape. The strength of half shells from the rounded end of eggs might also be compared with that of shells from the more pointed ends to find out how curvature affects strength.

Ask your pupils if they can think of ways that the eggshell shape is used in buildings. The rounded dome is like a half eggshell; its weight is evenly distributed to the supporting base of the dome (*see diagram*).



A dome is shaped like half an eggshell. Its weight pushes down evenly against the circular frame that supports the dome.

If the word "pressure" crops up in discussion of test results, point out that *pressure* means something more than *weight* or *force*. Pressure is the amount of weight or force pressing on a given area; it is usually expressed in pounds per square inch (psi).

Life in a Cave

Practically every state has at least one cave; some have hundreds. Caves are most common where there are thick deposits of limestone. This rock is composed of minerals from the shells of sea animals. Limestone is easily dissolved in water that contains carbonic acid.

A limestone cave begins when water trickles down into cracks and crevices, forming larger and larger cavities below ground. Sometimes entire rivers flow underground through passages worn away in the limestone.

In a cave, just as in a field or forest, there lives a community of animals that is particularly adapted to live there. Those species that live all their lives in caves, such as blind fish, have the most striking adaptations. Sometimes there are species that live part of their lives in caves and part in nearby springs or streams. These species usually have characteristics that are intermediate between permanent cave dwellers and species that live in the open.

As the Wall Chart points out, cave life is not very abundant when compared with the outside world. The absence of green plants forces the animals to depend mostly on imported food, either brought in directly (*e.g.*, by a flood) or indirectly (*e.g.*, in the form of bat guano).

Remind your pupils of the importance of green plants as food for all life; you can also use the examples provided in the Wall Chart to illustrate the idea of a "food chain" with food energy passing from one organism to another.

Warning: Cave exploration (spelunking) requires special equipment and caution. No one should ever venture into a cave alone. If any of your pupils are interested in exploring

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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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

nature and science

VOL. 5 NO. 7 / DECEMBER 18, 1967

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PICTURE CREDITS: Cover, H. E. Edgerton from National Audubon Society; pp. 2-3, 5-7, 13-14, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, Frank H. Wilcox; p. 7, photo by David Webster; pp. 8-9, photos (l. to r.) by Leonard Lee Rue III, Charles E. Mohr, Gene Wolfsheimer, Charles E. Mohr, from Photo Researchers, Inc., Alvin E. Staffan; pp. 10-12, courtesy of National Park Service; p. 15, courtesy of U.S. Army Corps of Engineers.

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

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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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

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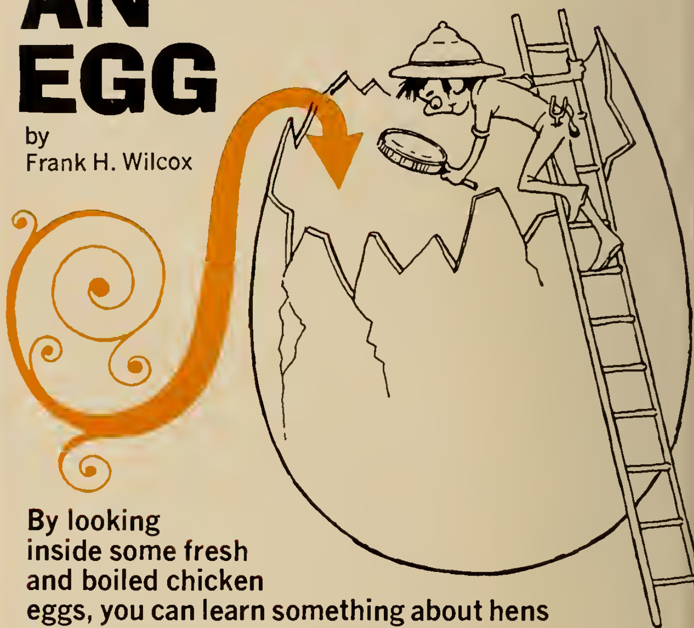
EXPLORING INSIDE AN EGG

by
Frank H. Wilcox



By looking inside some fresh and boiled chicken eggs, you can learn something about hens and their egg "assembly line."

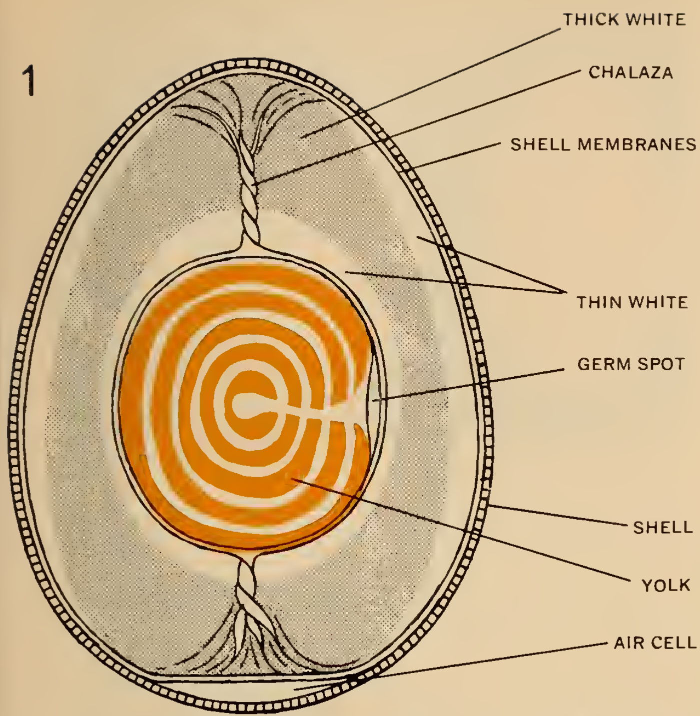
■ A hen puts out a neat little package when she lays an egg. What the egg is made of and how it is formed inside the hen is an interesting bit of biology.

The next time you break open an uncooked egg, look at the yolk. You should be able to see the germ spot, a tiny dot that is lighter yellow than the rest of the yolk. The germ spot is found on the top of the yolk because it is not as heavy as the rest of the yolk and rises to the top. It is at the germ spot that an embryo chicken begins to form, *if* the egg has been *fertilized.* (Eggs you buy in supermarkets usually have not been fertilized.)

In many eggs you can see two white cords in the egg white, one at each end of the yolk. These are called *chalazae (see Diagram 1).* They are fibers or threads in the egg white that have become twisted around each other. Now look at the inside of the blunt end of the egg shell. You'll see a membrane. Break it and you'll find a pocket of air called the *air cell.* It is between two membranes that go around the egg just underneath the shell.

The size of the air cell tells you whether an egg is fresh or not. When the egg is laid by the hen it has no air cell, but as the warm egg cools one begins to form. As the egg gets older it gradually loses moisture through its shell, and the air cell increases in size. In old eggs it is quite big. Therefore, an egg with a large air cell is certainly not a fresh one.

1



Carefully chip away half of the shell of a fresh egg and see how many of these parts you can identify.

Fresh eggs also have different looking whites than older eggs. The eggs you get in the store are usually reasonably fresh. If you open one onto a plate, you will notice that some of the white on the outside is thin and runny. The rest of the white next to the yolk is much thicker and almost like jelly. Older eggs have more of the thin white and less of the thick.

Clues from Eggs

You can tell a lot about a chicken just by looking at one of its eggs. For one thing, you can guess at the chicken's age. If the egg is small, it is almost certainly from a young pullet (about six months old) starting to lay. Chickens don't produce full-sized eggs until they've been laying eggs for several months. A large or extra large egg would be from a hen one or more years old.

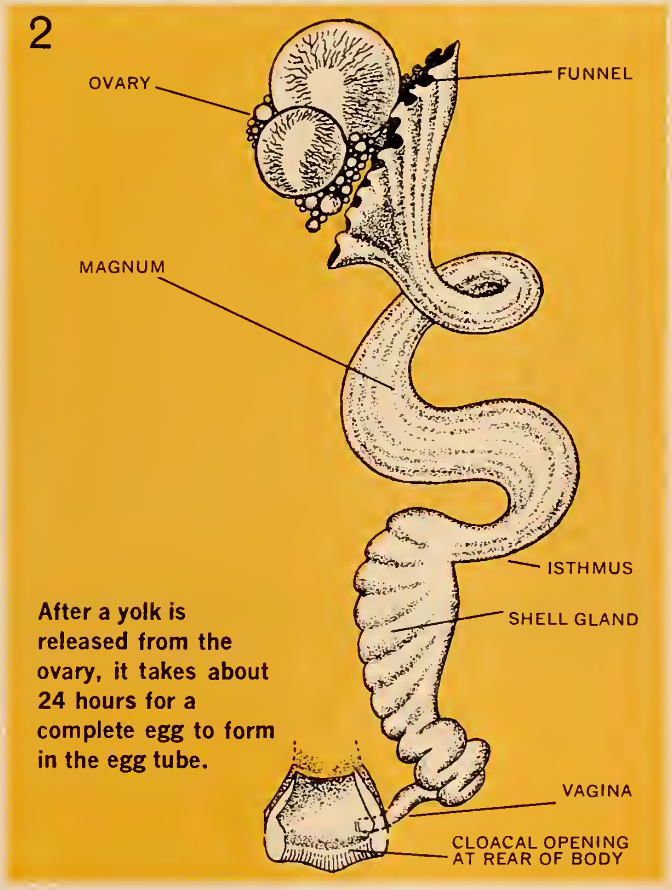
The color of the shell will give you a clue as to what breed of chicken laid an egg. You'd be right 99 times out of 100 that a white egg came from a White Leghorn. Brown eggs could have been laid by two or three different breeds. But there's only one chicken that lays a blue egg—a South American breed so rare that you'll probably never see it or its egg.

You can tell something about a chicken's diet and how the chicken was raised by the color of the yolk. Hens kept indoors and fed regular chicken feed lay eggs with rich yellow yolks. If white corn is used in the feed instead of yellow corn, the yolk will be pale. Hens kept in barnyard flocks where they pick up green food have rather dark yolks. Strangely enough, only the color of the yolk is affected by a hen's food. The egg white and shell remain the same color, no matter what the diet.

How an Egg is Formed

The egg is formed in the hen by a process that is like a factory assembly line. The yolk passes through a long egg tube, and as it moves certain things are added to it. By the time it reaches the end of the tube, it is a complete egg. Diagram 2 shows where each part of the egg is made.

The yolk is made in the ovary, which looks like a bunch of yellow grapes inside the chicken. Each yolk begins as a tiny portion of the ovary that looks like a small white pea. As this small particle gets bigger and bigger, it changes to a yellow color. Each night a lighter ring of yolk is added on, and each day a darker ring is added. You can sometimes see these rings in a hardboiled egg if you cut the yolk cleanly in half. There are usually nine dark rings and nine lighter ones, because it takes nine days for most of the yolk to be formed.



(Continued on the next page)

When the yolk has stopped growing, it is released from the ovary. Then it enters the funnel-shaped end of the long egg tube.

As the yolk passes down the *magnum (see Diagram 2)* the egg white is added to it, a little at a time. By the time the yolk has reached the other end of the magnum it is surrounded by a large amount of jelly-like egg white. The egg now has half its egg white. The egg next passes through the *isthmus,* where the membranes are added around the egg white.

After the isthmus, the egg moves into the shell gland. Here the rest of the egg white and shell are added. This takes a long time—in fact, most of the time the egg spends in the entire egg tube. The egg is here 20 to 24 hours, after only three hours in the magnum and about an hour in the isthmus. When the egg leaves the shell gland it goes quickly through the *vagina* and is laid.

An Egg a Day . . .

Chickens don't lay more than one egg a day. They have only one egg tube and it can handle only one egg at a time. Since each egg spends a full 24 hours or more in the egg tube, it is impossible for eggs to be laid faster than one a day. Some hens lay an egg every day for months.

In nature, birds usually lay just a certain number of eggs and then keep them warm until they hatch. Today's chickens are not allowed to do this. They try to replace the eggs that poultrymen gather daily from their nests. Some wild birds react in the same way. When eggs were continually removed from the nest of a flicker, she laid 71 eggs in 73 days before she finally gave up (or out!). Birds such as flickers and chickens keep replacing the stolen eggs in order to have the normal number in their nest. Some other species of birds, such as meadowlarks, do not lay any more eggs than normal, even if some are stolen ■

PROJECT

From a meat market or farmer, get a freshly-killed laying hen. With a sharp knife (and the help of an adult) you can *dissect* (cut open) the bird and look for its egg tube and ovaries *(use Diagram 2 as a guide).* You'll have to cut away most of the digestive system in order to easily see the ovaries. Work in the kitchen sink, and use running water to keep the body cavity clean of blood. If you're lucky you may find a partly-formed egg somewhere along the egg tube.

Some Unusual Eggs. Now that you know how eggs are formed, you can understand how some unusual eggs are made. The two most common types are double-yolked eggs *(left)* and dwarf eggs *(right).* You have probably seen a double-yolked egg, but not a dwarf one. They are so small that they are never used. A double-yolked egg is formed when two yolks are dropped from the ovary at the same time. These yolks stay close together while passing through the egg tube. They are treated as one yolk by the egg tube, which adds egg white, membranes, and shell. The end result is, of course, not two eggs, but a single large egg with two yolks.

Dwarf eggs usually weigh about 7/12 of an ounce, one fourth of the weight of a normal egg *(center in photo).* The smallest dwarf egg yet found weighed just 1/24 of an ounce. These small eggs have no yolk, but instead have a small particle in their center, such as a grain of sand. The particle is treated like a yolk as it travels down the egg tube. Egg white, membranes, and shell are all added to it. The finished product, the dwarf egg, is smaller than usual because the material starting down the egg tube was smaller.

Years ago it was not known how such eggs were formed, and they were the object of various superstitions. They were commonly called "cock eggs," and it was said that a cock (male chicken) laid only one of these eggs during his lifetime. It was believed they would hatch into a serpent whose breath was fatal. They have also been called "wind eggs" and "witch eggs." But they are no more than yolkless hens' eggs which could never hatch because the yolk with its germ spot is missing.

how strong is an EGGSHELL?

TO FIND OUT, ALL YOU NEED IS SOME BOOKS, CLAY, A BATHROOM SCALE, AND, OF COURSE, SOME EGGS.

by Laurence B. White, Jr.

■ Have you tried to break an egg by squeezing its ends between the palms of your hands, as suggested in "Brain-Boosters" last issue? If you have, you know that an egg's thin shell is surprisingly hard to break by pushing on it. Can you guess how many pounds of weight an egg will support without breaking? Here's a way to find out.

A Table with Egg Legs

The simplest test would be to put some weight on top of an egg and keep adding more weight until the egg breaks. It's practically impossible, though, to balance anything on top of something as rounded as an egg, so you might try supporting the weight on four eggs, instead of one.

As you probably know, each leg of a four-legged table supports one-fourth of the weight of the table top. If the top weighs, say, 40 pounds, the weight on each leg is 10 pounds. By making an egg-legged table, you can find out how much weight an egg can support.

This investigation always ends up being messy. Even if you enjoy making a mess, it's a good idea to make it an easy-to-clean-up mess. Set up your egg table on a cookie tin or a sheet of aluminum foil with the edges bent up to keep the mess off the table or floor.

Ask your mother for four eggs. Be sure to tell her that they are for a science investigation, and she will not get them back (or, at least, she won't want them back after they have been tested). You will also need a small amount of modeling clay, a plastic bag, a bathroom scale, and a

(Continued on the neggst page)

HOW IS AN EGG LIKE A ROCK?

To produce an eggshell, a hen's body must contain *calcium carbonate*, a substance commonly called *lime*. This substance is a combination of calcium, carbon, and oxygen, and it makes up the hard shells of sea animals such as oysters and clams. And the shells of these dead animals, falling to the sea bottom over thousands of years, are pressed together under their own weight to form the rock called *limestone*. The "mash," or chicken feed, used today usually contains all of the ground-up limestone that a hen needs for her eggshells.

An eggshell formed of this rocklike material is so thin that it changes shape slightly when you press on it. Place a curved piece of shell with a fairly round edge on the table, outside up, and press down on it gently. You should be able to see and feel the shell bend a bit before it breaks. Could you break an unopened egg so easily?

The curved shape of the unopened egg makes each part of its shell as strong as any other part. When you press on the egg the pressure is spread out evenly through the shell to every part of it. (Would this happen if eggs were square? Press your finger against the wide side of an empty match box or paperclip box and see how it bends.)

It's easy enough to break a whole egg by dropping it, though, or by striking it a quick blow with the edge of a knife. Do you suppose that the shell breaks because it is hit so hard, or so suddenly, or in such a small spot, or for all three reasons? Can you think of a way to find out?

great many books—probably 15 or 20. If you follow the instructions carefully the books will not be damaged, but it's best to use old books—not valuable ones, of course.

To make the eggs stand on end, like table legs, put a little clay on the cookie sheet for each egg to rest on. One of the books will make the table top; arrange the eggs on the sheet so that each one will support a corner of the book. Gently press the larger end of an egg into each bit of clay until it stands up by itself. Be sure the eggs are standing perfectly straight. Press another bit of clay on top of each egg to prevent the book from slipping off.

Now slip the book you have chosen for the "table top" into the plastic bag. This will protect it later when the eggs break. (Be sure to close the open end of the bag with a rubber band or tape.) Place the bagged book gently on top of the four eggs to complete the "table."

The Eggs-periment

Now for the fun. Start piling books, one at a time, on top of the plastic-covered egg-leg table. Do this slowly and with care. Place each book squarely on top of the others; if they are piled to one side, the eggs may roll over.

Each book will squeeze the eggs a bit more. When adding one more book makes the eggs break, quickly lift the books off the eggs. Remove the plastic bag from the bottom book, and stack all the books on the bathroom scale. How many pounds do they weigh? If you divide this figure by 4, you can tell how many pounds of weight it took to break any one of the four eggs. (Do you think that your measurement would be more eggs-act if you used many thin books instead of a few thick ones? Can you expain why?) ■

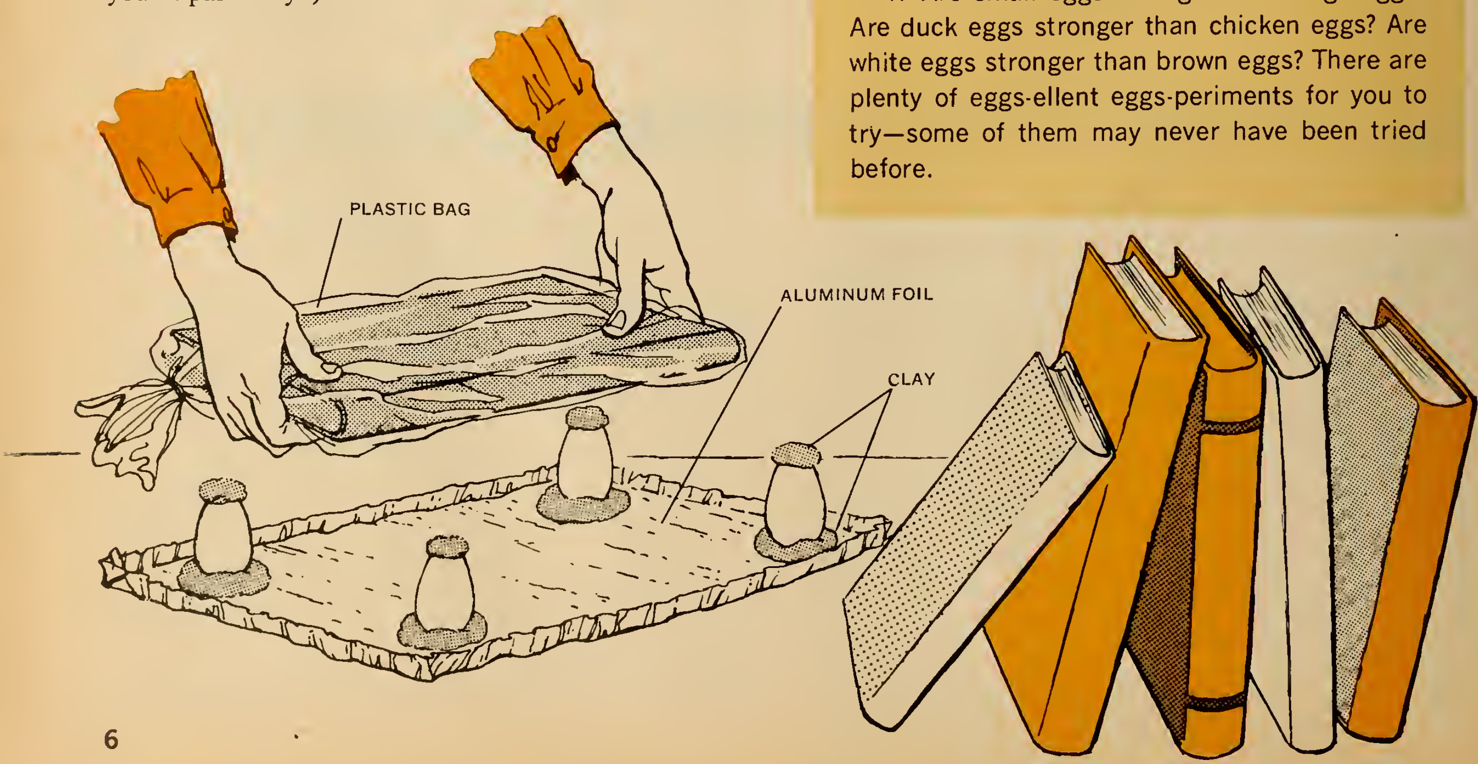
EGGS-TRA EGGS-PERIMENTS

1. If the eggs were being pressed at their sides instead of their ends, could they support more weight or less? You can find out by repeating the investigation with the eggs resting on their sides. Can you give a good reason for your results?

2. Because the insides of an egg are mostly liquid, they cannot be squeezed into a smaller space. If you press down on an egg, the liquid inside makes the sides bulge out. Use a needle to make a hole in each end of an egg. Blow hard in one hole, holding the other hole over a dish. The liquid will run out, leaving a hollow shell. Repeat the egg-table investigation with four hollow eggs to see if the liquid center helps to make an egg strong.

3. If you read "Exploring Inside an Egg" (see *page 2*), you know that eggs are not completely filled with liquid. Do you suppose an egg would support more weight, or less, if it were completely filled? Perhaps you could fill some of your blown-out eggs with water, seal the holes with modeling clay, and test them. Also, you can make the insides of an egg more solid by cooking the egg in boiling water for four or five minutes, and still harder by boiling it 10 or 15 minutes. Will a soft-or hard-boiled egg support more weight than an uncooked egg?

4. Are small eggs stronger than large eggs? Are duck eggs stronger than chicken eggs? Are white eggs stronger than brown eggs? There are plenty of eggs-ellent eggs-periments for you to try—some of them may never have been tried before.



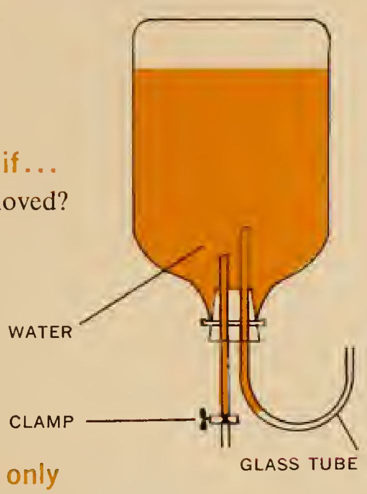
BRAIN-BOOSTERS

prepared by **DAVID WEBSTER**

What would happen if...

...the clamp were removed?

Submitted by Bradley Hedmen, Philadelphia, Pennsylvania

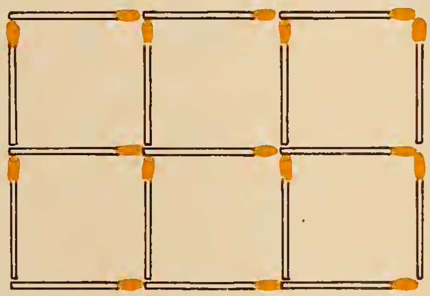


For science experts only

If goldfish have gills to get oxygen from the water, why do they die when they are out of water in the air?

Mystery Photo

Why is the name on the truck printed backwards?



Fun with numbers and shapes

Change the position of three matches to make five squares.

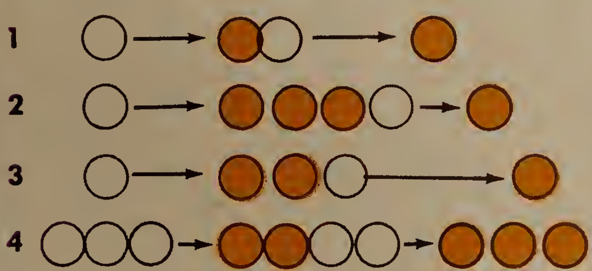
Can you do it?

Can you drop a full box of matches so it will land on its end?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo showed the inner stalks from a large bunch of celery.

What will happen when? The colored circles show how the pennies are spaced after the moving pennies hit the other pennies.



Can you do it? It is almost impossible to break an egg if you squeeze it the long way between your hands.

Fun with numbers and shapes: O T T F F S S E N T are the first letters of the numbers from *o*ne to *t*en.

For science experts only: The first satellite to circle the earth was the moon. The sun is a star. Can the moon ever be seen during the day?

LIFE IN A CAVE

■ To many people, the word "cave" means mystery, adventure, "spookiness"—the lure of the unknown.

One of the things that makes caves fascinating is the animals that live there. Because of the lack of green plants and other foods, not many kinds of animals live year round in caves. However, this scarcity of life makes caves especially interesting to scientists. Compared to the outside world, life in a cave is simple and easier for scientists to study.

The photographs on these pages show some of the animals you might find in a cave. The captions tell how these animals survive in their dark underground world. For more information about caves, including many color photos of caves and cave life, look in your library or bookstore for: *The Life of the Cave*, by Charles Mohr and Thomas Poulson, McGraw-Hill Book Company, New York, 1966, $4.95 ■

ZONE WHERE TEMPERATURE VARIES WITH SEASONS

Temperatures in this zone change only slightly with the change of seasons. In this zone you begin to find animals that are especially suited for life in caves, including blind fish and insects that spend their entire lives within the cave.

In one Kentucky cave, biologists studied a species of cricket that lives in this zone. They discovered that about a third of the crickets left the cave each night to feed. The crickets returned before dawn; another third of the population went out the next night, and so on. In this cave, the crickets are the main food supply. Beetles and other small animals live on dea crickets or wastes from crickets.

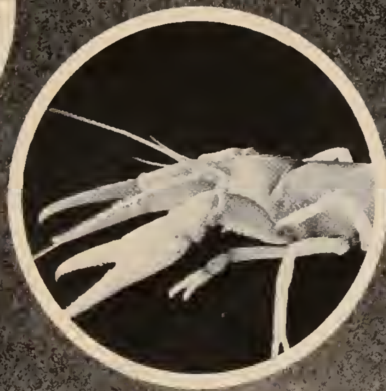
ENTRANCE AND TWILIGHT ZONE

No green plants can live beyond the twilight zone. The climate of this zone is cool and damp, but its temperature changes with the temperature outside. Many kinds of animals, including raccoons, venture into the twilight zone for shelter and food.

When biologists studied one kind of cave beetle, they discovered that the blind insect had an unusual way of surviving in its home where food is scarce. The female beetle lays especially big eggs which contain stored food. This food enables the young beetles to develop inside the egg for at least a month. When they hatch, they change quickly to the pupa stage without needing any food. Most kinds of beetles have little stored food in their eggs and the larva that hatch must eat before they change to pupae.

Bats are an important form of cave life because they supply food for many other animals. The bats catch insects outside the cave at night, then return to roost. The wastes from the digested food fall to the cave floor. This waste, along with the bodies of dead bats, provides food for beetles, millipedes, and flatworms. These small animals may then, in turn, become food for other animals.

This cave crayfish is blind and white. Its antennae are more sensitive to touch and smell than the antennae of its relatives outside of caves. This crayfish takes longer to catch food, such as a worm, but it locates the food more accurately than its relatives that can see.



nd cave fish have
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vision. These fish
more sensitive to
rations and smells
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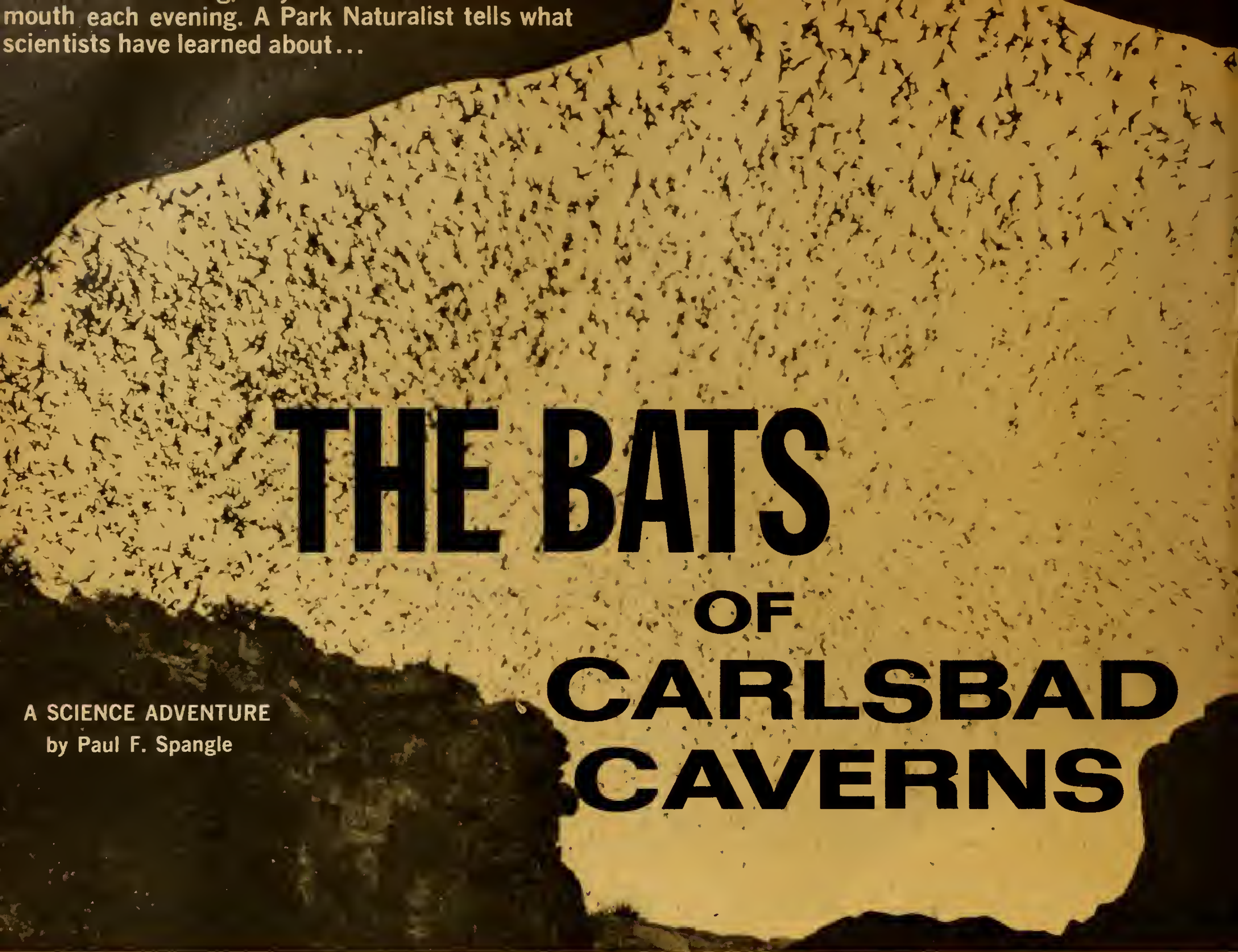
tives that live out-
e of caves.

ZONE WHERE TEMPERATURE IS CONSTANT

Deep in the cave, the temperature stays about the same all year long. Many of the animals in this zone are blind. The ancestors of blind cave animals could see, but after thousands of generations in a lightless world, these species have gradually lost their sight.

Many of the deep cave animals are white in color. Dark coloring matter (called *pigment*), which helps many kinds of animals to hide from their enemies, is of no value to cave animals in total darkness.

The number and variety of animals in this zone depends on the amount of food that is brought into the cave. Food may be carried in by annual floods, or by bats. Without such food sources, the deepest, darkest parts of a cave may be lifeless.



mouth each evening. A Park Naturalist tells what scientists have learned about...

THE BATS OF CARLSBAD CAVERNS

A SCIENCE ADVENTURE
by Paul F. Spangle

■ The soft fluttering of a bat's wings makes some people think of witches and their spells. When a bat swoops near a girl she may cover her head, thinking of the "old wives' tales" of bats tangling themselves in hair.

Many people fear bats, or at least are very curious about these flying mammals. That is one reason why, each year, thousands of people visit Carlsbad Caverns National Park in New Mexico, where a half-million bats live each summer. In the evening, people wait at the entrance to the caverns to watch the bats leave on their insect hunt. At dusk, a thin line of bats gradually thickens into a solid stream. They spiral clear of the entrance—like smoke pouring from a volcano—and swoop out over the valley of the Pecos River (*see photo*).

Into the Bat Cave

As a Park Naturalist at Carlsbad Caverns for several years, I had many opportunities to explore these vast, beautiful caves. In this article, I'll tell you about some of the things we have learned about the bats of the caverns, and some of the mysteries that remain.

Millions of people have followed the well-lit trails on tours of the Carlsbad Caverns. To study the bats, you must leave the main trails, scramble over some rocks, and use a flashlight to find your way along another passageway. Behind you, the lighted oval of the cave entrance gets smaller and smaller. A strange odor, a distant chirping, and the rustle of leather-like wings tells you that you are near the main home of the bats. It is called, simply, the Bat Cave.

Suddenly, instead of stumbling over rocks, you sink ankle deep into a soft carpet. Small pellets rain down out of the dark. If you sweep your light across the floor, you will see mounds of bat *guano*—the droppings of waste from generations of bats that have roosted on the ceiling.

Aim your flashlight overhead. The chirping and fluttering gets louder. There are the bats! A dense, wriggling mass, awakened by the light, begins to break up. One at a time, bats leave the tight-packed cluster and fly back and forth through the beam of light. These are Mexican free-tailed bats, the most common kind (*species*) at the caverns.

The free-tailed bats rest on the ceiling in tightly-packed groups, called "rugs" (*see photo*). There may be as many as 250 to 300 bats on a square foot of ceiling. A "rug" may cover thousands of square feet—that's a lot of bats!

Guano, Mites, and Young Bats

Walking deeper into the Bat Cave, you will come to an area lit by a hole in the ceiling of the cave. Scattered on the floor is a tangle of rusted cable, a big iron bucket, and scraps of lumber. This cave was once a mine, not for minerals, but for guano.

About 60 years ago some men discovered the vast mounds of guano here. They drilled holes from the ground above so they could get to the guano more easily. From these caves they took an estimated 50,000 tons of guano that had been left by untold millions of bats over thousands of years. People used the guano for fertilizer. It is no longer mined at Carlsbad but guano is sometimes taken from other caves in the southwestern United States.

The entire Bat Cave has been used, at one time or another, as a roosting area by the free-tailed bats. The colonies tend to move about during the year, perhaps abandoning one roosting area when it becomes too infested with fleas, mites, and other *parasites* (animals that live on the bodies of other animals).

During the summer, part of the ceiling becomes a nursery for baby bats. We can easily find the nursery by looking for the young during the night, when the adults are gone. When just a few days old, the babies are sometimes carried by their mothers. But they soon become too heavy and are left in the cave while their mothers hunt for insects at night. The young feed by sucking milk (like other mammals) while their mothers are resting after their return at dawn.

Hundreds of the young bats lose their grip on the ceiling and drop to the floor. Once they fall they are lost, because their mothers cannot rescue them. They soon die and become food for the many beetles, mites, crickets, and other animals that live in the guano piles. Some of these fallen young also are eaten by raccoons and ringtail cats (which are related to raccoons) that enter the cave in search of food.

Banding Bats

Scientists have put small aluminum bands on thousands of bats to learn more about them. Each band has a

(Continued on the next page)

The top photo shows a small part of a "rug" of free-tailed bats, clinging to the ceiling at Carlsbad Caverns. As many as 300 bats may be packed into a square foot of space. When a bat falls to the floor and dies, it is quickly eaten by insects and other animals. The photo below shows the bones of a bat on a pile of guano.

Part of a bat's body is still visible in this stalagmite. The bat died here and is now being covered by the limestone dissolved in water that drips from the ceiling.

The Bats of Carlsbad Caverns (continued)

different number and the numbers are recorded with the U.S. Fish and Wildlife Service in Washington, D.C. When a banded bat is found, the band is sent to Washington. There the records reveal where and when the bat was first banded. (The same system is used in banding birds.)

It was through the banding program that scientists first discovered that the free-tailed bats migrate. For many years it was thought that these bats slept in crevices during the winter, then awoke and crawled out in the spring. Then some scientists explored many caves throughout northern Mexico. Among the free-tailed bats wintering in these caves, they found many that had been banded at the Carlsbad Caverns. The free-tailed bats return to Carlsbad each spring. Exactly how bats, which are famous for their weak eyesight, fly hundreds of miles and return to the same roosting site each year is still an unsolved mystery.

While free-tailed bats migrate south from Carlsbad in the winter, other bats of the same species fly south *to* Carlsbad. One October, some free-tailed bats were captured inside the caverns. Several of them had been banded as young in an Oklahoma cave. Then, in the fall, they migrated south with the rest of their colony to Carlsbad.

Mysteries Deep in the Caverns

The Bat Cave area of the Carlsbad Caverns is the main roosting place for bats. But it is not the only place you can find evidence of bats. A mile away, in a series of small chambers 800 feet below ground, you can find the familiar signs of bats—guano, bones, and skulls littering the floor.

Glistening icicle-shaped formations (called *stalagmites*) stick up from the floor. A bat's skeleton is partly hidden in one (*see photo*). Probably the bat once roosted on the stalagmite. Now its remains are gradually disappearing. Water containing dissolved limestone (*see "How is an Egg Like a Rock?", page 5*) drips onto the stalagmite from the rocks above. The limestone hardens into rock. In this way the stalagmite grows and the bat's bones are slowly being covered.

Bats no longer live in these chambers, and the evidence they left behind is puzzling. Why did they come so far into the caverns to roost? Why did so many of them die, possibly at the same time? We still don't know the answers to these questions.

Deep in another part of the caverns—at least two miles from the entrance—is another bat mystery. A colony of yet another species, called fringed bats, lives here, more than 1,000 feet underground. The question is: How do these bats get in and out? As far as we know, they don't use the main entrance, as the free-tailed bats do. We suspect that there is a separate entrance to this part of the cave but we have never been able to find it. We have even tried exploding smoke bombs, hoping that the movement of the smoke would reveal some air currents from the entrance. The smoke gradually cleared away but we didn't find the hidden entrance.

We do know that fringed bats sometimes crawl through cracks and crevices. There may be a very small entrance to this part of the caverns that men may never find ■

BATS IN YOUR BELFRY

There are 38 species of bats in the United States; some bats probably live in your neighborhood. Few people know that these flying mammals are around, because most bats are small and are active at night. In the day, they rest—usually upside down—in caves, trees, deserted buildings, attics, and similar places. Because of their musky smell and body wastes, bats can be a nuisance in a house. Otherwise, they are useful animals. Most of the species of bats in the United States eat insects. At least two kinds of bats in the United States eat nectar and pollen from plants; one species eats some fruit. If you should find a bat, don't handle it. Bats are mammals, and the bite of any mammal can be dangerous.

To learn more about bats and to find out what kinds of bats live in your area, see these books: **Mammals, A Golden Nature Guide,** by Herbert Zim and Donald Hoffmeister, Golden Press, New York, 1955, $1 (paper); **The Mammal Guide,** by Ralph S. Palmer, Doubleday & Company, Inc., Garden City, New York, 1954, $4.95; **Bats,** by Charles L. Ripper, William Morrow and Co., Inc., New York, 1954, $2.94.

WHAT'S NEW

By
Roger George

The stars hardly twinkle at all in the sky above places in Chile where new telescopes are being located—and astronomers are glad of it. Stars normally twinkle because the earth's blanket of air scatters the starlight, making its brightness change. But the new telescopes will be on the tops of mountains 10,000 feet high, above the thickest part of the earth's atmosphere. So starlight will reach them with little change.

The area, about 250 miles north of Santiago, has other advantages that make sky-watching nearly perfect. There are no large towns nearby to light up the sky and interfere with viewing. The air is clear, with almost no dust, and clouds seldom block the sky. No wonder several telescopes have been completed and others are being built in this area, which may soon become the telescope center of the world.

If you could jump like a flea, you might vault over a 40-story building or leap the length of three football fields. Some of these tiny insects can jump up to 6 inches high (100 times their body length) and a distance of 12 inches (200 times their body length). How do fleas do it?

H. C. Bennet-Clark, a zoologist at Edinburgh University in Scotland, has studied high-speed films of jumping fleas. He has also made flea models out of wire, cord, and other material. Writing in *New Scientist,* he describes how a flea jumps with its hind legs. The bending of the legs seems to stretch an elastic pad in the flea's body. When the pad is released, the legs give a sharp kick, firing the flea into the air as fast as an air gun bullet.

"Drink your orange juice! The vitamin C in it is good for your cold." That familiar advice from parents is apparently wrong. But, oddly enough, it has probably helped many children get rid of colds more quickly. These conclusions come from a study made recently by British scientists.

Volunteers with colds were divided into two groups. Vitamin C was added to the diet of one group without either group knowing it. Result: Colds lasted equally long in each group. In other words, the vitamin C had no effect on the colds. But in a second test, the volunteers were told whether or not they were getting vitamin C. This time, the colds of those receiving vitamin C disappeared faster.

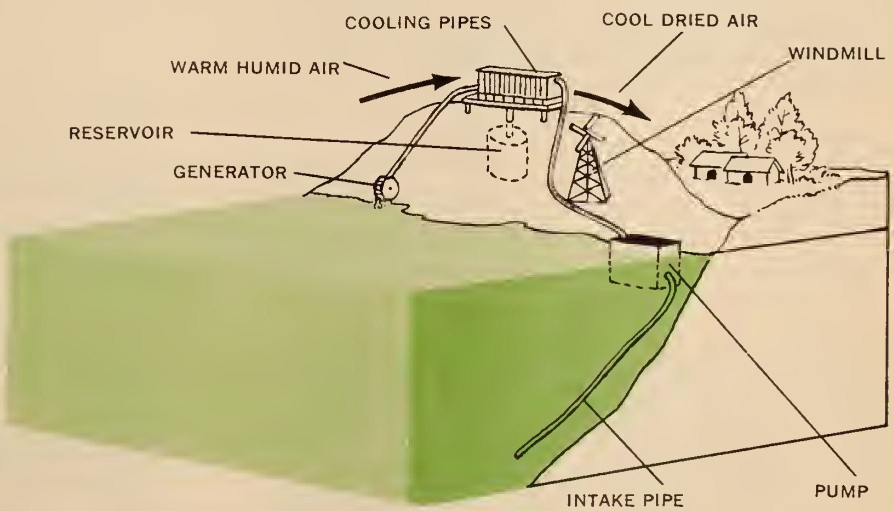
Surprising? Not really. Doctors have known for years that even sugar pills may help a patient get well if he thinks the pills are medicine. The vitamin C study is just one more proof of the important role the mind plays in sickness and in health.

By removing water from air, many islands and coastal areas could relieve their fresh-water shortage. And the cost would be far less than getting fresh water by desalting sea water, according to Robert D. Gerard and J. Lamar Worzel of Columbia University's Lamont Geological Observatory in Palisades, New York. Writing in the journal *Science,* they describe their scheme:

A huge open chamber with thousands of pipes running through it is built on the shore in the path of warm ocean breezes (*see diagram*). Deep, cold ocean water is pumped by windmill power through these pipes. As warm, humid sea air blows past the cold pipes, the air cools and its water vapor turns to liquid water that collects on the outside of the pipes and runs down into a reservoir.

Ten - thousand - year - old seeds have grown into healthy plants. A mining engineer found some seeds, along with a rodent's skull, inside old rodent burrows in permanently frozen ground in Canada's Yukon Territory. That was in 1954. The engineer didn't realize the importance of his discovery until last year when news of it reached scientists at the National Museum of Canada. They found the age of the seeds by comparing the skull and the burrows with similar finds that had already been "dated."

The seeds had remained "asleep" (*see "Sleepy Seeds,"* N&S, *October 16, 1967*) for at least 10,000 years because they were frozen, and for another 12 years because they were kept dry. But when museum botanist A. E. Porsild placed some of the seeds on a wet filter paper in a dish, six sprouted in two days. Later planted in pots, they grew into arctic lupines, a plant common today. Until now, the oldest seeds to sprout were believed to be 2,000-year-old seeds of the sacred lotus.



As warm, moist air from the ocean flowed through this plant on a coastal hill, water vapor from the air would *condense*, or change into water, on pipes containing cold sea water. The fresh water would be collected in a reservoir for use by people near the coast. A windmill provides power to pump the sea water through the pipes, and the water flowing back to the sea turns an electric generator.

CASE OF THE VANISHING BEACH

An ocean current usually feeds new sand to a beach as it carries old sand away. When man-made structures "starve" a beach for sand, men must find a way to feed it.

by Wesley Marx

■ One evening in 1963 Mr. Clifford Bell felt himself being nudged from sleep. His son said that water was seeping into the first floor of their beach cottage in the Surfside-Sunset Beach area of southern California. Mr. Bell quickly ran down the stairs, splashed across the living room and looked out the door. The beach in front of his cottage was missing. The Pacific Ocean lapped at his front door.

For the next two months, Mr. Bell and his neighbors stacked sandbags before their cottages to protect them against the winter storm tides. The sandbags protected Mr. Bell's cottage, but many of the others were pulled away from the shore by the tides and washed up as litter on other beaches. Tons of sand had to be hauled in to rebuild the beach and protect the remaining cottages.

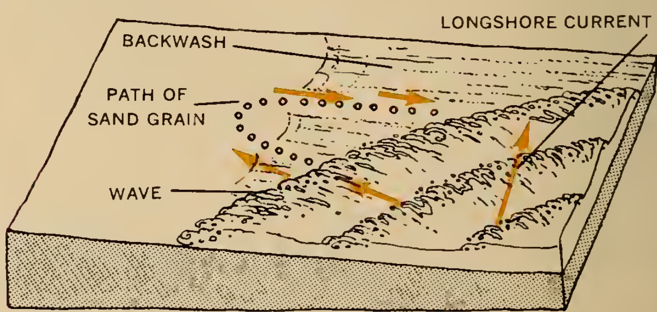
This was the fourth time within 16 years that this particular beach had been restored, and it will probably not be the last time. The feeding of a beach is an endless task.

The Changing Sands of a Beach

The sand that forms our beaches does not come originally from the ocean. It comes from the hills and mountains. There, frost, wind, and rain gradually grind down boulders into small particles. Mountain streams and rivers carry away these particles and drop them into the ocean at the mouth of the river. Later the *sand* grains—the particles from about 2½ thousandths to 80 thousandths of an inch in diameter—are picked up by the *longshore* ocean current and carried to the shore, where they form a beach.

If you have ever watched waves pushing water up on a beach, you have seen a longshore current at work. Perhaps you noticed that the waves almost always reach the shore at a slant, rather than head-on. (Can you explain why?) However, as the earth's gravity pulls the water back into the sea, it flows straight down the slope of the beach. In this way, water is moved farther along the shore each time it is pushed up on the shore in a wave *(see diagram)*.

This motion of the water along the shore is the longshore current. With each wave it delivers sand to one end of the beach, moves sand along the beach, or carries sand away from the other end of the beach—perhaps to another beach. Along the California coast, the longshore current distributes as much as a million tons of sand each year.



A wave striking a beach slantwise moves a grain of sand upward and sideways, then down the slope in the backwash.

Even though the sand in a beach is constantly being moved and replaced, the beach may last for years or even centuries. But if the supply of "new" sand is somehow cut down—or cut off—the current can no longer replace the sand it moves along and carries away, so the beach gradually disappears.

A Sand "Famine"

The causes of such a shortage of new sand were discovered some years ago by scientists working with the United States Army Corps of Engineers. (The Engineers Corps is responsible for protecting and improving the nation's beaches.) They found, for one thing, that a long dry spell that cuts down the water in California rivers also weakens their power to carry sand down to the shore. Dams, which are built to store river water and control floods, also block the flow of sand to the ocean *(see "Grandest of All Canyons," N&S, November 13, 1967, page 10)*. And the sand that does reach the ocean may be blocked by another man-made structure—a *breakwater* or *jetty*. Such structures are built out from the shore to pro-

(Continued on page 16)

The above photo shows the Pacific surf advancing on cottages at Surfside-Sunset Beach area in California. The jetty that protects Anaheim harbor *(top of photo)* dams up sand that the longshore current would otherwise feed to the beach. To protect the cottages, sand has to be dredged up from behind the jetty and pumped to the beach *(bottom photo)*.

THE SEARCH FOR BEACH PROTECTORS

Beaches are "buffers" that protect homes and communities from the fury of ocean storms. Many beaches are being destroyed because of man's actions—damming rivers, building jetties to protect harbors, and leveling beach dunes in order to build houses.

To stop beach erosion, people are trying to learn more about it and are investigating ways of stopping it. Along some New Jersey beaches, plastic seaweed is being "planted" offshore in order to weaken the power of waves. New Jersey beaches are also being rebuilt by sand brought from other areas. Sand for feeding beaches is getting scarce in some areas; in Hawaii, sand is now being manufactured out of gravel.

The Corps of Army Engineers is experimenting with breakwaters and jetties, trying to find a design that will not starve beaches for sand. The United States Navy is also interested in controlling beach erosion. A geologist at the Naval Electronics Laboratory at San Diego, California, is studying the flow of sand in coastal currents. Dr. Robert Dill uses ping pong balls instead of painted sand grains to follow the movement of sand along the coast. He has discovered that ping pong balls with holes in them (to make them sink) drift just like sand grains and are much easier to trace.

Engineers built this *groin*, or breakwater, into the Gulf of Mexico at Henderson Point, Mississippi, to restore the beach for swimming and to protect the shore from hurricane waves. The groin dammed up the sand and made the beach shown below—but as a result, beaches farther down the coast became starved for sand.

tect boats anchored in a harbor from waves; they often extend out into the longshore current and stop the movement of sand in the current.

Twenty years ago, the beach along the Surfside-Sunset Beach area was being "starved" for sand by both kinds of man-made sand stoppers—dams along the San Gabriel river, which pours into the ocean just north of the area, and a jetty that protects boats in Anaheim Bay harbor, also just up the coast from the area. In 1947, sand was dredged up from behind the jetty and poured in to build up the underfed beach. But the longshore current keeps carrying this sand away, and huge doses of sand have to be poured into the beach every five years or so to keep it from disappearing entirely.

Follow That Sand!

With the natural supply of new sand cut off by dams and jetties, the Army engineers had to find a new supply of sand for rebuilding the beaches. They knew that the longshore current was moving the sand they poured into the Surfside-Sunset Beach area to other beaches down the coast. But these beaches were also getting smaller and smaller. The engineers noticed that about 15 miles down the coast from Sunset Beach a deep underwater canyon extended out from the shore. They thought this canyon might be catching the sand from the upcoast beaches. If so, a breakwater might be built to block the flow of the sand into the canyon.

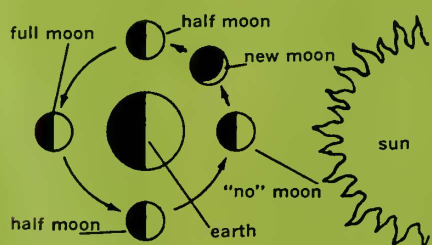
Before building such an expensive "dam," though, the engineers decided to test their suspicions by tracing the movement of some sand. They coated some grains with a *fluorescent* paint, and dropped them into the current at Sunset Beach. Samples of sand were taken from the current at different places between Sunset Beach and the underwater canyon, and were placed under an ultraviolet lamp that made the coated grains glow. From the numbers of coated grains picked up at different places, the scientists could trace the path of the sand being carried away from Sunset Beach by the current.

Their findings suggested, however, that a breakwater near the underwater canyon probably would not trap very much sand.

The engineers turned seaward in their search for sand to replenish the vanishing beaches. Normally, particles that have settled out of the longshore current are too small or too large to make good beach sand, but the engineers discovered some deposits of sand that would be suitable for beaches. The Corps now plans to "mine" these deposits. Special ships will dredge the sand from the bottom and then feed it to the nearby hungry beaches, including the beach in front of Mr. Bell's house ■

THE MOON AND THE WEATHER

■ How much truth is there in weather sayings? Down through the ages, many popular sayings have suggested that weather changes are somehow connected with changes in the moon's *phase*—the shape of the sunlit part of the moon that we see at different times in the moon's trip around the earth *(see diagram)*.



The sunlit part of the moon that we can see changes in shape as the moon moves around the earth.

Several scientists recently have combed back through weather records to find out what phase the moon was in at times of particularly heavy rainfall. After studying the records of more than 1,500 weather stations, covering the period from 1900 to 1950 in the United States, meteorologists have concluded that heavy rains or snowfalls come most often during the first and third weeks after the full moon. Two Australian scientists who have made similar studies of 50 weather stations in New Zealand came to the same conclusion. Interested by these findings, weather scientists in other parts of the world are now taking a new look at their own records. Do the moon and the weather change together? No one knows. This is the real part of the puzzle, and it is baffling astronomers and weather men alike.

—Gerald L. Shak

Using This Issue . . .
(continued from page 2T)

caves, they should contact a local spelunking club (you can get the address from the National Speleological Society, 609 Meadow Lane, Vienna, Virginia). The book cited in the WALL CHART, "The Life of the Cave," contains information on "How To Become a Spelunker."

Bats of Carlsbad Caverns

By taking the reader on a tour of parts of the Carlsbad Caverns, the author reveals something about the lives of bats, especially the free-tailed bats that live in southwestern North America. You might use discussion questions like the following to bring out some important ideas from the article.

Topics for Class Discussion

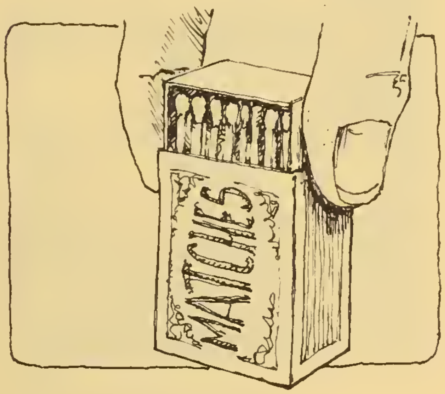
- *Are bats dangerous to humans?* Bats do not tangle themselves in hair and, except for vampires (which do not live in North America), do not usually get very close to humans. Like many other mammals, bats sometimes have the disease called *rabies*. The chances of encountering a rabid bat are slight, however. A good rule to follow is to avoid *any* wild mammal that seems tame, sick, or acts in any unusual way.
- *How do bats avoid obstacles and catch their food?* Bats are not blind, but rely on a remarkable "sonar" system to find their way and to capture insect food. High-pitched sounds are sent out as they fly; the echoes of these sounds bounce back and "tell" the bat what lies ahead. Using this system, a bat can catch as many as 175 mosquitos in 15 minutes. (For more information about the accuracy of bats' sonar, see the article "Hunting with Echoes," *N&S*, Oct. 17, 1966.)
- *Why is guano valued as fertilizer?* The wastes of bats are rich in nitrogen, and nitrogen is the element most often missing in soil. It is vital for the growth of plants.

Brain-Boosters

Mystery Photo. Perhaps some of your students have seen trucks with names printed backwards. If you have a hand mirror, let someone look in it while the picture is held behind him. This is what a driver would see in his rear view mirror as the truck approached him from behind.

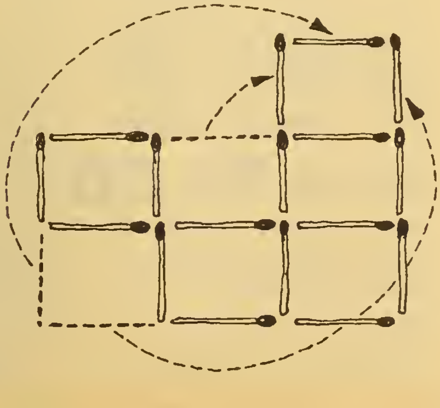
What would happen if? Arrange a bottle, glass and plastic tubing, and a two-hole stopper as shown, and let your pupils see what happens when the clamp is removed. Water will flow out of the straight tube and air will enter through the curved tube. Vary the arrangement by changing the position of the bottle or the length of the tubes, and see if the water still runs out the same way.

Can you do it? When you have a few extra minutes, hand out match boxes for your children to drop. It is almost impossible to make the match box land on its end, unless you first pull out the drawer full of matches about one-third of the way *(see diagram)*. Hold the



drawer loosely between the fingers so the box hangs straight down, then let go. It should land on its end. The drawer slides back into the box when it hits, and this helps to keep it upright. The same principle accounts for the fact that it is easier to balance on a bike when it is moving than when it is standing still.

Fun with numbers and shapes. Provide matches or toothpicks and let



your pupils try to solve the problem on their own. Perhaps some children could invent similar problems for other members of the class to work on.

For science experts only. This is a difficult question. When a goldfish is out of water, its gill filaments clump together like a cluster of wet feathers. This makes their surface too small to absorb enough oxygen from the air. (The gill filaments are spread apart in the water.) You can demonstrate this effect with a small paint brush. When held under water, the bristles spread apart; but when taken out, the wet bristles stick together. An even better way would be to obtain a whole fish from a fish store and cut off its head to expose the gill filaments. Then hold the gills under water to show how they spread apart.

N&S REVIEWS . . .
(continued from page 1T)

as well as others from Europe give the current status of our knowledge of the domestication of plants and animals and the establishment of permanent villages in these areas. The detailed descriptions of the find in both words and pictures is the book's greatest virtue. The reader is able to see the difference between wild and domesticated wheat, to learn how seeds are separated from the chaff, and to discover what querns, sickles, ear studs, and many other artifacts actually are. Too often writers assume their readers know about these esoteric things when, in fact, young readers and even older ones have misimpressions of ancient artifacts which hinder them from gaining even a rudimentary understanding of prehistoric life. *Life Long Ago* is a simple book on a professional level, and, for this reason, educates its audience in the best possible way.

The Riddle of the Past, by Gordon C. Baldwin (W. W. Norton and Co., Inc., 149 pp. $3.50). This lively book gives a nice account of archeological field and laboratory work. Its merit lies in the ability of the author to convey the reality of the archeologist's technical tasks. There is a description of the site survey, of digging methods,

(Continued on page 4T)

N&S REVIEWS . . .
(continued from page 3T)

and some words on record-keeping. There is also a discussion of the nature of artifacts and the information which can be gleaned from burials. The last three chapters deal with dating methods, hoaxes, and an archeological career. The book would have profited from a stronger emphasis on archeology as anthropology and history. As it is, the reader may be left with the impression that the technical aspect of archeology is all of archeology, when, in fact, it is only the most time-consuming part.

Exploring the World of Archeology, by P. E. Cleator; illustrated by Mary Gehr (Children's Press Inc., 141 pp. $4.50). The author presents a well-balanced and intelligent view of archeology as a discipline and an accurate and well-synthesized survey of the prehistory of the Old and New World. The first chapter traces the early history of classical archeology, and the next chapter discusses some of the methods of the archeologist. There is a small section on the Paleolithic, but the main focus of the rest of the book is on the later cultures of Egypt, the Middle East, Crete-Greece, and the Americas. The handsome format is hampered by photographs that are, almost without exception, out of focus, and the illustrator has succeeded in leveling the unique styles of diverse cultures to a single uniform "pop art" form.

Underwater World, by C. B. Colby (Coward-McCann, Inc., 48 pp. $2.68). This is a non-book; it is a series of photographs with somewhat longer than usual captions. The subject is the equipment and technique of underwater exploration. The author lacks an integrating point of view, and so the information is chosen haphazardly and presented disjointedly. The photographs are not credited, but seem to be institutional press releases. The section on underwater archeology has little to recommend it. I suspect that the rest of the book, which is better, is probably inferior to what is now available on underwater exploration.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 8 / JANUARY 8, 1968 / SECTION 1 OF TWO SECTIONS

Animals as Teaching Aids

by Robert G. Hudson

■ Most teachers are aware of the value of animals as teaching aids, but the thought of animals in the classroom usually raises these questions: What animals will best fit into your classroom situation? How will you house, feed, and care for the animal? What can you do with it so that the animal is a teaching aid instead of a pet?

Questions like these should be answered before you plunge into the classroom animal "game." The following suggestions are not intended to dampen enthusiasm but may help keep you from making some common mistakes.

First, set a limit on the kinds and numbers of animals, based on classroom space and time available for care. One or two species (and one or two individuals of each) should suffice. When a teacher gets involved with a classroom zoo, the menagerie soon becomes self-defeating.

Second, be sure that the children share the responsibilities of daily feeding and cleaning. Delegating these tasks to a committee with a rotating membership will insure that all the children have a chance to learn the basics of keeping animals healthy. Your role is supervisory, not custodial.

Third, expect problems to arise. The basic information that follows should help you avoid many problems but you will inevitably meet some. If additional help is needed, the books, pamphlets, and articles listed as references contain a wealth of detailed, specific information. In fact, research in books should be an integral part of a class project involving the care and study of an animal. The information below is only a basic guide; use the reference list to dig deeper.

Robert G. Hudson is Director of Operations, the Pennsylvania Society for the Prevention of Cruelty to Animals, Philadelphia.

MORRIS WARMAN

Some Animals To Try

From the vast array of animals that might adapt to a classroom environment, the following are specifically recommended:

FISH. In this group the goldfish are the easiest to maintain because they are "cold-water" animals. The tropicals are sensitive to sudden temperature changes, and their aquarium will require a water heater. Do not buy fish with skin abrasions or growths, or with torn fins. Such specimens are often diseased or parasitized. Select glass bowls or aquarium tanks with care; their size and shape are critical for the number of fish they will keep in good health. A container for fish should have a cover, to keep them from jumping out and to reduce water evaporation.

(Continued on page 3T)

IN THIS ISSUE

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

IN THE NEXT ISSUE

A special-topic issue of Communication: Finding ways to deliver a message . . . How other animals communicate . . . Can a chimp be taught to talk? . . . Tools for extending communication . . . Messages for the millions.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Work Like a Horse?

This investigation will help your pupils to grasp the concepts of physical *work* (moving weight through a distance) and *power* (the amount of work done in a given time). And the "project"—finding the horsepower of various appliances around the home—can lead to class discussion of the roles of energy and power in your pupils' lives.

Topics for Class Discussion

- Two kinds of non-animal power that were used before the steam engine was invented *(see article)* were water power and wind power. Flowing rivers and the winds moved ships, and water wheels and windmills turned such things as grinding wheels.
- *What makes a horse more powerful* than a human? A horse eats more food, which provides more energy, and the horse's larger body stores more energy than a human's. With more energy to draw on, the horse can run faster, or pull a heavier weight, or pull the same weight farther than a human can.
- *How can something as small as an automobile engine produce as much power as several hundred horses?* An auto engine gets its energy from gasoline, which has much more *chemical energy (see "The Spirit That Moves Things,"* N&S, *April 10, 1967)* than the food that animals eat. In addition, the engine burns gas much faster than a horse "burns" food.
- *Where does the energy come from to make the electrical appliances in your home do work?* It takes thousands of horsepower to turn the generators that make electric current and send it through the wires to your house. A generator is turned by a *turbine,* which is something like a water wheel with many tiny paddles. Some turbines are turned by falling water from dammed rivers, but most are turned by steam. The steam, in turn, is made by boiling water with heat from burning coal, oil, or natural gas—or with heat given off by radioactive elements such as uranium and plutonium as they change into other elements.
- *Since power can be measured in* watts *(746 watts = 1 hp), could you say that a 75-watt bulb produces about 1/10 hp when it is lighted?* No. A light bulb (or toaster, for example) changes electrical energy into heat energy, which makes the wire inside the bulb or toaster glow. The bulb heats up the air around it, but does not do any work in the sense of moving a weight through a distance. However, you could say that a 75-watt bulb uses as much current as a 1/10-hp motor.

A Better Airplane

This SCIENCE WORKSHOP is *not* really a contest, but rather an article to stimulate your pupils' imagination and encourage them to try to make a paper airplane that is both "different" and "better" than the conventional type. For your information and possible reference, a full account of *Scientific American* magazine's contest, together with photos and folding plans for a number of the winning planes, is published in a new paperback, *The Great International Paper Airplane Book*, by Jerry Mander, George Dippel, and Howard Gossage (Simon and Schuster, New York, 1967, $2.95). This book will be announced in the student's edition of *N&S,* April 15, 1968.

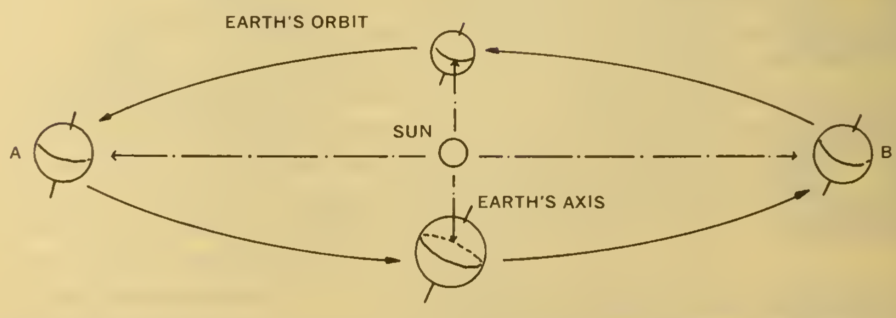
Keeping Track of the Year

This WALL CHART takes advantage of the time of year to direct your pupils' attention to the *timing* of the year—how it was measured in ancient times and how the calendar had to be corrected many times to bring it into step with the period of the earth's revolution around the sun.

Have your pupils think of some of the patterns of change that take place each year during the cycle of seasons—changes in temperature and precipitation; annual plants germinating from seeds, growing, flowering, producing new seeds, then dying; animals breeding, sometimes changing color or coats, and migrating or hibernating. Point out that these patterns of change, repeating themselves over periods of many days, probably gave early men their first concept of the "year."

Later men discovered that the alternate warming and cooling of the northern and southern hemispheres is caused by the earth's tilt on its axis and the position of the earth in its path around the sun *(see diagram).*

(Continued on page 3T)



When the earth is at A, the northern hemisphere gets sunlight longer and more directly each day (summer) than when the earth is at B (winter).

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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

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CAN YOU WORK LIKE A HORSE?

see page 2

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PICTURE CREDITS: Cover photo by The American Museum of Natural History; pp. 2-3, 6-10, 12, 13, drawings by Graphic Arts Department, AMNH; pp. 4-5, photos by Ruth Kirk; pp. 8-9, photo by Fritz Henle, from Photo Researchers, Inc.; p. 11, courtesy of the National Institutes of Health; p. 13, photo by Joan Hamblin; pp. 14-15, Robert G. Bryant; p. 16, United Press International.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; EXECUTIVE EDITOR Laurence P. Pringle; ASSOCIATE EDITORS Robert J. Lefkowitz, Steven W. Morris; EDITORIAL ASSISTANT Alison Newhouse; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Nesta Paley
CONSULTING EDITOR Roy A. Gallant

PUBLISHER James K. Page, Jr.
CIRCULATION DIRECTOR J. D. Broderick
PROMOTION DIRECTOR Elizabeth Connor
SUBSCRIPTION SERVICE Alfred Thiem

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, December through April; monthly September, November, May and July (July special issue). 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, N.Y. 10024

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CAN YOU WORK LIKE A HORSE?

You may think so, especially when you've just cleared a driveway of snow or a yard of leaves. Here's a way to measure your horsepower.

■ After shoveling snow off a sidewalk or driveway, or raking leaves and carrying them away in a basket, you may tell someone you've been "working like a horse." If your friend questions that statement, you will have to admit that you were stretching the truth a bit—but not that you were telling a complete falsehood.

"Of course," you could say, "a horse can't handle a shovel, but it can pull snow in a wagon. And that's the work I was doing—moving snow from one place to another."

"Yes," your friend is likely to say, "but you can't move as *much* snow as a horse can." There, you have him, because you can move as much snow as a horse can, and just as far. If a horse pulls with 1,000 pounds of force to move snow 200 feet, it does $1,000 \times 200 = 200,000$ *foot-pounds* of *work*. You can do that much work too; the difference is that the horse can do it in less time.

The amount of work you can do in a certain period of time is called *power*. And a horse's body can produce more power than your body can. This SCIENCE WORKSHOP will show you how to compare your power with that of a horse.

Why Measure a Horse's Power?

Until the steam engine was invented about 1700, most of the world's work was done by men and other animals, such as horses, oxen, and elephants. (Can you think of two other kinds of power that were used before then to move heavy objects?) About 200 years ago, a Scottish inventor named James Watt improved the steam engine

so that it could do more work in less time than the earlier engines. To compare the power of his engine with the others, Watt needed some kind of standard unit (such as the inch or foot-pound) for measuring power.

He tested a strong horse (an unusually strong one, it seems) and found that it could lift 330 pounds of coal 100 feet up a mine shaft in one minute. So Watt defined 1 *horsepower* as the amount of power needed to do 33,000 foot-pounds of work in one minute. An engine that does twice that much work in one minute has 2 horsepower. The power of electric motors, gasoline and diesel engines, and most other kinds of engines is still measured in units of horsepower, or *hp* for short.

Measuring Your Horsepower

Since a horse is more powerful than you are, your horsepower must be something less than 1. Do you think it is about ½ hp? ¾ hp? ¼ hp? Or closer to ⅛ hp?

You can get a good idea of your horsepower by measuring how far you can lift a weight in one minute. The weight is *you*, so you need to know your weight in pounds. You will also need a staircase that you can run up without disturbing anyone. And finally, you will need a friend and a watch with a second hand.

Have your friend stand at the top of the stairs and time how many seconds it takes you to run up the stairs. One trip up will probably take you less than one minute, so *walk* down and *run* up again. Have the timer write down how many seconds each trip *up* the stairs takes you. Keep doing this until you have been running up the stairs a total of nearly 60 seconds. On the last trip up, have the timer stop you where you are when you have been running upstairs for exactly one minute.

Count the number of steps you have climbed on all your runs up and multiply this figure by the height in inches of one step. Divide the result by 12 to find the number of feet you have lifted your body. Then multiply this distance in feet by your weight in pounds to find out how many foot-pounds of work you have done. Since one horse can do 33,000 foot-pounds of work per minute, divide the foot-pounds of work you did by 33,000 to find your horsepower.

Suppose, for example, that you weigh 50 pounds and ran up 165 feet of steps in one minute: $50 \times 165 = 8{,}250$ foot-pounds of work; 8,250 divided by 33,000 equals .25 or ¼ horsepower.

Do you think you could produce the same amount of horsepower for a longer period of time—say one hour?

—LAURENCE B. WHITE, JR.

PROJECT

HOW MANY "HORSES" IN YOUR HOUSE?

Make a list of all the different motor-powered machines that help your family do work around the house—things like washing machines, refrigerators, fans, mixers, vacuum sweepers, and furnace motors. Check each room and storage closet for machines such as electric clocks, can openers, toothbrushes, razors, record players, and so on.

The motors that power these machines may produce only a tiny fraction of a horsepower (hairdryer, for example), or as much as 2 or 3 hp (room air conditioner). Try to guess how many horsepower all of these motors running at once would produce. You can check your guess by finding the horsepower of each motor and adding.

The label on a motor usually gives its horsepower. If the motor is enclosed so that you can't get to it, look for a label on the machine that tells how many *volts* and *amperes* of electric current it takes to run the motor. (Volts are a measure of the strength of the current, and amperes measure the amount of current used.)

Multiply the number of volts times the number of amperes to get the number of *watts* of power produced by the motor. Since 746 watts equals 1 horsepower, divide the number of watts by 746 to find the motor's horsepower.

For example, a motor using 3 amperes of 115-volt current produces 345 watts of power.

$$\frac{345}{746} = .46 \text{ or about } \tfrac{1}{2} \text{ hp}$$

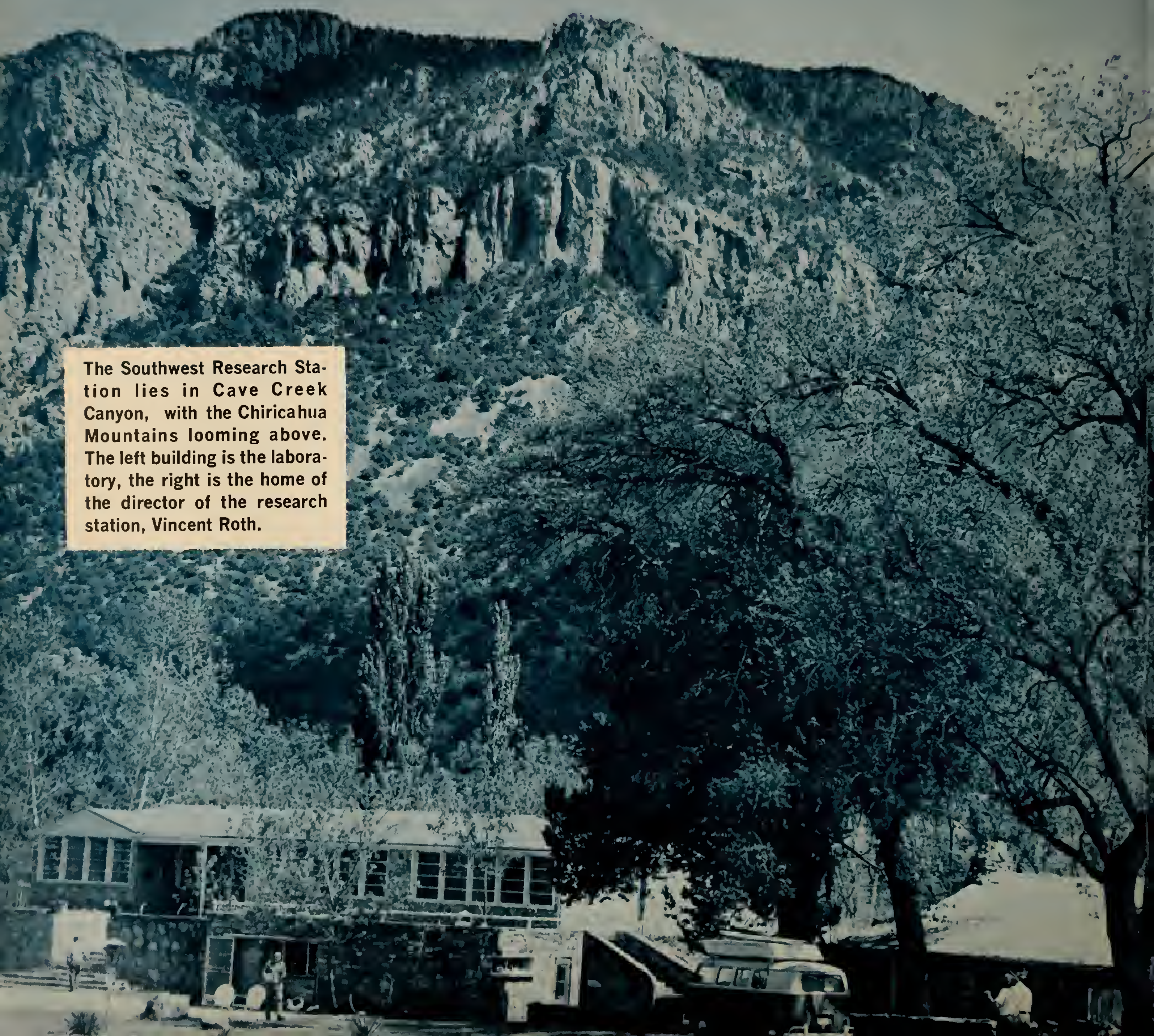
An Outdoor Nature Laboratory

■ The Chiricahua Mountains of southern Arizona are like an "island" that rises in a vast "sea" of desert. The area is a delight for biologists because there is such a variety of climate, terrain, and plant and animal life. In one day you can hike from a desert of sagebrush and cactus to the top of 8,000-foot mountains, covered with pines and Douglas-fir.

Tucked in a canyon of the mountains is the Southwest Research Station of The American Museum of Natural History. The station is a cluster of buildings—a dining hall and library, a laboratory, cabins for visitors, and a home for the director, Vincent Roth, and his family.

Scientists visit the station throughout the year, some for just a few days, others for weeks or months. Summer is the busiest season. Last year 89 scientists from 38 different colleges, universities, and museums came to the research station. Using it as their base, they roamed the surrounding desert, canyons, and mountains to study insects, spiders, birds, mammals, reptiles, and plants.

Visiting the station, you might find someone studying the behavior of katydids, another scientist trying to find out what foods are preferred by hummingbirds, and a third investigating the lives of bees. The photographs on these pages show a few of the activities at the research station when it was visited last summer by writer-photographer Ruth Kirk ■



The Southwest Research Station lies in Cave Creek Canyon, with the Chiricahua Mountains looming above. The left building is the laboratory, the right is the home of the director of the research station, Vincent Roth.

Dr. Curtis Sabrosky studies insects for the United States Department of Agriculture. At the research station he collects an abandoned nest of a cactus wren *(left)* and searches through it, looking for insects *(right)*. By collecting the insects soon after the birds leave the nest, Dr. Sabrosky learns about insects that live on young birds.

Late at night, Dr. Ethel Tobach of The American Museum of Natural History sets traps to catch small mammals alive *(1)*. At dawn, Dr. Tobach and her assistants check the traps *(2)*. One of the mice they caught is put into a cage *(3)* by Dr. Yves Rouger, a French scientist working with Dr. Tobach. They are comparing the behavior of newly-caught wild mammals with that of mammals that have lived in laboratories for many generations.

Whenever a mammal is caught at the research station, the lice, mites, fleas, and other parasites that live on its body are collected. In the left photo, Vincent Roth collects and identifies parasites from a pocket gopher. Bits of plant food stored in the animal's cheek pouches are also collected and identified *(right)*, revealing what kinds of plants it ate.

A lot of paper is usually used up in designing an airplane. You may need only a few sheets, though, to—

BUILD A BETTER AIRPLANE

■ *Whoosh!* The experimental plane took off swiftly, climbed high into the air, soared along its flight path, then went into a dive and crashed into the wall of a New York office building. A disaster? Not really. The flight engineers just picked up the folded piece of paper, straightened out the wrinkles in its nose, and sailed it again down the office corridor.

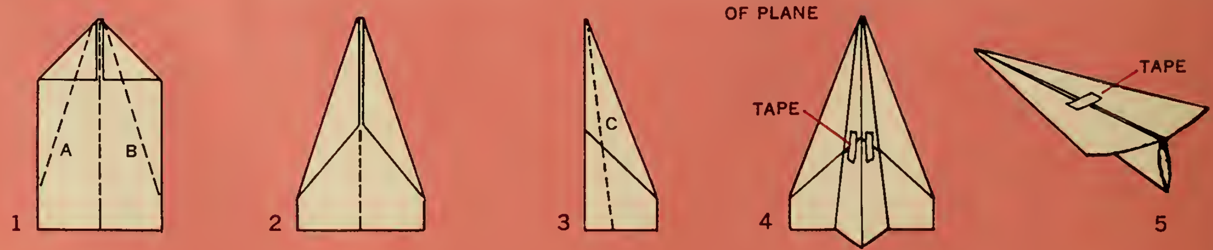
You could have seen this "air show" about this time last year as the staff of *Scientific American* magazine began testing entries in its First International Paper Airplane Competition. The magazine held the contest to see whether anyone could come up with a new paper airplane design that might be useful in making real airplanes. Before long, *Scientific American* had received 11,851 airplanes from people in 28 countries throughout the world.

On the cover of this issue you can see a few of the designs that went through final testing in the Hall of Science at the New York World's Fair grounds in Flushing Meadow Park. As you might guess, some of them are very difficult to make. But you can make copies of the planes on this and the next page by following the folding instructions next to each one.

After you've had some fun flying these planes, perhaps you can come up with a new design of your own. Can you make a paper plane that can fly farther or stay in the air longer than the ones on these pages? Can you make one that's a good "stunt" flyer?

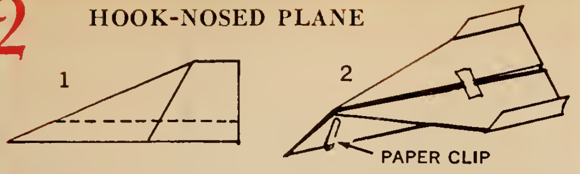
Nature and Science would like to know what new designs you may discover. If you find a good one, send it to us, along with folding instructions, and some information

1 DELTA-WING PLANE



Fold a piece of paper in half the long way, and open it again. Then fold the top corners in to the center, so it looks like Diagram 1. Now fold along lines A and B to get Diagram 2. Next, fold on the center line to the shape shown in Diagram 3. Then fold the "wings" apart along line C in Diagram 3. Now unfold the wings and turn the plane over. Use two pieces of sticky tape to fasten the wings to the "body," as in Diagram 4. Turn the plane over and bend the wings slightly upward as in Diagram 5. Fasten the wings together with another piece of tape. To launch the plane, hold the body between your thumb and forefinger and let it go as you give it a slight push forward. The plane should glide smoothly.

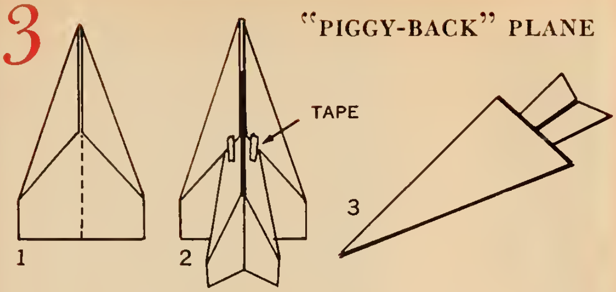
2 HOOK-NOSED PLANE



Here's how to make a different model of the delta-wing plane: When you get to step 3 for the delta-wing plane, fold the wings apart along the dotted line shown in Diagram 1 above. The "hooked" nose (see *Diagram 2)* will make the plane fly with a quick, dart-like motion.

You can also turn up the wing edges as shown in Diagram 2. What effect does this have on the plane? Try changing the "balance" of the plane by attaching a paper clip to the body, as shown in Diagram 2. Does the plane fly differently if you move the clip to different places along the body?

3 "PIGGY-BACK" PLANE

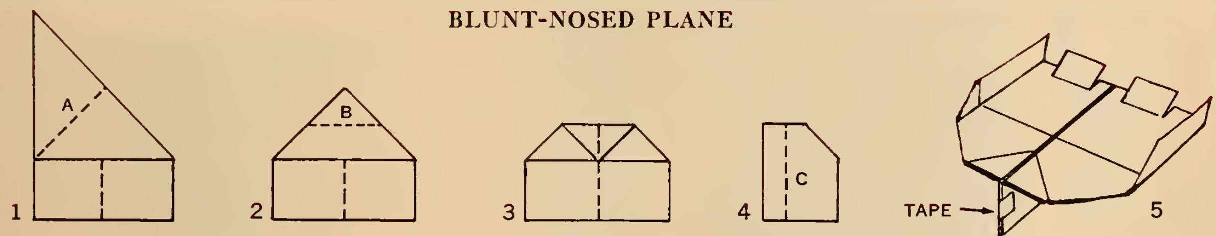


Want to make a plane that flies "piggy-back"? Start folding the delta-wing plane, but stop after step 2. It should look like Diagram 1 above. Then make a complete delta-wing plane from another sheet of paper, and slip it inside the first one, upside down, as in Diagram 2. Tape the two planes together at the undersides of the wings. When you turn the "piggy-back" plane over, it should look like Diagram 3.

about how long and how far it flew for you. Tell us also what you think makes it a good design for an airplane.

We will test fly all the planes we receive in the halls of The American Museum of Natural History in New York, and then select the ones that fly for the longest time or distance, or that have the most interesting designs or "flight patterns." The designers of these planes will receive the title of Honorary Airplane Design Engineer, and their designs will be shown in the April 15 issue of *N&S,* so that everyone can try them ■

4 BLUNT-NOSED PLANE



Fold the paper in half the long way, then open it again. Fold the top right corner over so that the top of the paper lines up with the left side of the paper, as shown in Diagram 1. Now fold along line A in Diagram 1 to get the shape shown in Diagram 2. Next, fold along line B in Diagram 2 to get Diagram 3. Then fold the plane in half along the original fold so that it looks like Diagram 4. Fold the wings apart along line C in Diagram 4. Then unfold the wings and bend up the edges as shown in Diagram 5. Tape the body together at both ends.

This plane will usually do some fancy turns in the air. See what happens if you weight the body with a paper clip, or if you make the wing flaps shown in Diagram 5. (Make short snips with a pair of scissors, and bend up the loose flaps.)

Send any plane that you think has an especially good design to:

Chief Airplane Design Engineer
Nature and Science
The American Museum of Natural History
Central Park West at 79th Street
New York, New York 10024

Be sure to include your name, address, age, and grade in school, as well as folding instructions and any other important information. If your plane can't be folded flat to fit into an envelope, you might be able to send it in an empty cereal box wrapped in brown paper. Airplanes can not be returned, so be sure to make a copy of your design for yourself.

Please send your plane (or planes) by February 1, 1968.

Keeping Track of the Year

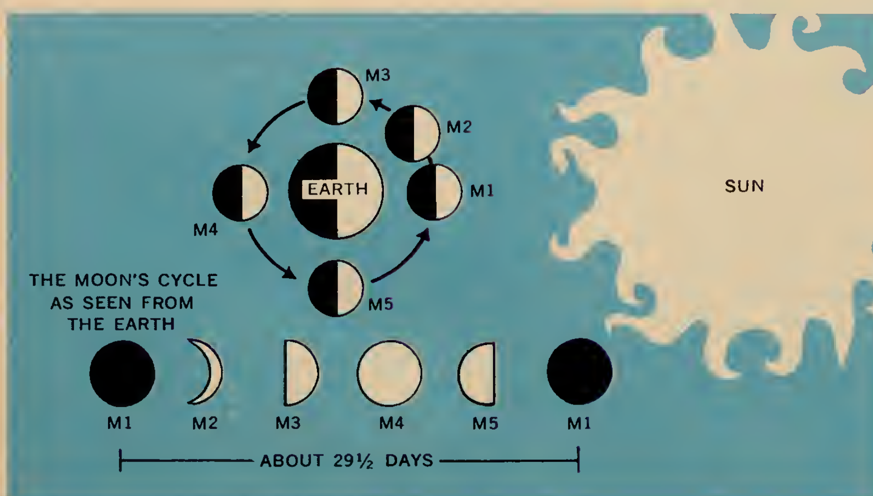
nature and science | WALL CHART

January 8, 1968

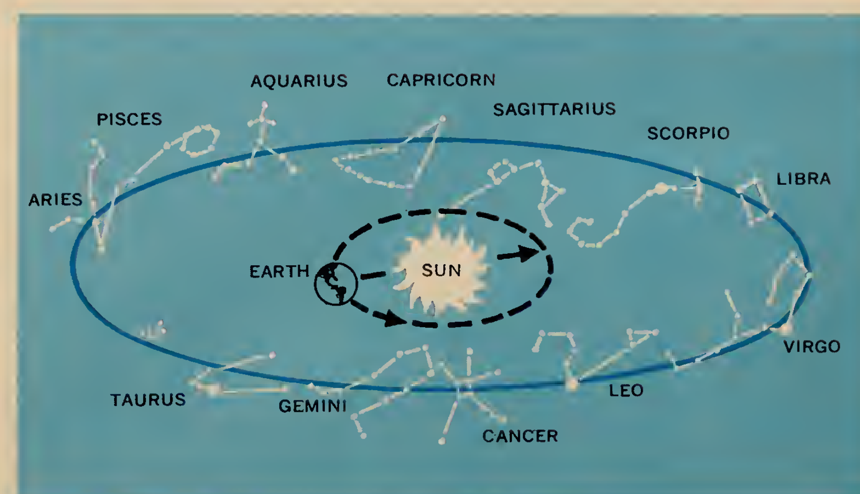
■ Thousands of years ago, when people got their food by hunting other animals and gathering wild plants, they had little need to keep track of time. They must have noticed how the sun's repeated trips across the sky divide day from night. And they may have noticed how things around them—the weather, plants, and other animals—change slowly through many days and then begin to repeat the same pattern of changes. But on the whole, each day in the lives of these people was much like the one before.

When men learned to raise their own plants and animals, measuring time became more important. They needed to know when to plant seeds and breed animals. Some people began to notice other *cycles*, or changes that are repeated over and over, in the world around them. They saw, for example, that the moon changes from a thin sliver to a full circle, then shrinks to nothing and reappears as a sliver in the course of about 29½ nights. Since 12 moon cycles take about the same time as one cycle of the seasons, these people made the moon's cycles the basis for the *month* and the *year*.

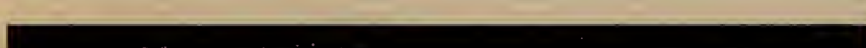
Other people noticed that the sun and the stars seem to change their positions in the sky in a cycle that is the same as the cycle of seasons. Measuring this cycle was difficult in ancient times, though, and the calendars had to be changed many times before they were in step with earth's yearly trip around the sun, which takes about 365¼ days.—MARGARET R. COOPER



The moon cycle (*see text and diagram*) was the basis for a calendar used by the Sumerians, who lived about 5,000 years ago in what is now Iraq. But their 30-day months and 12-month years kept getting out of step with the moon's 29½-day cycle and with the earth-sun year. The Babylonians, who ruled that land after the Sumerians, used six 30-day months and six 29-day months to keep the months in step with the moon, and added an extra month every three years or so to keep the year in step with the seasons.

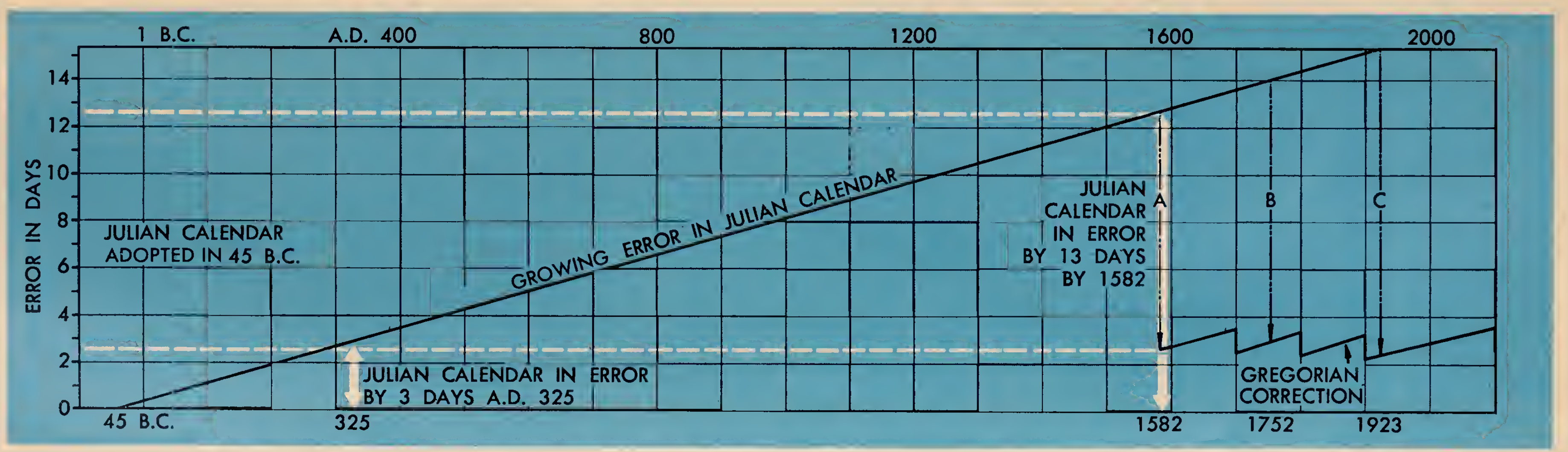


Later Babylonian astronomers saw that the sun seems to rise and set among different *constellations*, or patterns formed by stars, at different times of the year. This happens because the sun's direction from the earth changes as the earth moves around the sun (*see diagram*). They drew a map of the sun's "path" through the constellations, and divided this line—called the ecliptic—into 12 equal parts. Their calendar measured the year by the sun's position along the ecliptic.



The ancient Egyptians needed a way to judge when the spring flood of the Nile river would water their farmlands. About 5,000 years ago they noticed that Sirius, the brightest star they could see, appeared in the sky before sunrise just before the spring flood. They divided the time between these appearances of Sirius into 12 months of 30 days each plus five days of feasting and religious services each year.

This giant stone "calendar" built at Stonehenge, England, more than 3,000 years ago was designed so that a person looking out through the main arch would see the sun rise directly behind a large boulder outside on the *summer solstice*, the day when the sun rises at its farthest point northward on the horizon. Many scientists believe that other boulder arrangements at Stonehenge were used to predict when eclipses of the sun and moon would take place.



By the first century B.C., Egyptian astronomers knew their 365-day year was about ¼ day short of the time it takes the earth to make one trip around the sun. At that time the Romans used a 355-day moon-cycle calendar that was hard to keep up to date. In 45 B.C. the Roman Emperor Julius Caesar adopted the 365-day Egyptian calendar but added one day to every fourth year—"leap year"—to make up the extra ¼ day.

About 1,600 years later, European astronomers found that the earth-sun year is actually 365 days, 5 hours, 48 minutes, and 46 seconds long—just short of 365¼ days. The Julian Calendar had been getting one more day out of step each 125 years (see *chart*). In 1582, Pope Gregory XIII corrected the error by shortening the next year 10 days and dropping three leap years every four centuries.

The Gregorian Calendar was adopted in America in 1752, at which time 11 days had to be dropped from the calendar. When the Russians adopted this calendar in 1923, they had to drop 13 days. The Gregorian Calendar is accurate to one day in every 3,323 years.

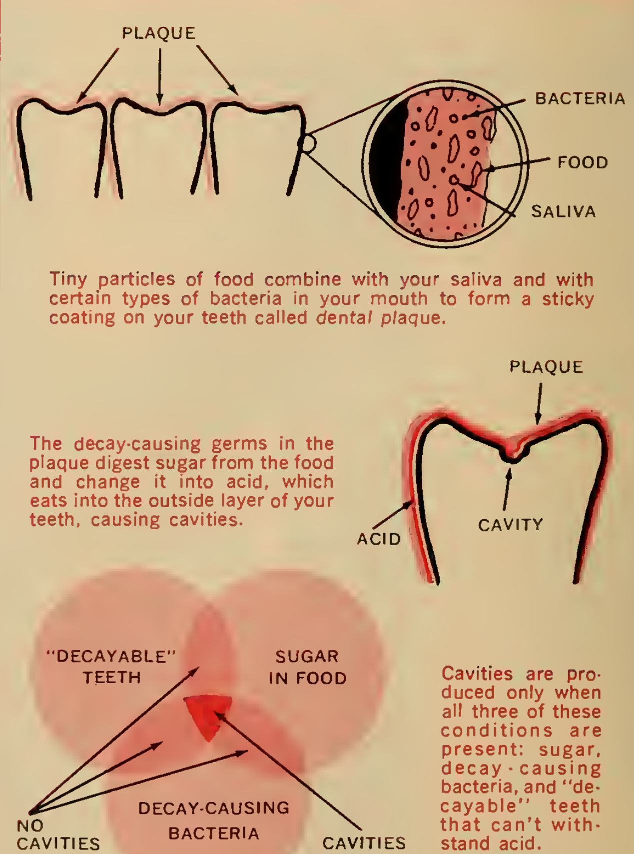
Scientists have found out how to keep rats from getting the disease called tooth decay. If they can make these methods work for humans, everyone may be able to say—

by Jerome D. Brent

■ The people who come to my office every day don't look sick, but most of them are suffering from a disease. You probably have the same disease—*tooth decay*. And you, too, probably go to the dentist regularly for treatment, or at least for a checkup.

Scientists have known for some years what makes teeth decay. Some of the sugar in food stays in your mouth after you eat. The sugar mixes with your saliva and with certain *bacteria* (germs) in your mouth to form a sticky coating on your teeth, called *dental plaque*. The bacteria in this coating change the sugar into an acid, which the coating holds against your teeth. The acid "eats" into your teeth and produces holes, or *cavities*. The less able your teeth are to resist the acid, the faster cavities may form.

If there were no sugar in your food, *or* if there were no bacteria in your mouth that could change sugar to acid, *or* if your teeth could be made "decay-proof," you would have no cavities. Dental scientists are trying to find ways to stop tooth decay by removing at least one of these things that work together to cause cavities *(see diagrams)*.



Tiny particles of food combine with your saliva and with certain types of bacteria in your mouth to form a sticky coating on your teeth called *dental plaque*.

The decay-causing germs in the plaque digest sugar from the food and change it into acid, which eats into the outside layer of your teeth, causing cavities.

Cavities are produced only when all three of these conditions are present: sugar, decay-causing bacteria, and "decayable" teeth that can't withstand acid.

What You Can Do To Fight Cavities

It is difficult to do away completely with sugar. Many of the foods you eat contain sugar or other substances that change into sugar when you chew them. Brushing your teeth after meals removes some of the food from between your teeth, so there is less sugar left for the bacteria to change into acid. But cleaning your teeth after eating still doesn't solve the problem if you eat a lot of snacks (such as candy, cookies, and soda pop) that may contain large amounts of sugar.

You probably know that some substances called *fluorides* help keep your teeth from decaying. About 25 years ago, scientists discovered that people whose drinking water contains fluorides get fewer cavities than people whose water supply does not contain these minerals. Investigations showed that fluorides seem to make the outer covering of your teeth more resistant to decay.

Many communities now add fluorides to their drinking water, and some young people who do not get fluoridated water now get fluoride in their vitamin drops or in tablets. The dentist can coat your teeth with fluoride and you can also use a toothpaste that contains fluoride.

Still, a great many people do not brush their teeth often enough, or well enough, and do not get protection against cavities from fluorides. Dental scientists say that more than 95 of every 100 people have tooth decay, and probably less than half of the American people get the proper dental care. They believe there are more than one billion unfilled cavities in the United States today. Because the problem is so big and serious, scientists are constantly searching for new ways to prevent tooth decay.

Experiments with Germ-free Animals

Recently, I visited the National Institute of Dental Research, at Bethesda, Maryland, where a number of important discoveries about tooth decay have been made in recent years. I spoke with scientists who have been investigating tooth decay in Syrian hamsters and rats. Usually, hamsters don't get many cavities. But these scientists have found that certain bacteria of a family called *Streptococcus* can cause decay in hamsters' teeth *(see photos).* (They also found that hamsters that have cavities produce offspring that also get cavities. Scientists would now like to find out how the disease is passed along from one generation to the next.)

Other scientists have mainly used *germ-free* rats in tooth-decay experiments. Rats, of course, are not normally free of germs. But an unborn rat is free of germs inside its mother's body. So to get a germ-free rat, scientists remove a young rat from its mother's body before it is born. Then the rat is placed in a container that keeps any germs from reaching it. When germ-free rats breed in these containers, their young will also be germ-free.

The scientists have found that germ-free rats do not get cavities even when they are fed a great deal of sugar. But when bacteria are put into the special containers, one type at a time, certain ones produce decay in the rats' teeth *(see photo).* *(Continued on the next page)*

Hamsters' teeth are often free of cavities, like those in the photo above. But certain bacteria (combined with sugar) can make hamsters' teeth decay. The photo below shows the same hamster's teeth, badly decayed after being exposed to some streptococcus germs.

This photo shows a scientist putting some streptococcus bacteria into the mouth of a germ-free rat. Gloves built into the germ-free container allow the scientist to handle the rat without opening the chamber and possibly letting in other germs.

Some of the bacteria that cause cavities in laboratory animals probably cause tooth decay in humans. You might wonder why the germ-killing drugs called *antibiotics* can't be used regularly to stop tooth decay. One problem is that after a while bacteria can get "used to" an antibiotic. Then the antibiotic can no longer kill the bacteria in the mouth or any other part of the body.

CAVITIES AND MODERN FOODS

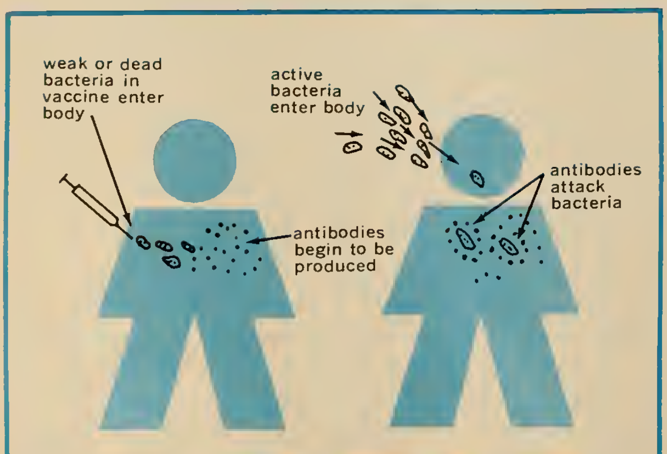
People who live by hunting game and gathering plant foods usually have very few cavities. But when these people begin to eat the kinds of "prepared" foods that most of us eat, they get many more cavities. Can you guess why?

Does Your Body Fight Decay-causing Bacteria?

Another way to fight bacteria, however, is by using the body's own defenses. When "enemy" bacteria enter your body, your body usually "fights back" by making an *antibody* that attacks those bacteria. Scientists at Northwestern University, in Chicago, and at the U.S. Navy's Dental Research Institute, in Great Lakes, Illinois, recently made a study to find out whether an antibody could protect teeth from decaying.

They chose 30 young sailors who had perfect teeth and another 30 who had many cavities. Each sailor's blood was tested to see whether it contained an antibody to one of the types of streptococcus that is believed to cause decay in human teeth. The scientists found more of the antibody to this germ in the blood of the men with perfect teeth than they found in the blood of those whose teeth were badly decayed. This doesn't *prove* that the antibody was protecting some of the men against tooth decay, but it is a possibility which the scientists are investigating further.

The bacteria in a vaccine make your body produce *antibodies* to them. If the same type of bacteria enter your body again, the antibodies already there will attack them.



If an antibody can protect a person from decay-causing bacteria, then scientists may be able to make a *vaccine* to prevent cavities. A vaccine contains weakened or killed bacteria that—when active—cause a specific disease. The bacteria in the vaccine aren't strong enough to bring on the disease, but they can make your body produce an antibody to the disease. And a small amount of the antibody will remain in your blood for some time, ready to attack the same type of bacteria if it comes along *(see diagram)*.

Trying Out a Vaccine

Some scientists are now looking for an anti-cavity vaccine. At the University of Notre Dame, in South Bend, Indiana, Dr. Morris Wagner and his fellow scientists made a vaccine by killing some streptococci of a type that is believed to cause cavities in rats. They vaccinated some germ-free rats with the killed bacteria, and exposed the rats to live bacteria of the same type. The rats did not get cavities. And antibodies to the bacteria were found in the rats' blood and in their saliva. A group of germ-free rats that were *not* vaccinated were exposed to the same live bacteria, and these rats got cavities.

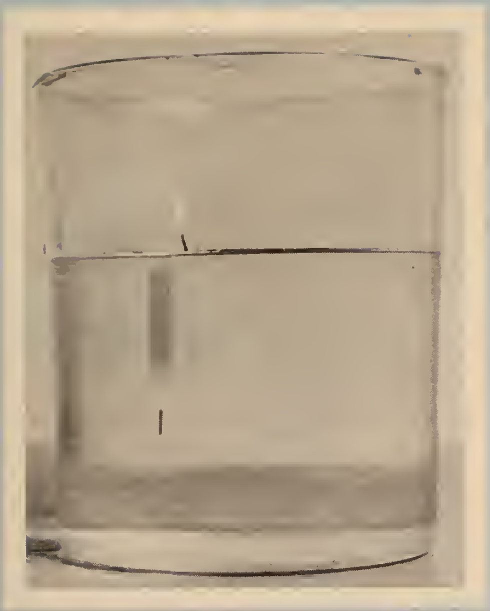
A vaccine like this might not protect rats that were not already germ-free, because they would probably have some types of decay-causing bacteria in their mouths that were not included in the vaccine.

Humans usually also have more than one type of decay-causing bacteria in their mouths. So a vaccine for humans would have to contain a number of different types of bacteria before it could be expected to prevent cavities. But scientists still don't know whether such a vaccine could keep humans cavity-free. Some believe that the decay-causing bacteria may not be active enough to cause an antibody to be produced in humans.

These are just some of the ways that dental scientists are investigating to help prevent tooth decay. Another way is being studied by two scientists in Rochester, New York. They are trying to make people's teeth "decay-proof" by coating the teeth with a clear plastic. The coating keeps food and bacteria from collecting in the tiny grooves of the teeth, where cavities often start *(see "What's New?", N&S, October 16, 1967)*.

Some time in the future, you may be able to get a "shot" or a vaccination, or have your teeth coated in some way, so that your teeth never decay. But it may be a long time before these things are possible. So right now, the best way to avoid this disease is to follow the advice you've heard so many times: Go easy on candy and other sweets; brush your teeth after eating; and visit your dentist regularly ■

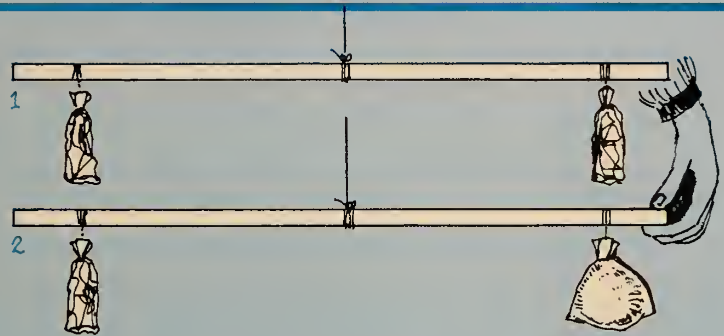
prepared by
DAVID WEBSTER



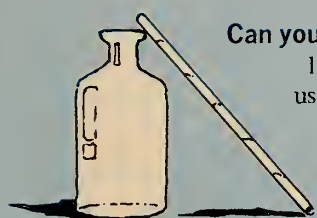
Mystery Photo The photograph shows a burning candle floating in a glass of water. A pin has been pushed into the bottom of the candle to make it float straight. Why does the flame seem to be detached from the rest of the candle?

Just for fun Here is an easy way to brighten up dirty pennies. Put them into a mixture of salt and vinegar. In a little while, the pennies will be shiny again. Will either salt or vinegar by itself clean pennies?

For science experts only If heat rises, why is the air in Death Valley (the lowest spot on the North American continent) so hot in the daytime?



What will happen if? Balance two empty plastic bags on a yardstick, as shown in Diagram 1. Then fill one bag with air and tie it to the stick again in the same place (see Diagram 2). Will the yardstick still balance?



Can you do it? Can you lift a small bottle using just a straw?

Submitted by Judy Francis, Bellevue, Ohio

Fun with numbers and shapes About how many stars can you see on a clear night without using binoculars or a telescope—

3,000?
100,000?
2,000,000?
6,000,000,000?

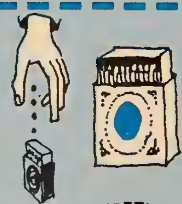
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The name on the truck is printed backwards so that it can be read properly in a car's rear view mirror.

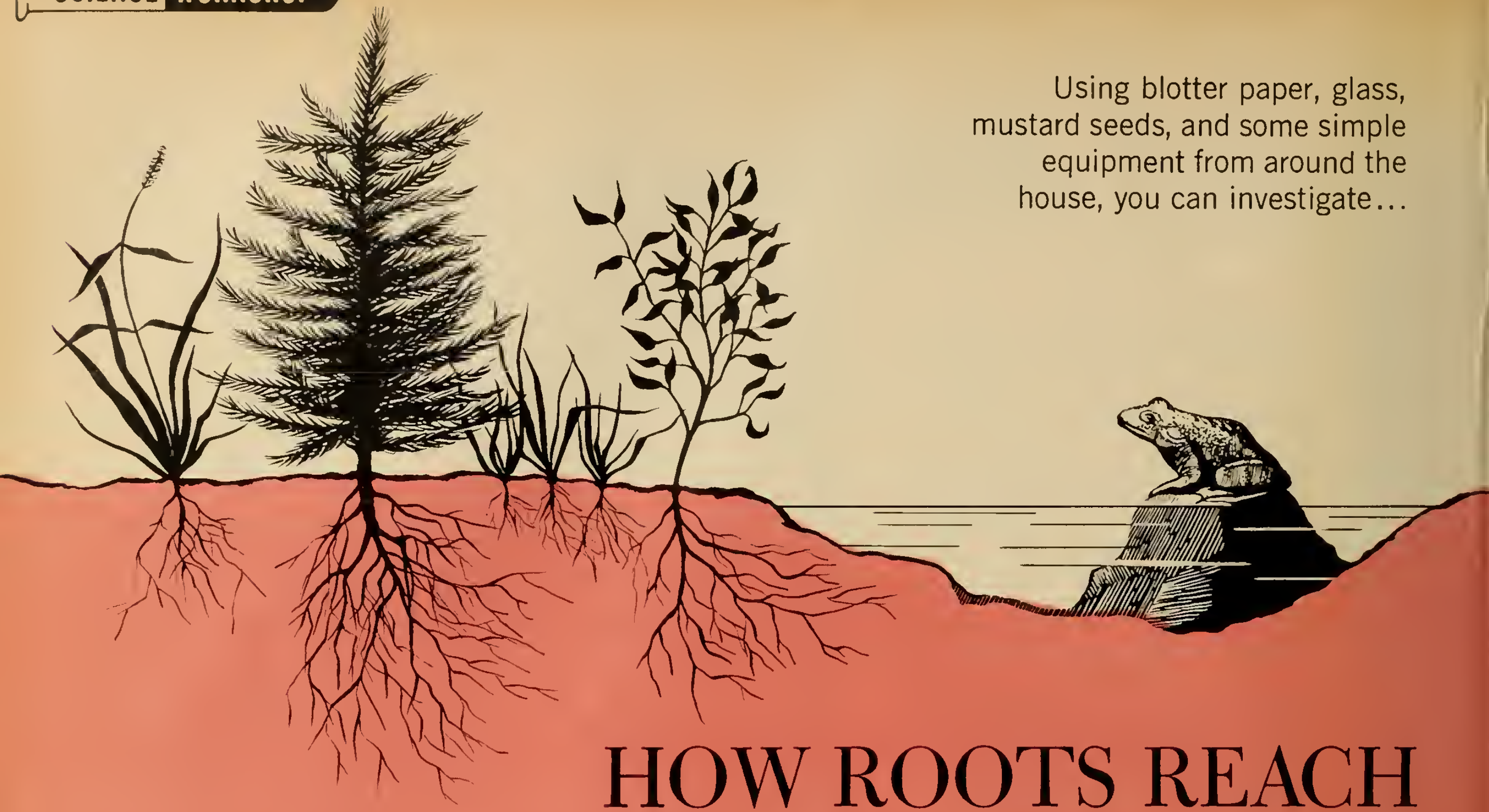
For science experts only: When a goldfish is out of the water, its gill filaments clump together like wet feathers. This makes their surface too small to absorb enough oxygen from the air. The gill filaments are spread apart in the water.

What would happen if? When the clamp is removed, water will flow out of the straight tube and air will enter through the curved tube.

Can you do it? To drop a full box of matches on its end, first pull out the match drawer part way. Then release it as shown, and it should land on its end.



Fun with numbers and shapes: Here is one way to move three matches and make five squares. Can you move four matches to make two big squares and two little squares?



Using blotter paper, glass, mustard seeds, and some simple equipment from around the house, you can investigate...

HOW ROOTS REACH FOR WATER

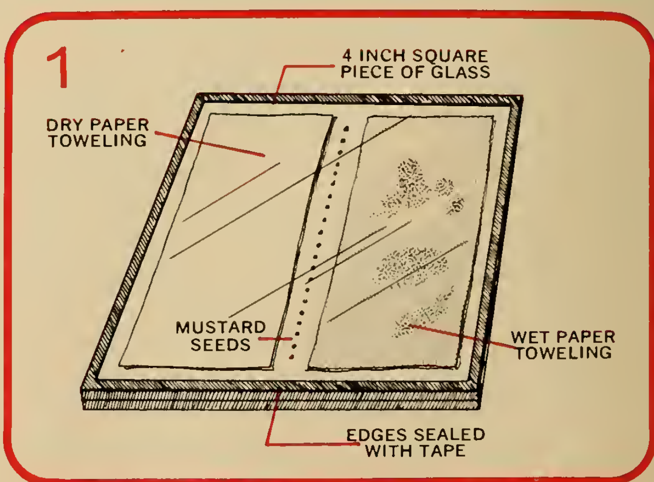
by Richard M. Klein and Deana T. Klein

■ Plants get most of the water they need through their roots. The roots of some desert plants, such as the creosote bush, may grow almost 100 feet to water *(see "Making the Water Last,"* N&S, *October 30, 1967).* Here are some simple investigations you can try to learn more about this powerful "urge" of roots to move toward a source of moisture.

Use mustard seeds for your investigations. They are small and they grow rapidly. You may find that the whole mustard seed sold in grocery stores for seasoning foods will still be alive. If not, you can get mustard from any seed company.

You will also need two pieces of plate glass, each four inches square. You can have the glass cut to size at a hardware store, where you can also have the edges polished (to avoid cutting your hands). You will also need some paper towels and some of the one-inch-wide cloth tape (such as Mystic Tape).

Next, make a "seed sandwich" like the one in Diagram 1. On the bottom piece of glass, make a line of mustard seeds right down the center of the glass. Then cut a number of sheets of paper toweling into rectangles, 4 inches by 1¾ inches. Lay a pile of the cut sheets of toweling along one side of the line of seeds *(see Diagram 1).* The thickness of the pile of sheets should be exactly the thickness of the seeds. (You will need about 10 or so sheets.)



On the other half of the glass plate put an equal pile of paper toweling sheets that have been soaked for a minute in water. Let the water drain off the paper before you

Dr. Richard M. Klein is Professor of Botany at the University of Vermont, in Burlington, and Dr. Deana T. Klein is Associate Professor of Biology at St. Michael's College, in Winooski, Vermont.

place it on the glass, and make sure that neither pile of paper touches the seeds.

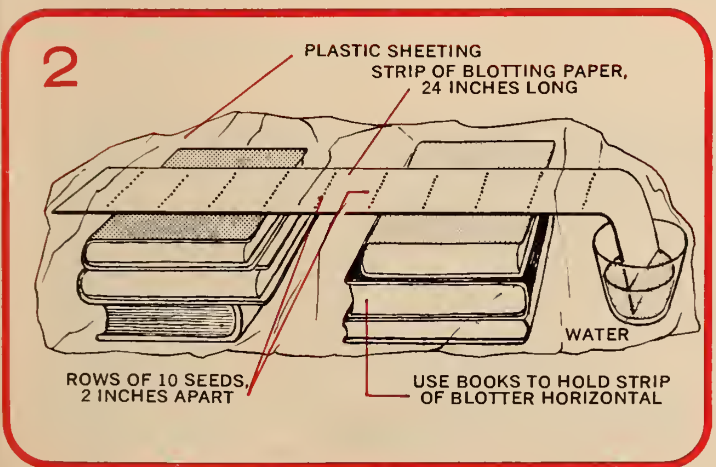
Put the second glass plate on top of the "sandwich." Then seal the edges of the plates all the way around with tape. Lay the "sandwich" horizontally in a dark place for two to three days, allowing the seeds to sprout and grow. Then examine the mustard seeds. Which way have the roots grown? Did they all grow in the same direction?

A Simple Choice for Seeds

This investigation is an all or none situation: water on one side of the seeds; none on the other side. You can also set up a "maybe" or "partly" situation where there are different amounts of water rather than all or none. For this investigation, you will need a water *gradient,* with a lot of water at one end, little water at the other end, and a range in between. There are several kinds of water gradients you can make. We will tell you how to make two different kinds; you might design another kind that will work even better.

You can make a simple gradient from a long strip of blotting paper which is dipped into water at one end. As the water moves along the strip, some of it will evaporate and the farthest end of the strip should be almost dry.

Get a white desk blotter from a stationery store. Cut a strip about a half inch wide from the long side of the blotter. Your strip will probably be 24 inches long. Make a two-inch fold at one end and put it in a cup of water. The



rest of the strip should be laid flat on a horizontal surface *(see Diagram 2).*

Make a pencil mark every two inches along the strip. Then put a row of 10 mustard seeds at every two-inch mark. Next, cover the whole strip with a piece of plastic sheeting (to slow down evaporation) and leave it undisturbed for two or three days. Finally, take off the plastic cover and let the seeds grow for a day or two longer. Those

GROWTH OF ROOTS TOWARD WATER

Distance from Water in inches	Number of Seeds That Sprouted	Root Growth in inches
2		
4		
6		
8		
10		
12		
14		

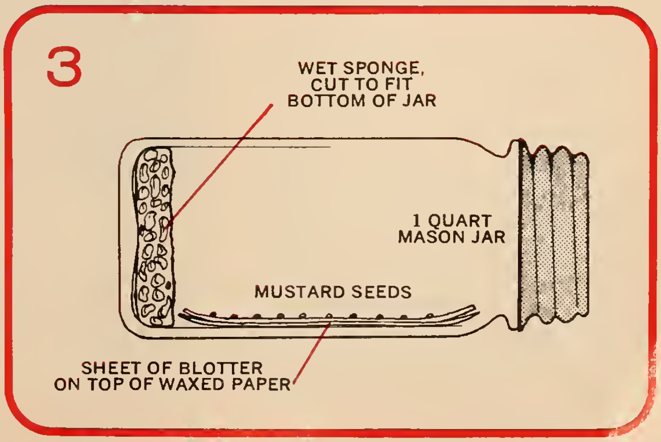
farthest from the water may dry up, but most of the seeds will continue to grow.

Use a clear plastic ruler to measure the growth in length of the roots. You should record the measurements in a table like the one on this page. How does the length of growth change with the amount of water available?

Can Roots "Reach" for Water?

Another way to make a water gradient is to wet a square of cellulose sponge and put it in the bottom of a quart mason jar. Lay the jar on its side. Next, put a piece of waxed paper or Saran Wrap just inside the jar opening and put a piece of blotter on top *(see Diagram 3).* Cover the jar tightly with its screw cap and leave it overnight. In a separate jar, let some mustard seeds sprout overnight on a wet blotter. Then transfer the seeds to the dry blotter in the quart jar. Use tweezers *(forceps)* to pick up the seeds.

After the seeds are in the jar, gently replace the cover and put the jar, still on its side, in a dark place. Leave it there for two or three days. Then notice which way the roots are growing. Are they able to grow toward moisture even if they are not in direct contact with the water? Do you think it is possible for plants to send down roots many feet before hitting water? ■



WHAT'S NEW

By Roger George

The "good old days" that older people talk about may not have been so good after all. Scientists have long suspected that people usually think the past was nice because they have forgotten the "bad" things that happened to them and remember mainly the "good" things. A study by scientists at Princeton University, in New Jersey, seems to support this.

The scientists flashed words on a screen and tested how well volunteers remembered them. At the time some of these words were shown, the volunteers were given a mild electric shock. The scientists found that words linked with an electric shock were forgotten more often than words that were not linked with a shock.

This year's Olympic Games may help answer a question that scientists and sports lovers are interested in: Can an athlete do as well at high altitude as at low? The games will be in Mexico City —which is 7,400 feet above sea level. Its thin air has 8 per cent less oxygen than air at sea level. Because a person's body needs oxygen to burn food for energy, a shortage of oxygen can mean a shortage of energy.

Some scientists think that because of this the athletes—especially long-distance runners — won't break many records in Mexico City. Others think an athlete can do as well as ever in the Olympics if he trains at high altitude long enough for his body to get used to it (*see photo*). Short-distance runners may even run faster in Mexico City, some think, because they won't have to push as hard to move through the thinner air.

Shooting antiaircraft shells into clouds can protect farm crops from hailstorm damage, Russian scientists say. By bouncing radar waves off clouds and studying the pattern of echoes, scientists can tell that certain clouds contain water droplets that are likely to combine into large drops which may freeze as hailstones. The scientists can prevent this from happening by firing into the clouds shells that scatter many tiny pieces of silver iodide and lead iodide—substances used by rainmakers to "seed" rainclouds.

In the hail clouds droplets of water cluster on the iodide particles. But there are so many particles that none gets enough water on it to form a very large drop. Any drops that freeze as hailstones are too small to cause damage.

A method like this may be tested in the United States, where hail causes millions of dollars of damage a year. Perhaps rockets will be used instead of shells.

Heat from inside the earth will produce electricity for a large area in Mexico. The heat is supplied by *magma,* or molten rock, that pushes up through cracks in the earth's crust and comes close to the surface in places. There it has heated water in the ground beyond the boiling point.

In Baja California, Mexicans have struck pools of boiling water by drilling wells from 3,600 to 4,900 feet deep. This water is under great pressure. When one well accidentally became uncapped, steam blew almost 500 feet into the air. The power of steam from such wells will turn generators that produce electricity.

This largest *geothermal* (earth-heat) power plant in the world will be completed in 1970. It will supply electricity to the whole Baja California peninsula and to the neighboring Mexican state of Sonora. Geothermal plants are already operating in another part of Mexico and in California, New Zealand, Iceland, and Sicily.

The earth could crash into a minor planet, says Dr. Harold Masursky of the U.S. Geological Survey. Minor planets known as *asteroids* (*see "Travel Guide to the Planets,"* N&S, *December 4, 1967*) have collided with the earth in the past and could do so in the future, he says. The asteroid Icarus, for example, could crash into our planet if it changed its orbit in a certain direction by a single degree. Asteroids range in size from one to 500 miles across, and the smallest could blast a hole in the earth 60 miles across.

Scientists should watch asteroids carefully, Dr. Masursky says. If one showed signs of crashing into the earth, it might be destroyed with a hydrogen bomb. Or maybe it could be pushed off course by a rocket. If nothing else, people on the earth could be warned to leave the area where the asteroid would hit.

A Swedish runner breathes through a device to measure how much oxygen he is using as he trains in Mexico City for the 1968 Olympic Games in the high-altitude city.

Using This Issue . . .
(continued from page 2T)

Some of your pupils may wonder how the week was invented. No one knows for sure, but it may have been devised when men began to trade with their neighbors, so they would know what days to get together at the marketplace, to rest from work, and to hold religious ceremonies.

Activity

Have your pupils try to make up a calendar in which the same day of each month would always fall on the same day of the week. This can be achieved in a year composed of thirteen 28-day months with a single "leap day" added at the end of each year. Each month starts on Sunday. (You might give your pupils some hints about adding a month, a day, etc.) Ask your pupils what advantages such a calendar might have, also disadvantages (for the superstitious – the 13th always falls on Friday, and there are 13 months).

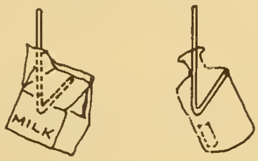
Brain-Boosters

Mystery Photo. It is easy to demonstrate this illusion with a birthday candle and a glass container. Heat a straight pin and push it into the bottom of the candle. When viewed from certain angles, the flame of the floating candle appears to be detached. This occurs because light is bent *(refracted)* as it travels from water into glass and from glass into the air.

What will happen if? Your pupils should find that a plastic bag filled with air weighs no more *in air* than an empty bag of the same size. The mass of the air in the bag has no effect on the balance, because it is being "weighed" in air of the same density. The same thing happens if you try to weigh water in water. You might have your pupils balance two "empty" half-pint milk cartons, then fill one with water and suspend it from the balance in a bucket of water. If the air-filled bag could be taken into space, it would weigh more than an empty bag.

Have your pupils use the yardstick balance to compare the weight of empty and inflated balloons. Blowing up a balloon squeezes more air into it than there is in an equal volume of space around the balloon. This makes the inflated balloon a little heavier, but the yardstick balance is not sensitive enough to detect this slight change in weight. The balance should, however, detect the weight change in a blown-up basketball or football, since more air can be forced into it than into a balloon.

Can you do it? If your students get milk in cartons at lunch, challenge them to lift the empty carton with a straw, without holding the carton on its side or upside down. This can be done by bending the straw back several inches from the end. When the bent end is pushed into the hole and pulled out, it should catch enough to lift the carton *(see diagram)*.



Fun with numbers and shapes. Children—and most adults—think there are millions of stars visible on a clear night. When everyone has had a chance to guess the correct number, you can surprise them with the fact that only about 3,000 can be seen. If they don't believe you, they can count the stars for themselves.

For science experts only. The air in most deserts is hot in daytime, because air is warmed by contact with the ground, which soaks up heat from the sun's rays. More of the sun's heat radiation reaches the ground through the clear, dry air of a desert than through the moist, dusty, and sometimes cloudy air over, say, a wooded or grassy region. When the sun goes down, the desert soil loses heat to the air very quickly, and the warm air rises rapidly. In humid climates, the ground loses heat at night, but some of this heat is bounced back by clouds and dust in the air and by tree foliage. Bodies of water soak up the heat from the sun's rays more slowly than soil, but the water retains heat longer after the sun sets.

Just for fun. Since this project is a little messy and smelly, it might be best to suggest that your pupils do it at home, under supervision.

Animals as Teaching Aids
(continued from page 1T)

AMPHIBIANS. The aquatic newts are ideal amphibians for classroom use. You can buy them at tropical fish stores which also sell the tubifex worms they eat. Their container should be covered to prevent escape. Frogs and toads can be housed in a terrarium, and you can buy their captive diet of mealworms at pet shops. The terrarium should also be covered, to prevent escape and to maintain a moist, humid atmosphere.

REPTILES. The American anole, often called a "chameleon," is an active lizard when kept at a temperature of about 80° F. It requires a varied diet but will survive for a long time on mealworms. Small snakes, such as a garter or king snake, offer many opportunities for studying their behavior, and for eliminating some myths and fears about these reptiles.

Of all the reptiles, turtles—especially the small, aquatic varieties – are most familiar to children. These turtles will stay alert and healthy when kept in clean water at 80° F. that is deep enough for swimming. Their food should be small pieces of raw meat, fish, and earthworms.

SMALL MAMMALS. A good choice is the guinea pig, ideal in size and temperament. Rabbits are good, too, but need much more living area. Hamsters have the disadvantages of sleeping during the day and becoming irritable; they are quick to bite when mature. Young white rats and mice are also suitable, but they too will bite as they mature. Keep in mind that mice always present an odor problem.

(Continued on page 4T)

What About Gerbils?

Gerbils are small, long-tailed rodents that are now available in some pet shops and from other sources. They have one advantage over most classroom mammals: Their cages need not and should not be cleaned frequently. More information about getting, keeping, and studying gerbils will appear in a forthcoming issue of *N&S*.

Animals as Teaching Aids
(continued from page 3T)

Troubles may develop if mammals are fed a continuous diet of commercial food pellets. Rats, for example, may suffer from a thiamine deficiency. Add fresh, green, leafy vegetables to the daily fare of small animals.

BIRDS. Canaries, finches, and parakeets are beautiful and have interesting habits. But they also tend to be noisy and can be distracting. Because these animals are easily subject to colds from drafts, cages should be in a warm area of the classroom.

Further Tips on Animal Health

The living quarters you provide for an animal have a great deal to do with its survival. Remember these three basic rules about an animal's cage or other enclosure: 1) It must provide a comfortable living area, free from temperature extremes. 2) It must be a container that can be kept clean and sanitary. 3) It should restrain and protect the animal, preventing escape and keeping children from hurting the animal. (There are times when you may want your pupils to touch or hold an animal, but you should choose those times.)

Keep the living quarters away from open doors, direct sunlight, steam pipes, and other sources of heat and drafts. Daily cleaning will help control the problems of disease and odor. For efficiency, give the animal fresh food and clean water right after a cage is cleaned. Make sure that food and water containers are also clean.

The nutritional requirements of most classroom animals are now well known. With the variety of fresh foods and commercial animal rations now available, there should be few problems in this area. However, some animals will need vitamin and mineral supplements.

When you decide to use an animal as a teaching aid, you also assume responsibility for its welfare. Its life is literally in your hands. Remind your pupils that the animal's survival depends on conscientious care.

References

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- *A Sourcebook for the Biological Sciences*, by E. Morholt, P. Brandwein, and A. Joseph, Harcourt, Brace & World, Inc., New York, 1966, $9.95.
- *Raising Guinea Pigs, Raising Hamsters*, and *Raising Rabbits* are among many inexpensive pamphlets available from the U.S. Department of Agriculture, Washington, D.C. 20250.
- *How to Care For Living Things in the Classroom*, NSTA Instructional Aid, 35 cents, available from the National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D.C. 20036.
- *Curriculum Aids for Teachers: Pets and Their Care* (a free list), Pennsylvania SPCA, 350 East Erie Avenue, Philadelphia, Pa. 19134.
- *Keeping Animals in the Classroom*, Cornell Science Leaflet, 25 cents, available from the Leaflet Office, Stone Hall, Cornell University, Ithaca, New York ■

nature and science
TEACHER'S EDITION
VOL. 5 NO. 9 / JANUARY 22, 1968 / SECTION 1 OF TWO SECTIONS

WHY STUDY COMMUNICATION?

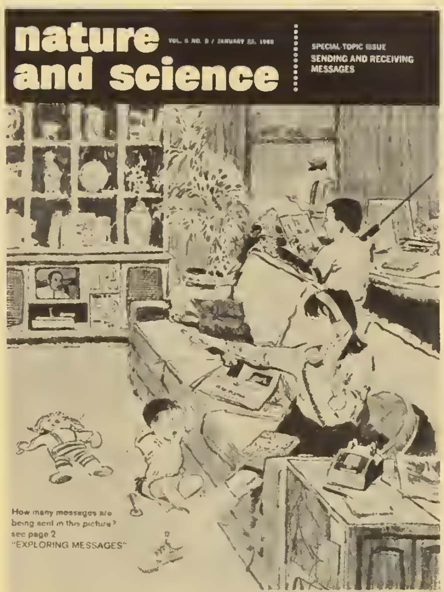
■ As a teacher, you know from experience and training the importance of being able to communicate successfully and of recognizing a "message" when someone sends you one. But while your pupils are constantly sending and receiving messages, they are probably not aware of it—or of the purposes and effects of all these messages.

This special-topic issue is devoted to bringing the process of communication to the level of your pupils' awareness, showing them how to test their own ability to communicate and how to evaluate the effects of others' communications on them, and bringing to their attention some of the ways that other animals communicate with each other.

Animals have been communicating with each other for millions of years, and the human invention of communication through symbols such as words and pictures is at least thousands of years old. Yet only in the past few decades have men begun to study this process in scientific ways. This "sudden" interest is probably the result of the tremendous upsurge in the world's population, economic conditions that tend to make people cluster in large cities, and technological developments that make it possible to communicate instantly over long distances with one or with millions of people. Whatever the cause, though, social scientists are constantly seeking ways to help individuals and groups of people to communicate more effectively with each other. And physical scientists are constantly seeking ways to expand channels of communication and use them more efficiently.

In recent years, a number of universities have upgraded their schools of journalism to schools of communication, widening their curricula to include media such as broadcasting, still and motion picture photography, and public relations, as well as newspaper and magazine journalism and advertising. Some teachers in high schools and lower grades try to give their students insight into the operations of the mass media and their effects on the individual, but a lot more could be done.

Communication, like medicine, is more of an art than a science. But, also like medicine, it is a vital art. Perhaps the most important thing you can teach your pupils is how to practice this art and use it effectively and honestly.—F.K.L.



IN THIS ISSUE

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

Special Topic: COMMUNICATIONS

IN THE NEXT ISSUE

How a flying biologist studies eagles (Part 1 of a three-part SCIENCE ADVENTURE) . . . Exploring action-reaction . . . Plant "homes" made by insects, and how to study them.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Exploring Messages

This SCIENCE WORKSHOP guides your pupils to a functional definition of a "message" that will help them discover that they are sending and receiving countless messages daily. It also suggests a way to test the "success" of a message and find out what caused a message to "fail."

Suggestions for Classroom Use

● After your pupils have read this article, have them list some of the signals (sounds, motions, expressions, and so on) they use to send messages, together with the meaning of those signals. Have them compare lists to see if a particular signal carries the same message to everyone. Could words be described as signals that you can hear or see?

● You might show your pupils some pictures and ask them to describe in a sentence the message they receive from each picture. Include a photograph, a drawing, a reproduction of an abstract painting, and perhaps a Rorschach-type ink blot (made by folding a piece of paper, dropping ink into the fold in an odd pattern, and pressing the sides of the fold together). Have them compare findings. Do they agree with the saying that "A picture is worth a thousand words"?

● Read (or assign) the class a few paragraphs from a newspaper story about, say, international finance, then have your pupils try to "feed" the message back to you, in writing. Have them compare their results and try to find out why they differ. Perhaps some of the words in the article were unfamiliar, or referred to something your pupils don't know about. Have them look up these words in a dictionary and see if that helps them get a better understanding of the message. (A dictionary often defines a word in other words that are equally unfamiliar. If you look up the "other" words, you may find them defined in terms of the word you looked up in the first place)

Point out to your pupils that words are simply "labels" that we give to things we can detect by our senses (objects and actions, for example) or that we make up in our heads (relationships, for example). Labels are handy "signals" for sending messages, as long as both the sender and the receiver know what the labels refer to (and as long as they don't mistake the label for the thing it refers to).

● Your pupils may think it would be simpler to describe a message as "something that transmits information." Ask them to describe "information," and they will see that this label can refer to so many different things that it doesn't help much in recognizing and analyzing a message.

However, you might point out that scientists who study *communication systems* do call the content of a message "information," for convenience. They make a simple "model" of a communication system like this:

SENDER → CHANNEL (OR MEDIUM) → RECEIVER

The *channel*, or *medium*, is what carries the message from the sender to the receiver–a note, telephone wires or the air (for spoken words), for example.

● Anything that interferes with the movement of the message through the channel is called "noise," whether it takes the form of other sounds, raindrops falling on a note written in ink, or whatever. If your pupils investigate what makes some of the messages they send "unsuccessful," they will probably find that the cause is usually some form of "noise." Sometimes, though, it may be that the message sent wasn't clear to begin with.

● The idea that every message is an attempt to affect the receiver in some way may surprise your pupils. Ask them how an "asking" message fits this description. (It is an attempt to make the receiver do or think something, even if just to send a message in reply.)

Activities

● Have one pupil write a short message such as "Can you direct me to a post office?" on a piece of paper and give it to you. Then have him try to communicate this message to his classmates without using any words–only motions and expressions. This will give your pupils an idea of the difficulty of trying to communicate with someone who doesn't speak their language.

● To demonstrate the importance of feedback in testing the success of a message, write a simple message on paper and give it to one pupil. Have him whisper the message to his neighbor, and so on around the class. Compare the message received by the last person to get it with the written message. Then repeat the process with a different message, but have each receiver repeat the message to the sender to be sure he gets it right before passing it on.

● Have your pupils write down some slang expressions they use in current communications with friends, write what the expressions mean to them, then compare "meanings" with each other. Do these words mean the same thing to all who use them? Do they mean anything to most adults? Are they a kind of secret code to keep "outsiders" from understanding messages–or just a way of demonstrating

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

nature and science

VOL. 5 NO. 9 / JANUARY 22, 1968

SPECIAL-TOPIC ISSUE

SENDING AND RECEIVING MESSAGES

How many messages are being sent in this picture?
see page 2 "EXPLORING MESSAGES"

nature and science

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** Robert J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Nesta Paley • **CONSULTING EDITOR** Roy A. Gallant

PUBLISHER James K. Page, Jr.
CIRCULATION DIRECTOR J. D. Broderick
PROMOTION DIRECTOR Elizabeth Connor
SUBSCRIPTION SERVICE Alfred Thiem

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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

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SCIENCE WORKSHOP

Do you sometimes have trouble "communicating" with people? You can find out some reasons why, and what to do about them, by—

EXPLORING MESSAGES

■ Guess how many messages you send and receive in a single day. Two or three? Fifty? Would you believe hundreds?

The process of sending and receiving messages is called *communication*, and by exploring this process you may find that you spend more time communicating than doing anything else.

You might begin by investigating messages. How would you describe a "message"? Our dictionary calls it "A communication in speech, writing, or signals." That tells you some ways that messages can be sent. But can you use that description to decide whether a particular bit of speech, writing, or a signal should be called a "message"?

How To Recognize a Message

By studying some examples of things that you call "messages," you can make up a description that will help you identify other "messages." Think of the word "message" as a label that you give to things that are alike in a certain way. Then write down five or six messages that you might send to a friend, and try to figure out how they are alike. Here are a few messages to start your list:

"Meet me after school."

"You have a spot on your collar."

"May I borrow your ruler?"

All of these messages are in writing, and all of them are written in words. Do you think that everything that is written in words can be called a "message"? Take these words, for example: "red up chair the laugh today." Would you call them a "message"? Can you explain your answer?

Scientists often find it useful to describe things by what they *do*, instead of how they appear or what they are made

A school crossing guard tells drivers to stop through a simple hand signal. A folk singer sends messages to his listeners in words and music.

of. If you think about what your sample messages do, you might say that each one either "tells" or "asks" something. (Do the words "red up chair the laugh today" do that?)

See if you can find any other group of words on this page that does not either "tell" or "ask" something. If not, then you are probably safe in calling any words that tell or ask something a "message." It doesn't matter whether the words are spoken, written, printed, carved, or in some other form.

Before you start counting how many messages you have sent and received today, remember that the dictionary also mentioned that a message can be in "signals," as well as in speech or writing.

Messages without Words

What is it you are doing when you ring a friend's doorbell? Or when you wave to a friend, moving your arm from his direction toward yourself? Or when you tap someone on the shoulder, or smile or scowl at him? The ringing bell, the wave, the tap, the smile, and the scowl are all *signals* that you send to either tell or ask something.

Does a picture "tell" or "ask" you something? How about a red light at a street crossing, the ring of your school bell, or the blast of a siren? Can you think of different signal messages that you receive through each of your senses —sight, hearing, touch, smell, and taste? You may find out that you have been sending and receiving many messages without even thinking about them!

Since a message is something that tells or asks, it must have a *sender* to do the telling or asking. And most messages are sent to a *receiver* (though you may sometimes send a message to no one in particular, for example, when you stumble and hurt your toe). You can be both the sender and the receiver. When you set an alarm clock at night, for example, you are sending a message that will tell you to wake up in the morning at a certain time. Most of your communications, however, are probably with other people.

Most animals are able to communicate with other animals of the same kind (*species*) by sending messages in signals (*see "The Language of Animals," page 5*). But only humans have become able to communicate in words (*see "Teaching a Chimp To 'Speak,'" page 10*), and only humans can send messages over vast distances to millions of people in almost no time at all (*see "Spreading the Word," page 8*).

Getting the Message Across

To live and work with other people, you have to be able to communicate with them. Scientists who study how people get along with each other point out that every message you send is an attempt to *affect,* or change, the receiver in some way. You may be trying to make the receiver do, think, or feel a particular thing. Or you may just be trying to add some information to the supply in his memory.

If your message changes the receiver the least bit in the way you wanted it to, you can say that your communication is "successful." But there are many things that can keep a communication from being successful. In a crowded room, for example, noise may keep some or all of your message from reaching the receiver. A person who is thinking about something else may not "receive" your message at all.
(Continued on the next page)

Or a person may not want to do what your message tells or asks him to do, so he pays little or no attention to your message.

Scientists who study communications use the label "noise" to describe anything that keeps a communication from being successful. Even spots that block out parts of a picture on your TV screen are called "noise." Usually "noise" can be overcome by sending a stronger signal. Talking louder, for example, may get a message across a crowded room to the receiver. Of course, talking louder probably won't make a receiver believe something he doesn't want to believe. But you can try making the message "stronger" by explaining why you are doing the telling or asking.

If you send a message in signals that the receiver does not understand, or that mean something different to him than they mean to you, your message is "weak," and it probably won't do what you want it to do.

You can usually tell whether you have communicated successfully with someone by the kind of message the receiver sends back to you. For example, if the receiver nods his head, smiles, does what you told or asked him to do, or tells you in speech or writing that he will do it, your message was probably successful. Such a message is called *feedback*, because it "feeds" back information to the sender about the effect of his message on the receiver. If the receiver says "no," scowls, argues, or raises his eyebrow, or simply does not do anything, the feedback tells you that your communication was not successful.

Considering how many messages you send and receive, and how important many of them are to you, you may want to look more carefully at some of your own communications and find out how successful they are. The following investigations will help you do this.—F.K.L.

INVESTIGATIONS

Are most of your communications successful? If not, can you explain why? By describing some of the messages you send in a table like the one below, you may be able to figure out what went wrong.

Under the heading "Message sent" write briefly what the message tried to tell or ask *(see table).*

Under "Receiver" write "father," "teacher," "Tom," "store clerk," "unknown boy on street," or whomever else you sent the message to.

Under "Form" write "speech," "writing," "picture," "arm wave," or other signal you used.

Under "Medium" write the device, if any, by which you sent the message ("note," "telephone," "doorbell," "classroom test," and so on).

Under "Result" write "successful" if you think the message did at least a little bit of what you wanted it to do, or "unsuccessful" if it did not. (Did you receive any feedback?)

Under "Comments" try to explain why you think an unsuccessful message didn't work. For example, "Noise in street kept receiver from hearing," "Receiver wasn't interested," or "Message didn't tell enough."

● You might make a similar table for studying messages that you receive. If you receive a message clearly, you should be able to describe what it tells or asks and decide whether it is successful. If it is not, can you explain why?

● Do you communicate more successfully in writing, speech, or signals? Do you communicate more successfully with people you know (your parents, friends, and teachers) than with people you don't know very well? Do you receive messages more successfully if you read them or hear them?

● You can probably think of many more questions that can be answered by investigating your communications this way.

MESSAGE SENT	RECEIVER	FORM	MEDIUM	RESULT	COMMENTS
Meet me after school	Margaret	Words	Note left on desk	Unsuccessful	Receiver didn't find note.
Read pages 10-23 for homework.	Bob	Words	Telephone	Unsuccessful	Noise from his radio made receiver hear "10-33."
Don't make me drink milk!	Mother	Scowl	Vision	Unsuccessful	Receiver paid no attention, having received same message before.

A grunt,
a touch,
a flash of color,
a scent on the wind—
these are the sorts
of signals that
make up . . .

THE LANGUAGE OF ANIMALS

by Millicent E. Selsam

■ Watch a flock of starlings as they come in to roost on a winter evening. They shift, turn, and dive together, like a troupe of dancers in the sky. Signals of some sort pass between the birds, telling each one when to turn.

Other kinds of animals also have ways of relaying messages. The monkeys in a zoo, the dogs on a street, the chickens in a barnyard, the starlings, and most other animals have ways of communicating with one another.

These animals have a language, just as humans do. In trying to understand it, however, we have to forget the human idea of language, with its words and sentences. We also have to stop thinking that other animals see things, hear sounds, and smell odors the same way we do.

It helps to know, for example, that a dog can't see colors, but can smell the faintest odors and can hear much higher sounds than we can. Birds have keen eyes but hardly any sense of smell. To find out how dogs, birds, and other animals communicate, we must look at the world from their point of view.

Scientists who study the language of animals work both in the lab and outdoors, or "in the field." They may spend many months watching a herd of deer, a flock of gulls, or clans of monkeys.

As the scientists observe the day-to-day life of the animals, they may think of explanations for the animals' behavior. For example, they may hear gulls making certain sounds when the birds find food. Are these sounds a call to other gulls? To find out, the scientists can make a recording of the call, then broadcast it through a loudspeaker. If gulls are attracted by the call, the scientists have evidence that this particular sound attracts other gulls to food.

While many studies of animal communications are done in the field, others are done in zoos, aquariums, or in lab-

(Continued on the next page)

oratories. Sometimes it is difficult or impossible to study an animal as it lives in the wild, so captive animals are used. In the lab it is also easier to set up experiments designed to answer questions about the animals' language.

A Message in a Song

At one time or another, you may use all of your senses to communicate with other people. Most often, however, you use your sight and hearing. The same is true of birds.

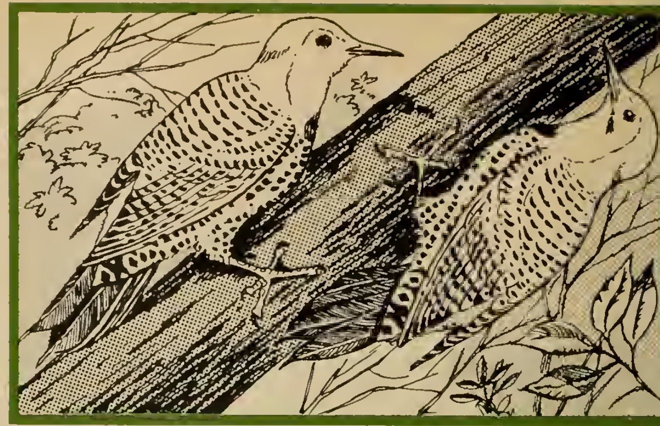
Suppose that all of the bachelors in your neighborhood rented apartments with balconies and then stood on them, singing songs to attract girls and to keep rivals away. This picture gives you an idea of what goes on in the bird world.

The male bird generally arrives first in the spring and claims a piece of ground *(territory).* Then he picks a prominent place and sings from this perch. Once the territory is established, no other male of the same species can enter without a fight. The fight, however, is usually just a singing contest that ends when the rival leaves the territory.

The songs of the male also attract the females. Here is where another sense—sight—often comes in as part of the language of birds. The females of many species of birds have duller colors than the males. The difference in colors helps the sexes recognize each other.

For example, a male flicker has a mark that looks like a black moustache *(see diagram).* This is a sign of his "maleness." Once a biologist caught a female flicker, painted a black moustache on her face, and then released her to see what would happen. When the bird returned to her nest, the male didn't recognize her, and drove her off.

In some species of birds, such as song sparrows, the male and female look alike. When a male song sparrow meets a female for the first time, the male bristles at the stranger. The stranger does not fight or run away—a signal that would mean "male." Instead, the bird crouches and makes a soft call. In the language of song sparrows this means "female."



A black moustache mark is a signal that tells flickers whether a bird is a male or female. Males have the mark; females do not. Otherwise the birds look exactly alike.

Communicating with Parents

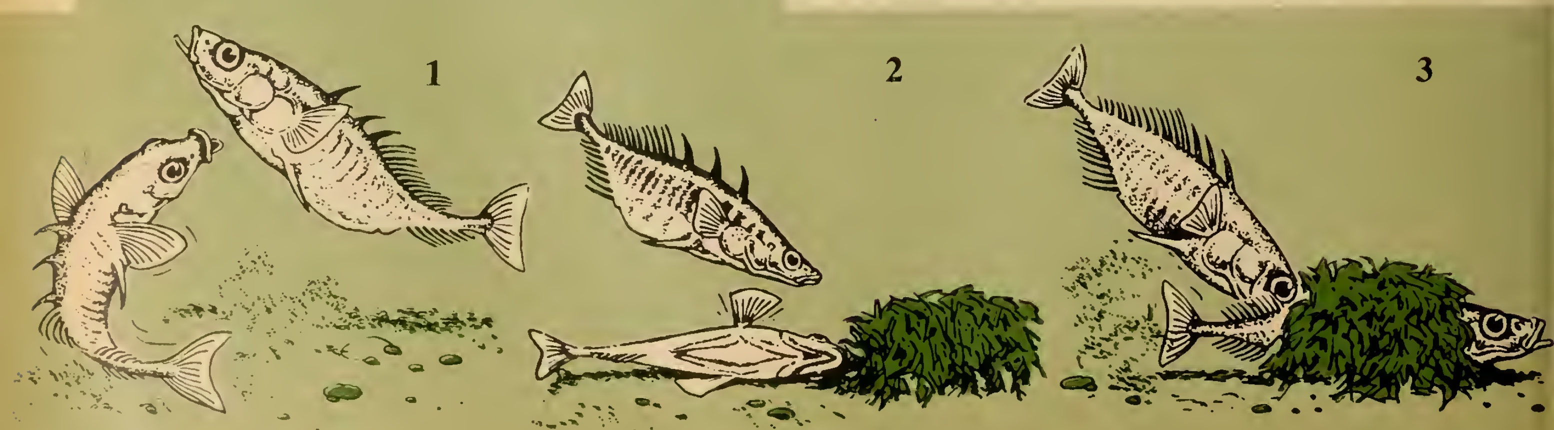
Signals of sound and color are also important to the lives of young birds. Within 15 minutes after hatching, young chickens give distress calls if they are lost, cold, or hungry. A chick may be hidden from its mother, but when it gives a distress call, the hen goes toward the sound. A scientist once placed a chick in a glass jar so that its calls could not be heard. The hen could still see the chick clearly, but without the sound signal she paid no attention to the chick.

Chicks also get messages from the hen. One sound seems to mean "follow me"; another announces "here's some food"; and other sounds warn the chicks of danger.

Stickleback Signals

The sense of touch is an important part of the language of some animals. In the spring, a male three-spined stickleback (a kind of fish) builds a hollow nest of water plants on the bottom of a pond *(see diagram).* When the nest is

Sticklebacks send messages of sight and touch when they mate. The male does a zigzag dance and the female swims toward him (1). Then the male leads her to the nest (2). A prod from the male (3) signals the female to lay her eggs.



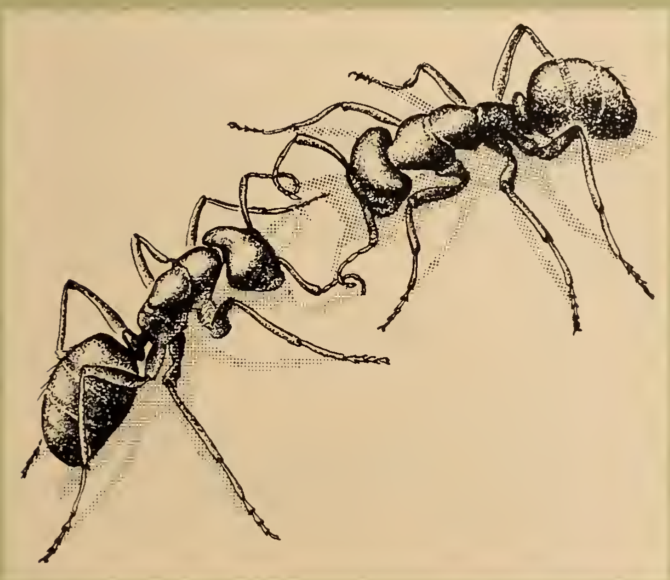
finished, he swims near it and his belly gradually turns bright red.

This is a signal to a female stickleback. When she comes near, the male does a zigzag dance. In turn the female swims toward the male with her head up. This is a signal for the male to lead her to the nest. He turns on his side and points his snout at the nest entrance. The female responds by going into the nest. The male then prods at the base of her tail and she lays her eggs. After she leaves the nest the male enters and *fertilizes* the eggs (deposits male sex cells on them).

The proper signals must be given in the right order. And the last signal—when the male prods the female—is just as important as the earlier visual messages. In fact, the prodding signal is more important than the presence of the male fish. At this stage, you could take the male away and prod the female yourself with an object like a glass rod. The female would then lay her eggs.

From Ant to Ant

For many years scientists wondered how ants communicate. After observing ants and studying their sense organs, they discovered that ants see only dimly but are very sensitive to odors. They do not have noses, but smell with their "feelers," or *antennae*. Watch two ants meet and see how they stop and tap each other with their antennae *(see diagram)*. They are exchanging smell signals. In this way they recognize members of their own colony.



Through their sensitive antennae, ants exchange smell signals with other ants. The antennae also detect food.

When an ant finds food, it lays a trail of a special chemical on the way back to the nest. As it runs along, it stops every once in a while and touches the ground with the tip of its abdomen, leaving a spot of this chemical. When the ant reaches the nest, the other ants smell this chemical and this makes them rush out of the nest and follow the trail. That is why you may soon find many ants in your kitchen after one ant discovers a bit of food left there.

If you happen to be watching a line of ants moving toward food, rub your finger across their path. Watch to see how they react to your breaking of their scent trail.

Scent messages are the main language of some other kinds of insects, too. With the sensitive smell organs on its antennae, a male moth can detect the smell of a female a mile away. The male then flies in the direction of the odor until he finds the female and they mate. Scientists are now investigating ways of using scents to lure moths into traps. They hope to use this method to control the numbers of certain moths which are harmful to trees and crop plants.

Howling Monkeys also Cluck

Some kinds of insects, such as crickets and katydids, send sound signals. Sound is also an important part of the language of the howling monkeys, which live in the deep forests of Central and South America. These monkeys spend much of their time in the tops of trees where the leaves often hide them from one another. A biologist named C. R. Carpenter spent nearly two years watching howling monkeys and their ways.

Each morning and evening the forest echoes with the roars and howls of these monkeys. Each clan starts and ends the day by letting the neighboring clans know its position. Every clan has its own separate territory, but the territories overlap a bit. When one clan gets too close to another, there is a tremendous roaring on both sides until one or the other group moves off.

Any alarming situation brings forth this roaring, which prepares the group for attack or defense. If the situation is only mildly alarming, you will hear a series of gurgling grunts.

Another signal keeps the clan together as it moves through the forest feeding on buds, fruits, and leaves. When any one of the males finds an easy pathway through the trees, he gives a deep metallic *cluck*. This makes the whole clan move toward him to follow his particular trail. Howlers have other sounds that are used when a young monkey is lost, or when an older monkey wants to halt the noisy play of the young.

The languages of monkeys, birds, and other animals seem very limited when compared with that of humans. But these languages enable the animals to find food, avoid enemies, mate, raise young, and keep members of a group in touch with each other. These few signals are enough to help the animals to survive ■

SPREADING THE WORD

■ A young baby's cry is a signal that something is wrong. His message doesn't tell very much, and it doesn't travel very far or reach many people. Soon the baby learns to send other messages with his body by smiling, kicking, pointing, and making different kinds of sounds. These messages tell much more than a simple cry does.

When the child learns to form word sounds, he can tell many more things in a message. He can send messages to someone hundreds of miles away by telephone, and receive messages from people all over the world by television. Later, when he learns to draw pictures and write, he can send messages to people who are not even born yet.

The history of man's communications is something like that of a child's. Before early men learned to form word sounds, they must have communicated only by simple sounds and signals, like animals of other species. Later men learned to draw pictures, and then to use pictures to write words. The earliest writing we know of was invented by the Sumerians about 6,000 years ago—only a short time back in the history of man. This WALL CHART shows some of the ways that man has gradually expanded the range of his communications to send messages faster, farther, and to more people at one time ■

MARGARET R. COOPER

Fires and drums may have been used by early men to send simple messages beyond the reach of the human voice. Smoke puffs by day, flares at night, and drum beats anytime can be made in patterns that the sender and receiver have agreed will mean certain things. Can you think of other things—flags, for example—that are still used to send messages as far as you can see or hear?

Trail markers, such as a pile of rocks or a piece carved out of the bark of a tree, were probably an early form of today's road signs. Such signals send messages through time, rather than through distance. Whenever someone who understands the sign comes to it, he receives the message. Lighthouses and buoys mark "trails" for ships.

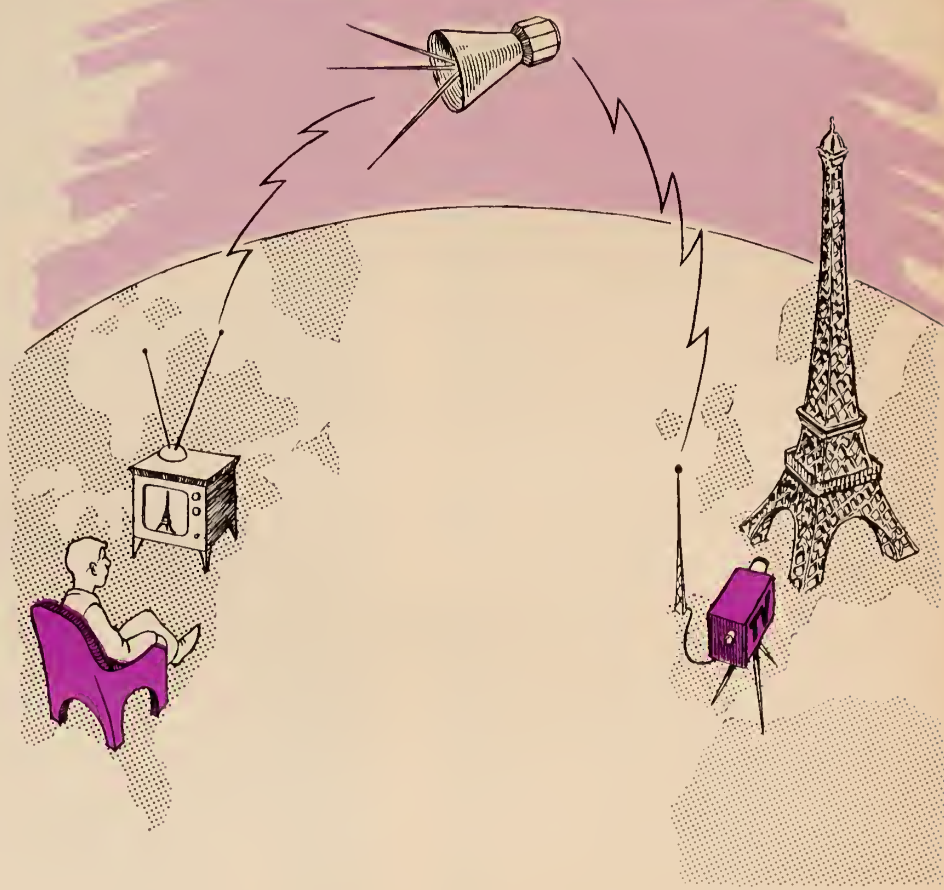
Men drew pictures at least 20,000 years ago. But not until they began to live together in cities and keep accounts did they feel the need for a system

Written messages can be carried from place to place, or stored and "received" whenever desired. During the fifth century B.C., Persian horsemen the sound "cap" and be written in a word like "capture," which has nothing to do with a cap. Finally, symbols became letters of the alphabet that can be put together to send messages in words. Does writing communicate through space, or time—or both?

ters were posted for people to read as they passed by. The first airmail letter was carried from London to Paris in 1783—by balloon. Now a letter crosses the Atlantic in a few hours.

Movable type—letters of the alphabet carved on wood blocks—was first used in Europe in the 1400s to print many copies of a message in a short time. Printed messages can be sent to many more people than a single written message. Modern printing presses print thousands of copies of a newspaper or magazine in an hour.

An electric current can carry signals through wire over long distances in a tiny fraction of a second. In 1831, the first signals were sent by switching a current on and off to produce sound signals at the receiving end of the wire. To send word messages, short and long signals ("dots and dashes") were combined in patterns to represent letters of the alphabet. By 1876 the telephone extended man's voice beyond the distance that sounds can be heard, by changing spoken words into an electric current of varying strength, then back into word sounds at the receiving end.



The discovery that electrical energy can be sent over long distances without wires led to the invention of radio about 1890. Radio signals can carry "dot-and-dash" messages like the telegraph or sound messages like the telephone. And today, through television, you can communicate instantly with millions of people all over the earth, as if you were in the same room with each of them.

Can a chimpanzee brought up like a baby learn to form words as a baby does? A scientist and his wife spent years finding out.

teaching a chimp to "speak"

This chimpanzee was brought up as the "daughter" of Mrs. Keith Hayes (in the picture) and her husband. When her "mama" said "do this," Viki would imitate (1) lifting her eyebrows, (2) touching her nose, and (3) clapping her hands.

■ Man's closest relatives, the apes, are smart enough to do things that are more complicated than saying a simple word. Yet apes do not speak.

Man is the only animal that puts sounds together to make words. We know that human babies learn to talk partly by hearing their parents and other people. Would an ape that was raised the same as a child learn to talk too? A scientist and his wife decided to find out.

Dr. Keith Hayes was studying animal learning at the Yerkes Laboratories of Primate Biology in Orange Park, Florida. From the laboratory he got a tiny, three-day-old chimpanzee named Viki and brought her home to his apartment.

Like very young humans, Viki spent most of her first days asleep in her crib. She never cried as human babies do when they want food, a burping, or dry diapers. Being a quiet baby is probably necessary for survival in the jungle, the Hayeses decided.

She Sounds Like a Chimp

When she was one week old, Viki was saying *uh uh uh uh* to anyone who bent over her crib. Sometimes this sounded like breathy panting, at other times like sharp scolding. Four weeks later, someone tried to hold her still when she wanted to move, and she gave her first "chimp bark," a sharp *rhow* like the bark of a small dog. After that she used that sound whenever she was angry or surprised.

At 14 weeks she began making "food barks." If she was just thinking about food these sounded like the *uh uh uh* sound, but when she was really hungry she drew her lips back from her teeth and let out a stream of sharp sounds like the "e" in "wet."

These are sounds that all chimps make. They are *reflex* sounds, like the sounds you make when you burn your finger or get cold water splashed on you. Up to age three months, the chimp probably makes more different sounds than a human child, who usually just cries, or makes a few *coo* sounds when he is feeling good.

But once a child is three months old he begins to play at making sounds like those of "m," "p," and "b," and *oo* and *ah*. Soon this sound play, or babbling, includes sounds found in all of the different languages that humans speak. Besides having fun, the child is learning to use his lips, tongue, and breathing to make the sounds he wants.

Viki, on the other hand, after she was four months old, made few noises other than reflex sounds. When she was five months old the Hayeses began teaching her to speak.

Making Sounds for Food

"One day," said Mrs. Hayes, "I put her in her chair, held out some milk to her, and said 'speak.' She made no sound, just looked at the milk with her beautiful brown eyes. When I stood up to leave she made sad *oo oo* sounds, and I gave her some milk to drink. When I got up to leave again she sputtered out some food barks, and I gave her more milk."

By tricking Viki into making reflex noises, and then giving her food, Dr. and Mrs. Hayes tried to make her understand that making sounds was the way to get food. They hoped she would then speak on her own to get food more quickly. For five weeks they tried this.

Suddenly one day Viki made a rasping *ahhhh* sound like someone whispering as loudly as possible. Her face was screwed up and her eyes stared. After she made the sound she reached for the milk as if she was sure she would be allowed to have it. She had realized that speaking got her food. *Ahhh* became her asking sound. Soon she was using it not only for food but also for whatever else she wanted, such as toys or a piggyback ride.

In photo 4, Viki listens in on a telephone conversation. She sometimes squealed or grunted into the phone, but never spoke or answered, though she had learned to say a few words.

When she was 14 months old they decided it was time to teach Viki her first real word. They chose "mama." Said Mrs. Hayes, "we knew that whatever word we tried, we would have to form Viki's lips for her. To form an 'm' sound we would only have to press her lips together and let go while Viki said *ahhh*."

Dr. Hayes started the training one day while the three of them were at breakfast. He told Viki to speak, then held her lips together with one hand while he held food in the other. The sound came out—*mmmaaah mmmaah*. Then he gave her food.

After a few meals she learned to wait for him to hold her lips together before she tried to say *ahhh*. If he was slow getting his hand to her lips, Viki would reach out and bring the hand there so she could make the sound and get her food.

One day not long after the training started, Dr. Hayes noticed that Viki's lips were moving under his fingers, forming the words by themselves. From then on, at each meal, he held his fingers farther toward the side of her mouth, until finally only the tip of one finger was touching Viki's upper lip. Finally even this was removed, and one

(Continued on the next page)

day two weeks after the training started Viki said her first "mama" without any help.

Now Say "Papa"

It was not until she was almost two years old that Viki learned her second word. Long before this she had learned to give a "Bronx cheer," a sound made up of repeated "p" sounds produced by sticking the tongue out between the lips and blowing, letting the air flutter the lips. The Hayeses showed her how to make softer "p" sounds, and gave her presents if she copied the way they did it.

"Three months after this training began," said Mrs. Hayes, "we asked her for just two quick, soft 'p' sounds. What came out was a whispered 'papa.' We were overjoyed." From then on Viki used "papa" as well as "mama" to ask for food or favors—no matter whom she was talking to. She didn't know what the words meant.

Half a year later Viki happened to hear Mrs. Hayes use "k" and "p" sounds together. These were two of her play sounds, and Mrs. Hayes was surprised to hear Viki repeat *k-p,* which became her third word—"cup." That word came to mean "I want a drink."

If you had seen Viki at age three you might have thought she knew a lot of language. She followed many commands her "parents" gave her, and could do things that chimps ordinarily can't do. But along with many spoken commands, the Hayeses gave her extra hints such as pointing or looking in a certain direction, or speaking in a different tone of voice. "Without these hints," said Mrs. Hayes, "I would guess that she could understand not more than 50 ideas that were said only in words." A child at this age, on the other hand, knows hundreds of words and can combine them into thousands of sentences.

As time went on, Viki learned more commands, but they were always simple ones like "bring the cup." The Hayeses kept trying to teach her to say more words, but it seemed that because of the way ape brains are built, she would never be able to say very much ■

INVESTIGATION

Some people talk to a pet dog as if the dog can understand the words they are saying. If you (or a friend) have a dog that has been trained to "come" or "sit" when ordered to, try this experiment. Have the dog's owner use the same tone of voice he always does when he tells the dog to "come" or "sit," but say instead, "bum" or "hit." Do you think the dog understands *words*, or *sounds?*

WHAT'S IN A DOT?

A dot can tell a lot, and lots of dots can tell lots more.

by Franklyn K. Lauden

■ The smallest mark you can write that will carry a message is at the end of this sentence. Because of its location it tells you that the sentence is ended. The square dot at the beginning of this article tells you where the article starts. Can you find any other "messages" in this magazine that are sent to you in dots?

Probably most of the dots you see are written or printed in black on white paper. Sometimes, though, you see dots in color, or even in white (on a polka dot dress or tie, or in the "Mystery Photo" on page 16, for example). You might describe a "dot" as a tiny mark that you can see because it is different from the space around it. Could you call a spot of light from a flashlight, a star, or a traffic light a "dot"?

. .. ., and so on

A dot can carry other messages besides "beginning" or "end." For example, you and your friends could take a secret vote on some question by agreeing first that a dot on your ballot means "yes" and no dot means "no" (or the other way around). Either way, if everyone pretends to be writing a dot, no one can tell how each of you voted.

You can use a single dot to "send" a message as long as a book! The trick is to send the message to the receiver beforehand with a note telling him not to read the message (or not to pay any attention to it) unless he receives a signal from you—say a dot on a piece of paper or a dot of light from a flashlight.

The message that launched Paul Revere on his famous ride in the American Revolution was something like that. The message was agreed on beforehand. Revere knew that lantern lights in the bell tower of the North Church in Boston meant that the British were coming—one light if they were coming by land, two if by sea. Two it was, and these dots of light were kept "on" to make sure that Revere would not miss seeing them.

You can make a dot of light even dottier, though, by flashing the light on and off. And if you know the Morse code, which was first used to send messages by telegraph *(see "Spreading the Word," page 8)*, you can send messages of any length in dots of light (or "buzzes" or "beeps" of sound, for that matter). Samuel Morse could have used dots of the same "length"—say one dot for "A," two for "B," three for "C," and so on. Why do you think he used patterns of "short" and "long" dots instead?

"Dotty" Pictures

Have you ever made a picture by drawing lines between numbered dots on a newspaper or magazine page? Men did something like that in ancient times when they began to make maps of the stars. By drawing lines between the stars in a particular "group" they made pictures of animals and other objects. They named each star group, or *constellation*, for the object pictured *(see diagram)*.

You can draw pictures made only of dots, though, without any solid lines at all. In fact, every picture in a newspaper or magazine or book is made up of dots. Look through a magnifying lens at the photo printed on this page and you can see them. (Do you know why photographs are broken apart into dots before they are printed?) In the same way, dots of light can be used to send messages in words or pictures. Have you ever seen a sign made up of hundreds of light bulbs? *(See photo.)*

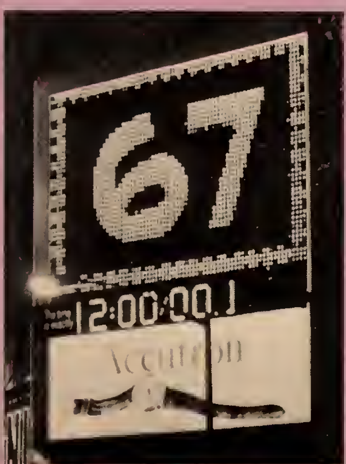
Long-Long-Distance Messages

The close-up pictures of Mars, and some of those of the moon, that you have seen recently were made up of dots even before they were "dotted" for printing in the newspapers. The pictures were "taken" by a television camera in the Mariner or Explorer spacecraft and sent to the earth in dots of radio energy. These signals were then changed into lines of dots on paper to make the pictures.

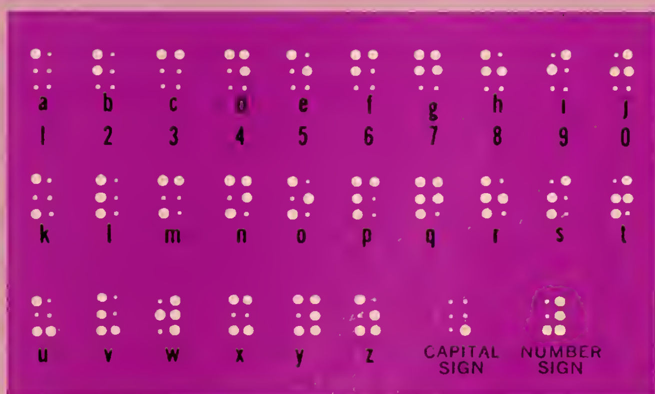
Radio telescopes like the ones that received the moon and Mars picture signals are also used to receive radio energy that is produced by the sun and several of the planets. But this radio energy comes continuously, not in short "bursts" or any other kind of pattern that could be called a signal. Still, some scientists think that if there are any "intelligent beings" on other planets in the universe, they might some time try to communicate with us by sending dots of radio energy.

Can you think of a message in dots that might tell a creature on another planet something about earthlings? ■

To ancient astronomers, this group of stars seemed to form a "Great Bear." To us, part of the group looks like a "Big Dipper." Learning and experience often make people "get" different messages from the same pattern or picture.



This sign in New York City sends messages in letters, numbers, and even "moving pictures"—all made up of dots of light or dark produced by switching bulbs on or off in certain patterns.



Blind people can "read" through their fingertips by feeling raised dots on paper. The dots are arranged in the patterns of the braille code to represent letters and numbers.

MESSAGES FROM STRANGERS

Thousands of communications are sent to you daily. Here's a way to find out how "successful" they are.

■ From the time you wake up until you go to sleep you are bombarded with messages from people you don't even know (except maybe by their names or pictures). These messages are brought to you by the *mass media*—newspapers, magazines, radio, television, and movies—which carry messages to great masses of people. (Books also carry messages to many people, but not to as many as the other media reach.)

You could easily spend all of your time receiving these messages. That wouldn't leave you any time, though, to do other things you want to do, including communicating with your friends and with yourself. Or you could avoid the messages completely by simply not reading, listening to, or watching the mass media. But if you want to get along with other people in this world, you have to know something about what is going on in it.

Since you give a good bit of your time and attention to these media, you might like to investigate how their messages affect you. This article will suggest some ways to go about it.

Getting Your Attention

Take *Nature and Science,* for example. You must be giving your attention to this article, or you wouldn't be reading these words. What "caught" your attention—the title? the pictures? both? Large type, bright colors, and large pictures are some of the devices a sender uses to "stop" you at his message in a newspaper or magazine. See if you can find some others. (How does a sender draw your attention to a radio or TV message?)

Once your eyes or ears are "tuned in" to a message, it may hold your attention with promises about what it will tell you, or by questions that stir your curiosity. Some senders even try to "shame" you into receiving their messages. Can you find some other "tricks" that a sender may use to try to keep your attention on his message?

Look at an article in this issue (or in a newspaper or other magazine) that caught your attention. If you read the entire message, can you explain why? Was it because of *what* the article told you, or because of the *way* it told you—or both? Was it because you wanted to read it, or because someone made you read it? Or for some other reason?

If you only read part of the message, why did you stop? Perhaps you already knew what it was telling you. Or you felt that you had already received the important part of the message. Maybe the subject, or the language, of the message was too hard to understand. Or maybe you just lost interest in the message.

(Finding the real answers to questions like those is not always easy. Sometimes the answers seem too silly to admit even to yourself. But you are investigating how mass messages affect yourself, and no one else needs to know what you discover.)

What Is the Message Trying To Do?

To find out how a particular message affects you, it helps to try to describe the message in as few words as possible. Ask yourself: What does the message tell or ask me? Take this article, for example. Do you think the third paragraph from the beginning sums up its message? Try to describe the message of each article in this issue, in one sentence for each one. (This is good practice, because being able to sum up a long message in a few words will come in handy all through your life.)

Once you know what the message tells or asks, you can usually figure out how the sender wants to "change" you. (The writer of this article, for example, is trying to get you to find out for yourself how messages in mass media affect you.) Many of the messages carried in mass media are sent simply to make you feel good (entertainment) or to increase your supply of knowledge about things (news stories and pictures, for example).

Many messages in newspapers, magazines, and radio and TV programs try to make you buy something from the sender (advertisements). In other messages (editorials, "columns," and some advertisements, for example) the sender is trying to change your beliefs or feelings about something or someone, or trying to make you *do* something—say, help keep your city clean.

There is nothing "wrong" about a sender trying to do any of these things to you. But to protect yourself, you need to know about some of the "tricks" a sender often uses to achieve his goal. Such tricks are used widely in advertising, as well as in other kinds of messages. The Institute for Propaganda Analysis, in New York City, lists seven kinds of tricks to watch out for in messages that try to "sell" you something:

1. *Bad names*—Words that have unpleasant meanings to most people are used to make you dislike something.
2. *Glad names*—Words that have a pleasant meaning to most people are used to make you like something.
3. *Transfer*—Something you like (ice cream?) is mentioned along with something you haven't tried (chocolate-covered ants?) to make you like the untried thing.
4. *Testimonial*—A well known person tells you how much he likes a certain breakfast cereal.
5. *Plain folks*—"Hot dogs 'n' apple pie are good 'cause there's nothin' fancy about 'em."
6. *Stacking the cards*—Telling only part of the truth about something that would seem quite different if you knew all about it.
7. *Bandwagon*—"Everybody's doing it, so why not you?"

Look for examples of these and other "trick" ways of affecting you in some messages you find in the mass media. One that is frequently used in advertising is this:

Big shot—"You'll really stand out from the crowd if you use———————!"

Judging a Message

The real test of a message is whether or not it is "successful." If it does to you at least a little bit of what the sender was trying to do, it deserves that label. If the message was intended to make you buy his toothpaste, for example, you can tell easily whether it was successful or not. And the sender can get a fairly good idea of its success by the amount of toothpaste he sells.

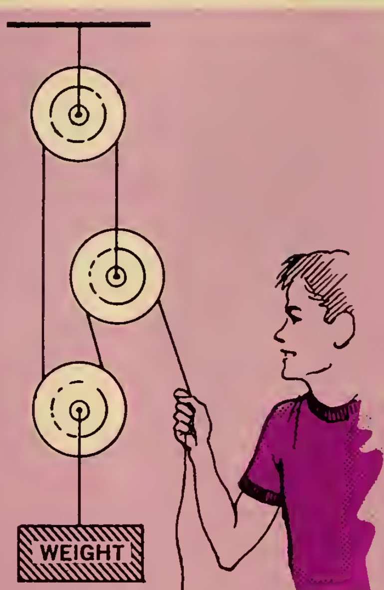
If the sender was trying to make you take some action—say, to drop pop bottles in the litter basket instead of throwing them on the street—you can tell easily whether the message was successful.

If the sender was trying to change the way you think or feel—about keeping your city clean, for example—see if you can remember how you felt about it before you read the message.

If the sender—like this writer—was trying to add to your supply of information, ask yourself: "Did I learn anything new?"—F.K.L.

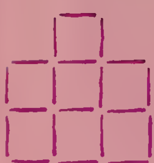
prepared by **DAVID WEBSTER**

BRAIN BOOSTERS



What would happen if?

How would the weight move if the rope were pulled down 1 foot?



Fun with numbers and shapes

Change the position of 4 toothpicks to form only 5 squares.

Submitted by Bryce Martens, San Francisco, California

For science experts only

What fruit has its seeds on the outside?

Can you do it?

Can you make a paper airplane glide for more than 10 seconds?

Mystery Photo

What happened here?

ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

Can you do it? Here is how to lift a small bottle with a straw.

Fun with numbers and shapes: On a clear night you can see only about 3,000 stars without a telescope or binoculars.

Mystery Photo: The flame appears to be detached from the candle floating in the water because light is *refracted*, or bent, as it travels from water into glass and from glass into air.

What will happen if? A plastic bag filled with air weighs no more than an empty plastic bag. Why does a blown-up football weigh more than a deflated football?

For science experts only: The air in most deserts is hot in the daytime, because air is warmed by contact with the ground, which soaks up heat from the sun's rays. More of these heat rays reach the ground through the clear, dry air of a desert than through the moist, dusty, and sometimes cloudy air over, say, a wooded or grassy region.

Using This Issue . . .
(continued from page 2T)

that you are "hep" to the jargon?

● Your pupils might investigate the meanings of different colors and symbols on highway signs. Should such messages be "sent" in the same colors and symbols on the highways of every state?

The Language of Animals

Humans seem to be the only species of animal that communicates "unnecessary" information. Among other animals, messages usually have an effect on the survival of the individual. At first, the language of an animal may seem complicated. After study, however, the language can usually be broken down into a few simple messages. And these must be sent in the form of signals, for the animals other than humans cannot communicate in symbols, such as words and pictures.

To understand the language of an animal, an important first step is to determine what kinds of receptors it has and the range of their sensitivity. This is sometimes difficult, and biologists may have to depend on instruments that perceive things that humans can't detect. For example, bees see by ultraviolet light. We cannot, and so we don't see patterns of color on some flowers that lead bees to the proper place for pollination. Using special film, biologists can photograph flowers and then "see" what a bee sees. In the same way scientists have used special devices to record and study the high-frequency sounds of bats.

Activity

Have your students investigate the communications of some animals, such as the goldfish in an aquarium, birds at a feeder, pets at home, or animals in a zoo. A thorough study of an animal's "language" might take hundreds of hours, but something can be learned by a few hours of patient observation and note-taking.

References

● *Animal Behavior,* by Niko Tinbergen, LIFE Nature Library, Time, Inc., New York, 1965. $4.95.

● *Animals and Their Ways,* by J. D. Carthy, Natural History Press, Garden City, New York, 1965, $4.95.

Spreading the Word

This Wall Chart shows some of the ways that humans have invented to extend their communications beyond the limits of content, space, and time that help keep other animals from developing cultures of the kind man has produced.

The most important of these inventions are speech and writing—the use of sound and sight signals to represent things, actions, relationships, and ideas. These symbols—words and pictures—are used *in place of the things they represent* (or at least they should be used that way). And the symbols can be sent one inch or to the moon in the same instant.

But what makes these symbols most important is that they can bridge time as well as space. A human can tell his offspring all the things he has experienced; the children need not go through the same experiences to learn what he learned. Without symbols, no other animals can offer such a legacy to their offspring.

Discovering things yourself is a potent way of learning, but writing and pictures can tell you of thousands of years of discoveries—more than an individual could discover by himself in many lifetimes. The written record of the past sometimes ties us to the past and restrains us from changing our ways in a world that is constantly changing. But that record also enables us to keep building on the past, and from it,at an ever increasing rate.

These are some ideas you might discuss with your pupils.

What's in a Dot?

To carry the point of this article one step further, you could say that we see everything in dots of light, for the tiny rod and cone cells of our eyes change the light energy that reaches their tiny surfaces to electrical signals that carry the message to the brain.

Not all of the moon surface photos were sent back to earth in "dots," or on-and-off signals, of radio energy. Some were sent back by a continuous signal that varied in strength or frequency with the dark and light areas of the photo.

A message that might tell creatures (if any) on another planet something about earthlings might be sent out into space in dots of radio energy that could be recorded like this:

Messages from Strangers

This article suggests some ways for your pupils to investigate how they are affected by messages in newspapers, television, and other mass media. Self-studies cannot be considered very scientific, because there are too many factors that can't be controlled, and it is difficult to answer questions like those asked, even to yourself, without rationalizing. Still, your pupils may be able to get a better idea of how mass messages affect them in this way than by reading even a digested account of more scientific studies that have been made.

If this article helps to make your pupils aware of the strong influence that newspapers, magazines, books, radio, TV, and movies have on them, it will have served a useful purpose. If it helps them understand some of the ways this influence is exerted, that can be considered a bonus.

Brain-Boosters

Mystery Photo: Your pupils will probably have little difficulty recognizing this as an X-ray photo of a snake that has swallowed another animal. Ask them what clues there are for identifying the swallowed animal (a hamster). This is difficult, but the shape of the skull can at least identify the animal as a rodent.

Call your pupils' attention to the large size of the hamster relative to

(Continued on page 4T)

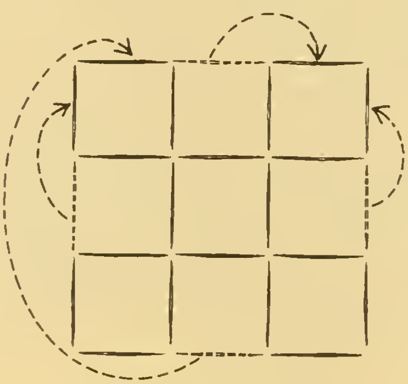
Using This Issue...
(continued from page 3T)

the snake's mouth, and see if they can guess how the snake could have swallowed the hamster whole, without breaking any of its bones. It is the stretching of elastic tissue connecting the two parts of a snake's lower jaw that allows the snake to swallow something larger than its own mouth.

What would happen if? The weight will not move at all when the rope is pulled down one foot . You could rig up the arrangement with spools and string to demonstrate this, and then ask how the system could be altered so that the weight would move when the string is pulled.

Can you do it? If your pupils have tried making and flying paper airplanes recently *(see "Build a Better Airplane,"* N&S, *Jan. 8, 1968),* they will know that it is extremely difficult to make a paper airplane that will glide for 10 seconds or more under ordinary conditions. But almost any paper airplane will stay aloft that long if it is launched from a high window.

Fun with numbers and shapes: Give out toothpicks so that your pupils can try this problem on their desk-tops. The solution:



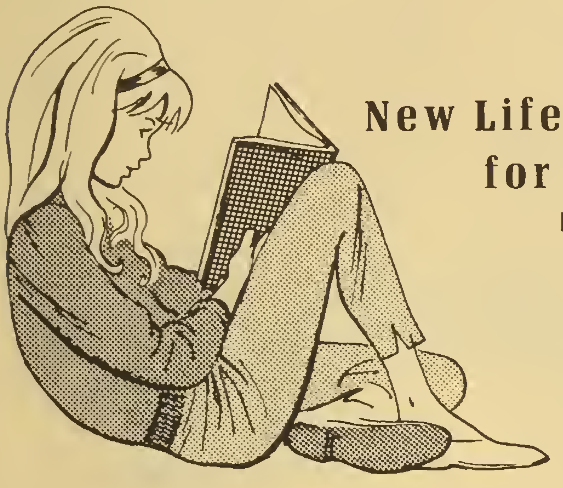
Have your pupils see whether they can devise similar problems with their toothpicks for their classmates to solve.

For science experts only: A strawberry has its seeds on the outside. You might ask other questions about seeds, such as: Can you think of some fruits that have only one seed? (Peach, apricot, avocado.) What fruits have seeds that we eat? (Stawberry, raspberry, banana.) What fruit has no seeds at all? (Hybrid, or *navel* orange.)

nature and science
TEACHER'S EDITION

VOL. 5 NO. 10 / FEBRUARY 5, 1968 / SECTION 1 OF TWO SECTIONS

◀ N&S REVIEWS ▶



New Life Science Books for Your Pupils

by Barbara Neill

How Animals Tell Time, by Millicent E. Selsam (William Morrow & Co., Inc., 94 pp., $2.95). We have learned that the earth's own rhythms of the seasons, the rhythms of days and nights, and of the tides and waves, often set the "clocks" of animals, but our knowledge of how and why is limited. How do birds know when to fly south? Why do oysters keep to the feeding schedule of high tide, even in an aquarium? Such questions are not easy to answer. Research has taught us a great deal and Mrs. Selsam explains clearly how some of the answers have been found. But the book is just as valuable for telling us how much we don't know. A thought provoking book for children 10-14. Bibliography and index.

Walt Disney's Worlds of Nature, by Rutherford Platt and the staff of the Walt Disney Studio (Golden Press, Inc., 176 pp., $4.95). A potpourri of material based on the True-Life Adventure series of movies. The subjects range from the Arctic to Africa with deserts, prairies, swamps, and fields of the United States between. There are one or two color photographs on every page; all are good and some are spectacular. The color reproduction varies, but this is to be expected in such a reasonably priced book. The text, though stressing the dramatic and rather given to unqualified (and therefore sometimes misleading) statements, does contain a great deal of information, and the writing is lively enough to engage the interest of children of sixth grade and up who might not otherwise read a natural history book.

The Story of Dogs, by Patricia Lauber (Random House, Inc., 64 pp., $1.95). Simply written but authentic and entertaining, this book will be enjoyed by children 8-12. The origin of dogs and the history of their life with mankind is well told. And there are several pages about heredity to explain the many types of dogs today. Brief foreword by Conrad Lorenz. Illustrated with black and white photos.

The Mighty Bears, by Robert M. McClung (Random House, Inc., 83 pp., $1.95). A good introduction to these popular animals, this book describes the various species of bears in this country

(Continued on page 3T)

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York.

IN THIS ISSUE

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

IN THE NEXT ISSUE

Raising and studying gerbils... A SCIENCE MYSTERY: Did ancient sailors map the Antarctic coastline? ... Biologist David Hancock continues his adventures with the bald eagles... Make your own batteries.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Flying with the Eagles

Your pupils will enjoy reading about the adventures of biologist David Hancock and his wife as they study bald eagles along the coast of British Columbia. As the author points out, eagles are plentiful in that area, and offer an opportunity for scientists to gather a lot of data. Remind your pupils of the importance of making a large number of observations before coming to a conclusion. A great deal can be learned by watching a single pair of eagles, but you can't conclude that your observations apply to eagles in general.

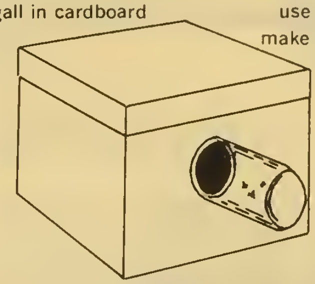
Have your pupils discuss how they can apply this rule to their own lives. Is it wise to look in several different newspapers and magazines to get different views on a subject? Is it possible that even this effort won't give you both sides of a story? Should a youth marry the first girl he dates, or goes steady with? Or should he "observe" a large sample of girls before deciding whom to marry?

Topic for Class Discussion

- *How abundant is the bald eagle throughout North America?* The bald eagle has declined seriously in many parts of the United States, especially in the northeast and Great Lakes areas. It is still plentiful in Alaska. The decline is probably caused by several things, including environmental pollution by biocides such as DDT. The threat of extinction to the American eagle will be covered in detail in the March 4 issue of *N&S*.

Plant Galls

The insects and other animals that come out of plant galls are attracted to light. You can take advantage of this characteristic by making an emergence cage like the one shown in the diagram.



The gall-causing animals illustrate the concept that *organisms are adapted to their environment.* Nearly all of these animals are *host-specific*—they live on a specific kind of plant and none other. Another example of their adaptations is the role played by the larvae of some insects in "preparing" for the emergence of the adult. The WALL CHART describes two species of insect where the larvae (with chewing mouthparts) cut an escape tunnel for the adults (which lack chewing mouthparts).

Frozen Laboratory

Antarctica lures scientists for many reasons. For one, the natural community of plants and animals there is simpler than in many other areas. For another, the Antarctic is the only place left on earth where humans have not drastically affected this community. Information acquired there doesn't apply only to Antarctica. Knowledge about the past climate of Antarctica, for example, may reveal something about the past climate over the rest of the earth.

Some scientists are concerned that the very efforts of man to learn about the fragile network of life in Antarctica may be doing serious damage to the plants and animals. Disposal of sewage, garbage, and other wastes is already altering the plant-animal communities near bases like McMurdo. Some countries have permitted dogs to roam freely from their research stations, raiding penguin colonies. As more and more people, including tourists, visit the Antarctic, the dangers of such damage will increase and the tremendous value of Antarctica as a unique laboratory may be lessened.

The "Law" of Pushing

There are countless ways to demonstrate that *to every action, there is an equal and opposite reaction.* Have your pupils try to think of more examples, such as: When you jump off a raft, it is pushed down into the water; a rotating lawn sprinkler is pushed around by the reaction to water pushing out of the spouts; when a gun is fired, its "kick," or *recoil*, is a reaction to the forward push the exploding powder gives the bullet. A jet engine draws air in at the front, squeezes the air and mixes kerosene into it. The mixture burns like a blowtorch, pushing out the back of the engine and pushing a jet plane forward.

Brain-Boosters

Mystery Photo: See whether anyone can guess that the photo is a "bulb's-eye-view" of a porcelain light socket.

You might sometime have your own Mystery Photo Contest in class. Pupils could try to identify photos that other pupils have taken, or cut out of magazines or newspapers.

What will happen if? Two ice cubes from the school refrigerator and two glasses, one empty and one filled with water, are all that are needed to set

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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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

nature and science

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When you give someone a push, do you expect to get pushed back?

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THE "LAW" OF PUSHING

Join a biologist and his wife in an airplane and go... Flying with the Eagles

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** Robert J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Nesta Paley • **CONSULTING EDITOR** Roy A. Gallant

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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, December through April; monthly September, November, May and July (July special issue) Second Class postage paid at Garden City N Y and at additional office

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flying with the EAGLES

PART 1

I have a job that lets me do the two things I like best—piloting an airplane, and studying the majestic bald eagle.

by David Hancock

■ Our helicopter made a short trip along the beach, then skimmed over the forest. Our goal was in sight. Perched 160 feet up a giant Douglas fir was a huge nest of a bald eagle.

At 100 yards we could see the female eagle in the nest. The distance shortened. Now we were just 50 feet away. The eagle still sat defiantly, her bright yellow eye glaring at us. She withstood three close passes of our noisy machine. On the fourth pass, I opened the window and shouted, "Hello there!"

That did it—off she flew. With my head stretched out the window, I just managed to get a glimpse of something white in the nest. While we circled to make another pass, the female returned to the nest. But this time she jumped to the edge of the nest, and we could still see the nest's center. There, cradled in a soft cup of moss and lichens, were three gleaming white eggs.

I was thrilled with the excitement of discovery. Finally, I had succeeded in finding a way to count the number of eggs in an eagle's nest.

An Eagle Named Venus

For the past four years I have studied bald eagles as part of my work for a degree in wildlife management at the University of British Columbia, in Vancouver. From past experience, particularly as a high school student who loved hiking and boating, I already knew that the southern British Columbia coast *(see map on page 5)* was the home of many bald eagles.

My interest in this majestic bird goes back 12 years. As a high school senior, I was interested in the sport of *falconry*—the training of meat-eating *(predatory)* birds to catch their prey for man. I had trained several smaller hawks, but always marveled at the sight of lofty eagles. I dreamed of some day being able to tame one. But such dreams seldom have a basis in common sense. Then one day, the opportunity came—I was given a young bald eagle just out of the nest.

She was a beautiful and spirited bird. I called her Venus, in honor of the Roman goddess of beauty. Her wing span was 7½ feet and she weighed nearly 12 pounds. I've never seen a larger eagle.

Like so many dreams, mine were based on fantasy or only on partial truth. I soon found that she weighed too much for me to carry her on my wrist, her temperament was unpredictable, and the strength of her talons was too

(Continued on the next page)

The author and his wife, Lyn, are using a float plane to fly near eagle nests and count the number of eggs or young. They may survey up to 400 eagle nests in one day.

great. However, I became so interested in Venus that I found all my spare moments were devoted to learning more about the lives of eagles.

The inspiration I got from watching the flight of eagles and hawks prompted me to try flying myself. I took flying lessons and received my private pilot's license in the 12th grade. Then I had a big decision to make: After high school, should I go to a university to become a wildlife biologist or should I become a commercial pilot and just study nature as a hobby? I chose the latter—at least temporarily. Then, after three years of flying, I went to the University of British Columbia to begin my studies. With the financial help of The American Museum of Natural History, the Canadian Audubon Society, the National Audubon Society, and the University of British Columbia, I have had the good fortune to be able to study my favorite bird, the bald eagle, using my favorite machine, an aircraft. Although I've had my aircraft burned, and once was stranded in an eagle's nest for nine hours, I wouldn't trade jobs with anyone.

Seeking Answers from the Air

When I gave up a flying career to enter the university, it wasn't because I didn't like flying. On the contrary, I enjoyed it so much that I had figured out how a career in wildlife biology could be aided by being able to fly. I knew I wanted to study bald eagles by using an aircraft. My flying experience told me that I could locate eagles, and their nests, from the air.

Since there were lots of eagles on the coast, I wanted to do what scientists call a population study. I wanted to observe the habits of many eagles to get a picture of what the whole population of eagles does.

For example, how many young are produced on the average in each nest? Where bald eagles are living in large numbers, how do they go about sharing or dividing up the available food? Do they defend large territories, as the mountain-dwelling golden eagles do? Just how large is their defended territory? Do all of the bald eagles eat the same things? Do the eagles eat different foods in different seasons?

These questions are better answered by studying many eagles rather than following the life of one pair. Nature is always so variable that if you studied just one pair, you would never know if they behaved like the majority, or were unusual.

In the same way, if you wanted to know how much time the average sixth grade student spends on homework each night, you wouldn't get a very good idea if you asked only one or two pupils. One student may not spend any time studying; another may spend several hours. To get an

average picture, you would have to question many students. The more you asked, the greater your accuracy.

Biologists who have studied eagles in other parts of North America have been faced with a lack of birds to study. Sometimes they could study just one pair of birds. In my research, however, I have been able to observe hundreds of eagles along thousands of miles of shoreline—from the state of Washington, up the British Columbia coast, to the Alaskan border.

A Survey Flight to Barkley Sound

There is nothing routine about our flying trips to study eagles. They are full of surprises and adventures. To give you an idea, here is the story of one of our flights up the British Columbia coast. We started from a lake by our home, near Victoria, British Columbia.

My wife, Lyn, finished packing the camping and food supplies into the plane as I put in the gas and oil. Then Lyn carefully placed four freshly baked cakes on top of the gear. The ropes were untied. At Lyn's "thumbs up" signal of OK, I pulled the starter and the float plane started to pull away from the dock. At the last instant, Lyn gave a goodbye smile to a friend who was filming our takeoff, and jumped from the dock to the aircraft. Once inside, she got the work maps ready while I checked the engine.

"All ready," Lyn signaled. We started taxiing along the surface. The water was glassy calm and our speed increased. I eased back on the stick but the plane didn't lift into the air. Then I tried lifting one float out of the water at a time. Still the craft wouldn't break free from the smooth surface of water. I made two circles on the water and then cut across my waves. Still we scooted along on the surface. We just didn't have enough lift. Back to the

From his home near Victoria, the author flies along most of the British Columbia coast, searching for eagle nests. The photo shows a small part of Barkley Sound, where about 170 pairs of eagles nest.

dock we taxied, a little embarrassed.

"That was a short trip. See many eagles?", our photographer friend greeted us. She was a little annoyed! She had taken a whole roll of movies of our taxiing and now had no film for the take-off.

There seemed to be only one thing to do. Reluctantly, we unloaded the four cakes from the plane.

That was just enough. Soon we were flying along the coastline, skimming 200 feet over the beach, next to the trees. We would be able to survey 100 miles of coastline for eagles on the way to Barkley Sound. After surveying the sound, we planned to spend a couple of weeks, as usual, studying the eagles' habits.

"One adult... two small downy young and adult by empty nest... immature flying... two adults above nest with one medium sized young." As I called out my observations of eagles, Lyn carefully recorded them on the maps.

"Adult on nest containing—oops the adult was standing in the way." I banked the aircraft tightly to the left for another look at the nest. This time I planned on putting the nest between the aircraft and the adult perched on the nest edge.

I sideslipped the aircraft within 50 feet of the huge nest. The female eagle stared hard at us as we passed by.

"Two, no *three* small downies," I yelled and Lyn smiled back her delight. "I'd better check again. This is most unusual."

I banked the aircraft steeply. Sure enough, there they were: three small eaglets, covered with downy gray feathers and about 10 days old. This was the first nest with three young in over 1,000 nests checked. Our previous flights had shown that about half the nests have only one young, 25 per cent of the nests have two young, and the remaining 25 per cent fail to produce any young.

After flying up the 100 miles of coast facing the open Pacific Ocean, we rounded Cape Beale and entered Barkley Sound *(see photo)*. Before us lay an eagle watcher's delight —nearly 200 islands and islets among which we had located 170 active nests. This maze of islands was also a nightmare. Somehow, I had to circle each island to locate all the eagles and check the content of each nest. Eagles were everywhere; I hardly stopped shouting out observations. However, my job of piloting the plane around the islands, trying to miss the trees and flying eagles (which paid no attention to our aircraft) and looking for eagles' nests was relatively simple. Lyn, on the other hand, had to keep looking out the window to keep track of where we were, then focus her eyes back on the map to record my observations. This continuous change of focus causes motion sickness. Only a person with a very "strong stomach" can stand more than an hour of this without becoming sick.

Whenever I took a man along as assistant, he usually got sick within two hours. Fortunately, women seem to have "stronger stomachs" than men. I usually tried to get a girl to be the recorder. One of these girls is now my wife, Lyn. I have often kidded her that the main reason I married her is that she was such a good assistant on her first flight (which was in very "rough" air).

"There's Lionel in the boat," Lyn shouted, pointing at a speedboat carrying our assistant, Lionel Hughes-Eames, toward the camp which was our headquarters. Soon after we landed Lionel showed us 25 bags of eagle food leftovers —old bones, feathers, rotting flesh. These would be added to nearly 200 more bags of these remains collected from in and below eagle nests. Later, during the winter, we would examine the leftovers in the university laboratory and try to learn more about what bald eagles eat.

When we first began studying eagle leftovers, it seemed that what we collected in and below nests was different from the foods we saw eagles actually catch and take to the nest. Because of this, we decided to make a more detailed study of the feeding habits of several pairs of eagles ■

In the next issue, David Hancock tells how he and his wife watched eagles feeding along the coast and rivers of British Columbia, and how he climbed the tall nest trees of the eagles.

WHAT'S NEW

By
Roger George

Bullheads use their noses to tell what's going on in the murky waters they live in. The bullhead (*see photo*) is a kind of catfish that is most active at night. If it meets two other bullheads, it can tell one from the other by odor, and can even smell whether one of them has won or

lost a fight. This was reported recently in the journal *Science* by Drs. John H. Todd, Jelle Atema, and John E. Bardach of the University of Michigan, in Ann Arbor.

Bullheads have harmless fights with each other to decide which will be the "boss" of a group. In experiments with yellow bullheads, the winner and loser of a fight were kept together in an aquarium. Then the winner was removed. The loser would then attack any bullhead put in the aquarium except the winner. It would even attack the winner if the winner had in the meantime lost a fight with another bullhead. Apparently something in a bullhead's odor signals its wins and losses.

The mightiest earthquake recorded in North America rocked Alaska in the spring of 1964. Ever since, scientists have been studying its effects. Recently the United States Government's Environmental Science Services Administration told how strong it was: Some Alaskan mountains were wrenched five feet to the side. Others sank seven feet. One section of ocean bottom rose 50 feet, and waves piled as high as 220 feet above sea level. Damages totaled $750 million, and 131 people lost their lives, mainly because of high water. Vibrations from the quake reached Atlantic City, New Jersey, more than 4,000 miles away. They were strong enough to shake water over the rim of a hotel swimming pool. Almost 24 hours after the quake, vibrations from it were detected in Antarctica, 8,445 miles away.

Can frogs learn? Simpler animals, such as worms, can. So you would think frogs could. But scientists have had trouble working out experiments that clearly answer this question. Fortunately, a suitable experiment has been suggested by the behavior of bullfrogs in a laboratory at Indiana University, in Bloomington.

As their daily feeding time approached, these frogs would gather in the part of their pen where they were fed. Noticing this, Dr. W. A. van Bergeijk changed the feeding time and area several times, and recorded what happened. In a week, the frogs would learn to gather in a new place at a new time. They even learned *not* to gather anywhere on weekends and holidays when they weren't fed at all. They must have learned that no people meant no food.

Green bread may seem strange to you, but children of the South Pacific island of New Guinea eat it and like it. What's more, it's good for them. The bread is green because there's grass in it. Grass is rich in protein, and many New Guinea children need more of this basic food in their diet.

In North America, we get much of the protein we need from meat, eggs, and cheese, but these foods aren't as plentiful in New Guinea. That's why scientists from nearby Australia recently developed the green bread. It's easy to make. Simple machines crush grass and remove its fibers. The grassy pulp is then mixed with bread dough.

Hitting a light pole at 50 miles an hour isn't as dangerous in the Minneapolis-St. Paul area of Minnesota as it is elsewhere. The state highway department has put up 2,000 special light poles there. These stainless steel poles are lightweight and are fastened down by rivets that give way when a pole is struck by a 2,000-pound car traveling at 20 miles an hour (*see photo*). In tests, cars hitting poles at 20 to 50 miles an hour were damaged only slightly. Drivers said the impact was "like hitting a shallow puddle of water on the highway."

This picture was taken right after a car struck a new type of light pole at 30 miles an hour. The pole bounced into the air and landed on the car top, but it was so light it made only a slight dent. The driver was able to keep the car under control.

What causes those odd-looking bulges on the leaves and twigs of trees and bushes? By collecting and keeping some, you can explore...

the mysterious world of plant GALLS

by Margaret J. Anderson

■ Lumps, bumps, and clumps—that's what most of them look like. They're called plant *galls,* and chances are you can find some in your neighborhood.

There are galls that look like flowers, cones, apples, and even little dunce-caps. Some are beautiful. Some are coarse and ugly. Some grow in complicated ways, while others are just blisters on leaves.

Winter is a good time to start looking for galls—they are easily seen on bare twigs. There are more than 1,500 kinds of galls in North America, so you shouldn't have much trouble finding some of them. (The drawings on pages 8 and 9 show some common kinds.)

What's Inside?

Once you find some galls, you will wonder: What caused them, and why? What's inside a gall? You can find the answer to that question with a sharp pocket knife, but your answer may be "nothing." Or, you may find a developing insect larva inside.

Most galls are caused by insects or mites, but these animals don't make the galls. The plant does that. The insect or mite causes the gall growth to start. Just how the gall does start isn't completely understood. It probably varies with different kinds of galls.

When an insect lays its egg in a leaf or other part of a plant, some chemical or mechanical damage makes the plant grow extra cells, and these form into the gall. The gall is a home for the insect that develops from the egg. The tissue of the gall is nourishing food for the insect. It seems that the gall insects have found an ideal way of life. But there are problems, even inside a gall.

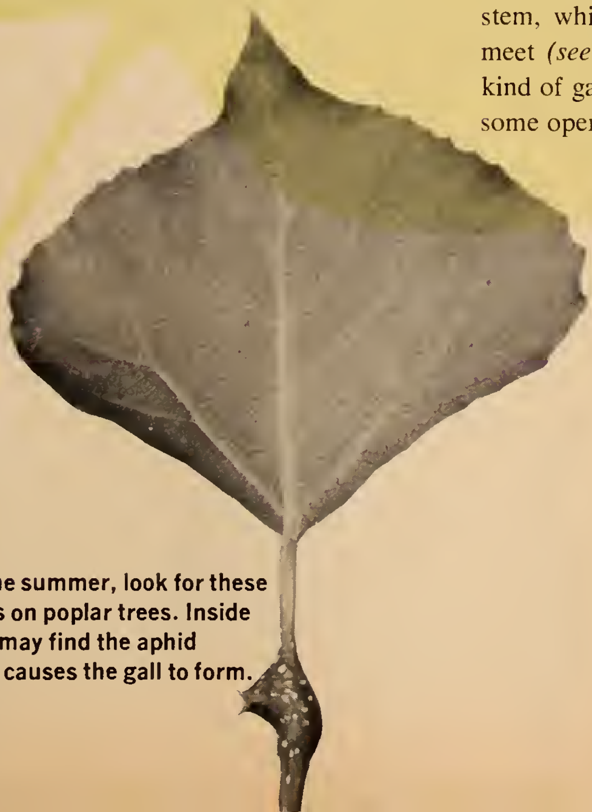
Other insects take advantage of the safe hiding place and move in. Some lay their eggs in, or on, the original larvae; and the larvae become food for the young insects that hatch from the eggs. Some insects cut their way into the gall and eat the eggs or larvae they find there. And some just move in and share the gall, eating the gall tissues.

This explains why you may discover several kinds of insects coming from one gall. Which one caused the gall? One way to solve this puzzle is to follow the development of a particular gall.

A Home for Aphids

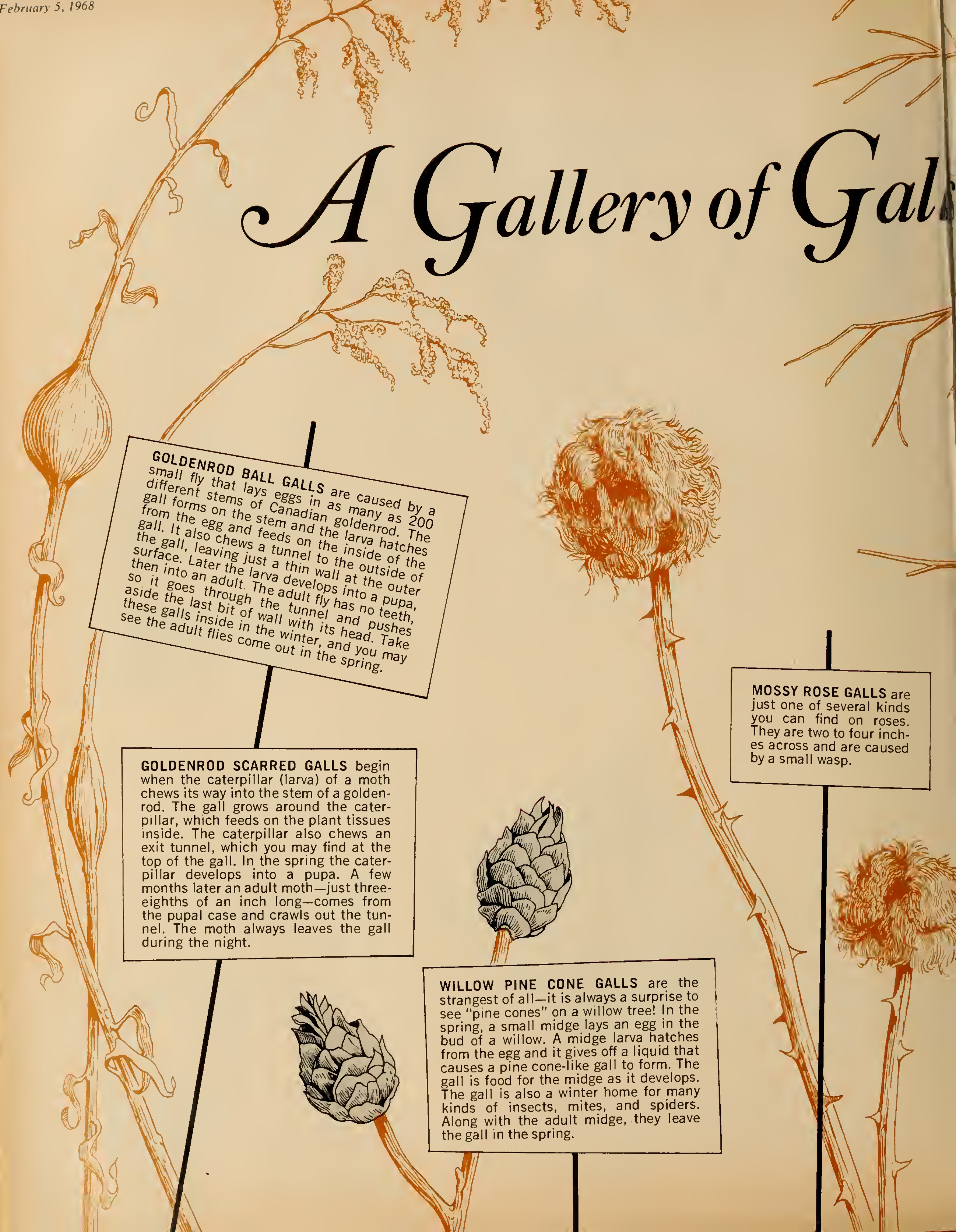
One gall to look for is quite common on poplar trees in the late spring. It is a pinkish swelling on the leaf stem, up to half an inch across, and is caused by an aphid called *Pemphigus.* There are different types of *Pemphigus* galls. One called the "purse gall" forms half way up the leaf stem, while another is formed where the leaf and stem meet *(see photos).* There are usually many of the same kind of gall on one tree. This gives you a chance to break some open and find out what's going on inside.

(Continued on page 10)



In the summer, look for these galls on poplar trees. Inside you may find the aphid that causes the gall to form.

A Gallery of Gal



GOLDENROD BALL GALLS are caused by a small fly that lays eggs in as many as 200 different stems of Canadian goldenrod. The gall forms on the stem and the larva hatches from the egg and feeds on the inside of the gall. It also chews a tunnel to the outside of the gall, leaving just a thin wall at the outer surface. Later the larva develops into a pupa, then into an adult. The adult fly has no teeth, so it goes through the tunnel and pushes aside the last bit of wall with its head. Take these galls inside in the winter, and you may see the adult flies come out in the spring.

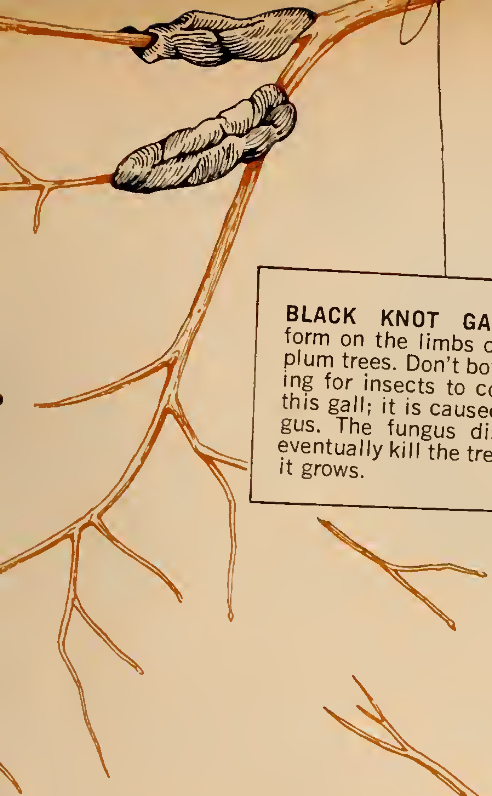
GOLDENROD SCARRED GALLS begin when the caterpillar (larva) of a moth chews its way into the stem of a goldenrod. The gall grows around the caterpillar, which feeds on the plant tissues inside. The caterpillar also chews an exit tunnel, which you may find at the top of the gall. In the spring the caterpillar develops into a pupa. A few months later an adult moth—just three-eighths of an inch long—comes from the pupal case and crawls out the tunnel. The moth always leaves the gall during the night.

MOSSY ROSE GALLS are just one of several kinds you can find on roses. They are two to four inches across and are caused by a small wasp.

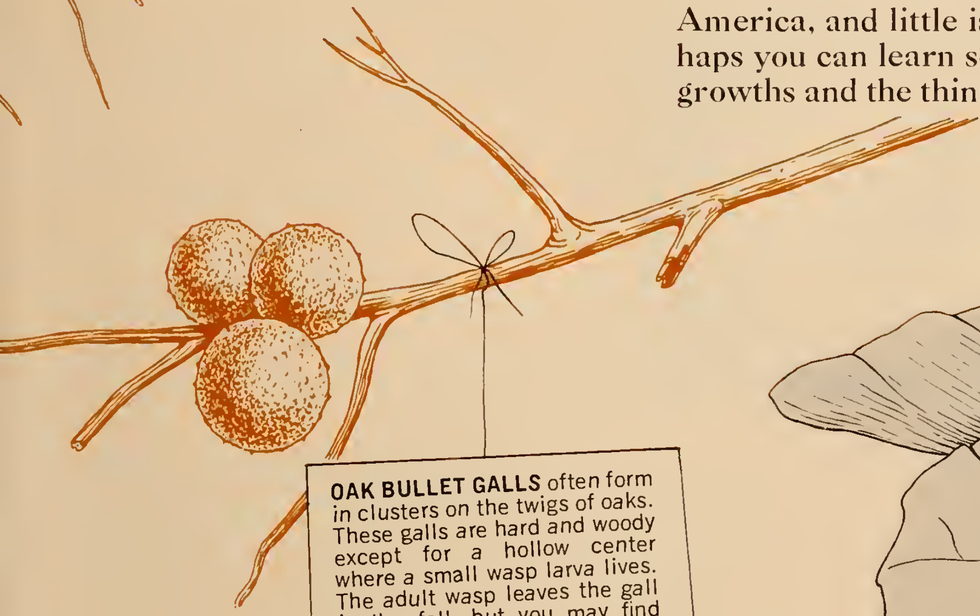
WILLOW PINE CONE GALLS are the strangest of all—it is always a surprise to see "pine cones" on a willow tree! In the spring, a small midge lays an egg in the bud of a willow. A midge larva hatches from the egg and it gives off a liquid that causes a pine cone-like gall to form. The gall is food for the midge as it develops. The gall is also a winter home for many kinds of insects, mites, and spiders. Along with the adult midge, they leave the gall in the spring.

■ There are many different kinds of plant galls, yet each one is different from the others. You can usually identify them by using such clues as their shape, the plant they grow on, and the part of the plant they grow on. The goldenrod ball gall, for example, is a ball-like swelling on the stem of the Canadian goldenrod plant. You won't find it on any other plant, not even on other kinds of goldenrod.

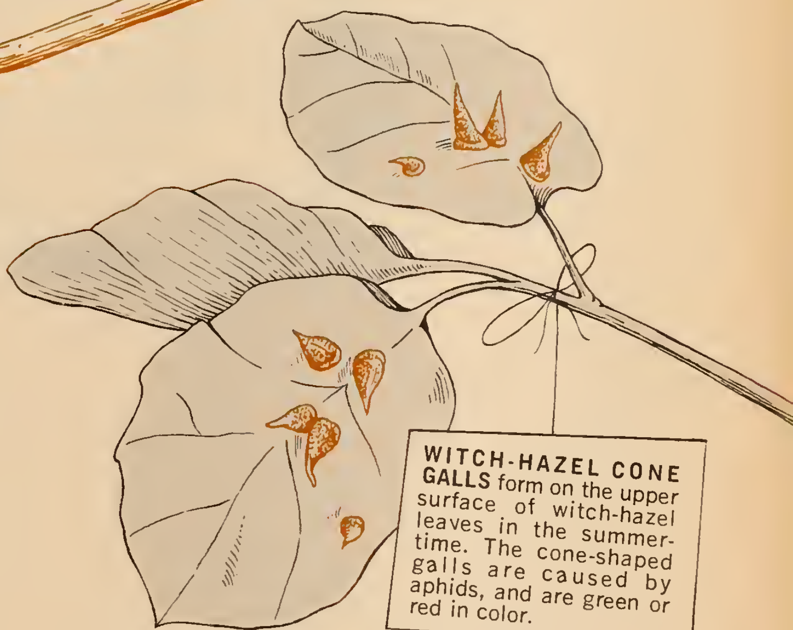
The drawings on these pages show some common kinds of galls. You can probably find some galls like them—as well as other kinds—in a nearby field, forest, or vacant lot. Look for a hole in the gall, a sign that the animal that caused the gall has already left. If you find no hole, collect the gall and watch to see what comes out (*see "Investigating Galls," page 10*). Try to identify the insect, mite, or other animal that comes out. There are more than 1,500 different kinds of galls in North America, and little is known about most of them. Perhaps you can learn something new about these strange growths and the things that cause them ■



BLACK KNOT GALLS often form on the limbs of cherry or plum trees. Don't bother watching for insects to come out of this gall; it is caused by a fungus. The fungus disease may eventually kill the tree on which it grows.

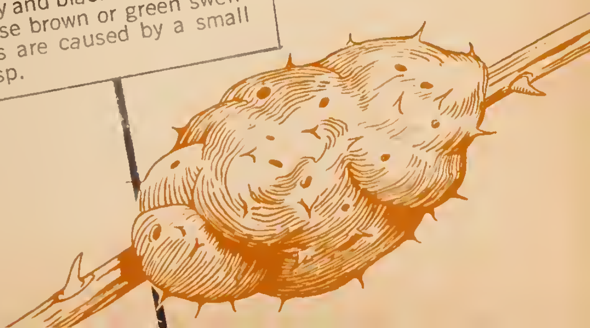


OAK BULLET GALLS often form in clusters on the twigs of oaks. These galls are hard and woody except for a hollow center where a small wasp larva lives. The adult wasp leaves the gall in the fall, but you may find other tiny animals living inside during the winter.



WITCH-HAZEL CONE GALLS form on the upper surface of witch-hazel leaves in the summertime. The cone-shaped galls are caused by aphids, and are green or red in color.

GRAPE TUBE GALLS form on grape leaves in the summer. Tiny midges develop inside the cone-shaped green or reddish galls.



RASPBERRY KNOT GALLS are one of several galls that grow on the stems of raspberry and blackberry bushes. These brown or green swellings are caused by a small wasp.

When you open the gall you will see a small colony of developing aphids. You should be able to spot the "stem mother." She is about five times bigger than the young aphids. It is the stem mother that causes the gall to start growing, and she produces the other aphids. If you break open a different gall every few days you will find them becoming more and more crowded as more young are produced.

Tie small muslin bags over a number of leaves with galls so that you can trap the winged aphids when they come out. How many aphids come out of a single gall? Over how many days or weeks do the aphids continue to emerge? Do the biggest galls produce the most aphids?

If few aphids come out of the gall, then cut it open and look for an insect that eats aphids. Inside the gall you'll also find the cast-off skins of aphids. The insects shed their skins five times as they grow, so there will be many skins inside the gall.

There is one insect, called the pirate bug, that eats *Pemphigus* aphids. It goes into the gall and releases a chemical that kills the aphids. Then it eats them. Within the gall you may find other insects which do not eat aphids but are attracted by the sweet, sticky, honey-dew that the aphids give off.

After the aphids emerge from the gall they fly away and find another plant home. The purse gall aphid settles upon the roots of lettuce and goes on producing young for the rest of the summer. Then the females return to poplar trees. Each lays one egg which develops into the stem mother the following spring.

"Apples" on Oak Trees?

One of the most common galls is the "oak apple" *(see diagram)*. There are actually many kinds of oak apples and they are all caused by small wasps. The wasp lays its egg on the end bud of an oak twig in late winter or early spring. Then, early in May, a gall starts to form. It grows very quickly. The adult wasps come out in July.

The next step in the story of these gall wasps is a strange one. The female lays its egg on the oak leaves, twigs, or roots (depending on the kind of wasp), and galls form. But these galls are not oak apples, and the adult wasp that finally emerges is quite different from its parents. It is so different that sometimes it has been given a different name by mistake. This wasp crawls to oak buds during the late winter or early spring and lays its eggs. This causes the oak apples to form again.

In the life of this wasp, the "parents" and the "grandchildren" are alike, living in oak apples in early summer. The "children" and "great-grandchildren" are alike, causing galls which last through fall and winter.

The oak apple gall looks like a small, brown apple on an oak tree. A small wasp develops inside and comes out in the summer.

So, if you follow the development of an oak apple from May through July, you know only half of the story. To find the other gall requires good detective work and some luck, too.

There are still many mysteries surrounding plant galls and their causes. This makes the study of galls difficult but exciting ■

For help in identifying plant galls and their causes, see pages 8 and 9, and look in your library or bookstore for: **Field Book of Insects**, by Frank Lutz, G. P. Putnam's Sons, New York, 1948, $4.50; **Plant Galls and Gall Makers** by E. P. Felt, Comstock Publishing Co. Ithaca, N.Y., 1940 (out of print).

Investigating Galls

Late winter or early spring is a good time to collect some galls and see what is living inside. Try to get several different kinds of galls and put them in jars or plastic containers. Have a separate container for each gall, or you will not know for sure which gall and animal go together. Don't collect galls that have holes in them where the insects may already have escaped.

Put a layer of soil in the bottom of the container (some insects leave the gall and live in the soil for a time before becoming adults). Keep the container moist by wetting the soil or by including a damp piece of paper towel. Also, don't put the container in direct sunlight or too near a radiator. Cover the top of the container with a piece of cheesecloth held by a rubberband.

Remember, not all galls are caused by insects. Some are caused by mites, worms called *nematodes*, or fungi. The best way to find out if a gall contains an insect is to wait and see.

brain boosters

prepared by DAVID WEBSTER

Fun with numbers and shapes

About how many people live here?

2,000
20,000
200,000

Can you do it?

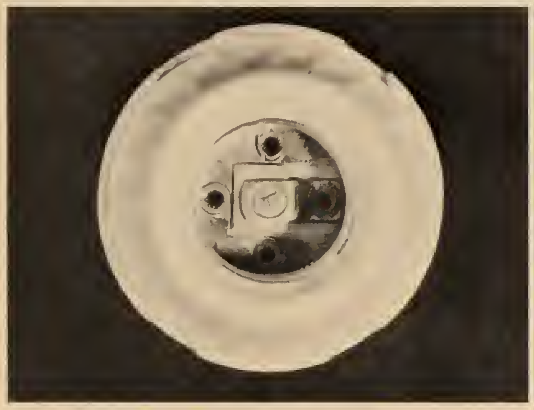
What could you use to find out if your bedroom window is higher or lower than a window in the house next door?

What will happen if...

...you put one ice cube in a glass of cold water and another ice cube in an empty glass? Which ice cube will melt first?

For science experts only

If you were on the moon, in what phase would the earth appear when the moon is full?



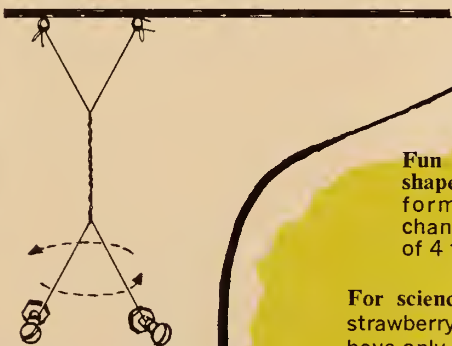
Mystery Photo

What is it?

Idea submitted by Mark Grinnell, Cleveland, Ohio

Just for fun

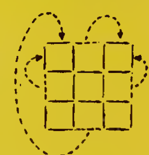
Hang two weights on strings and start them swinging around one another. How long will the weights keep winding up and unwinding?



CORRECTION! If a wet washcloth moves a door more than a ball of equal weight moves it when both strike the door with the same force (*see "Brain-Booster Answers,"* N&S, *November 13, 1967*), it is probably because the washcloth and the ball did not strike the door in the same spot. Several readers have pointed out that the ball-door collision is an *elastic*, or "bouncing" collision, which produces a different effect from a *non-elastic* collision because the ball is moving backward after the collision.

ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

Fun with numbers and shapes: Here is how to form 5 squares by changing the position of 4 toothpicks.



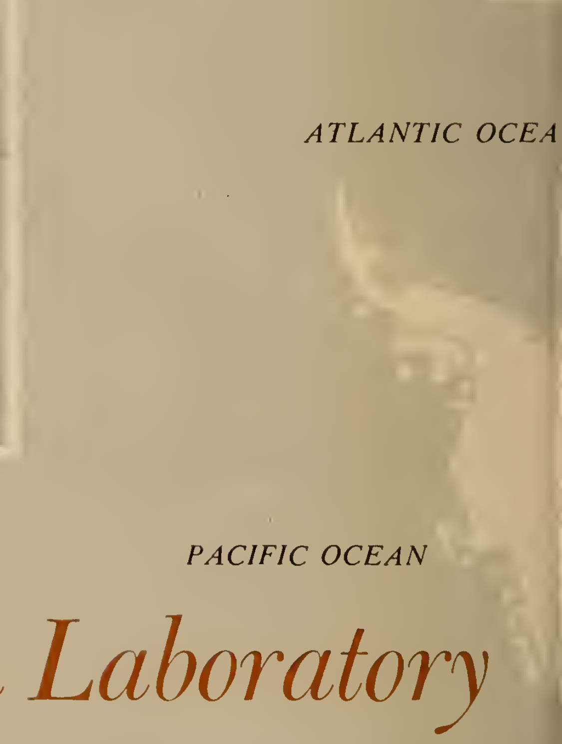
For science experts only: The seeds of a strawberry are on the outside. What fruits have only one seed?

Mystery Photo: The Mystery Photo is an X-ray of a snake that has just swallowed a hamster. Did the snake break any of the hamster's bones?

Can you do it? One of the easiest ways to make a paper airplane glide for 10 seconds is to throw it from a high window.

What would happen if? If the rope in the pulley arrangement were pulled down 1 foot, the weight would not move at all. What *would* move?

Traveling across 1,200 miles of ice this summer, 10 explorer scientists are measuring the thickness of the ice (by setting off an explosion and timing the return of its echoes from the rocks under the ice); measuring how fast the ice is flowing toward the Antarctic coasts; and examining the structure of ice crystals found in different places. The scientists travel in "sno-cats," tractors with large rubber tires in which gasoline is stored.



The World's Largest Frozen Laboratory

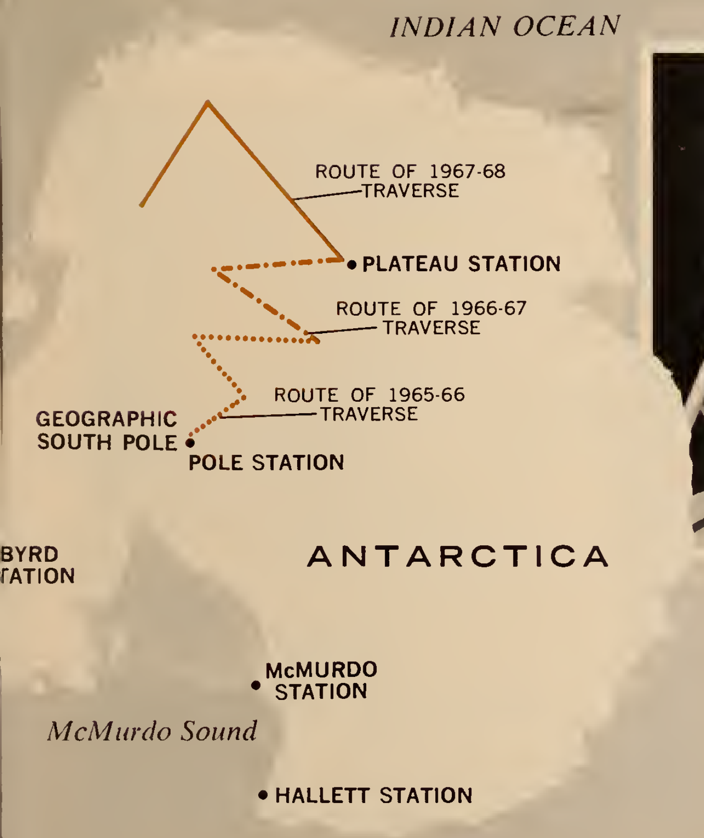
■ Imagine a mass of land bigger than the United States that is almost entirely covered with ice. This is the continent of Antarctica. When it is winter in the northern hemisphere, it is summer in Antarctica. Even in summer, however, it is very cold there. The summer temperatures range from 45 degrees above zero to 70 degrees below zero Fahrenheit. Scientists have found Antarctica an ideal place to study how living and non-living things change in a place that is cold throughout the year—a place that has so far been changed but little by humans.

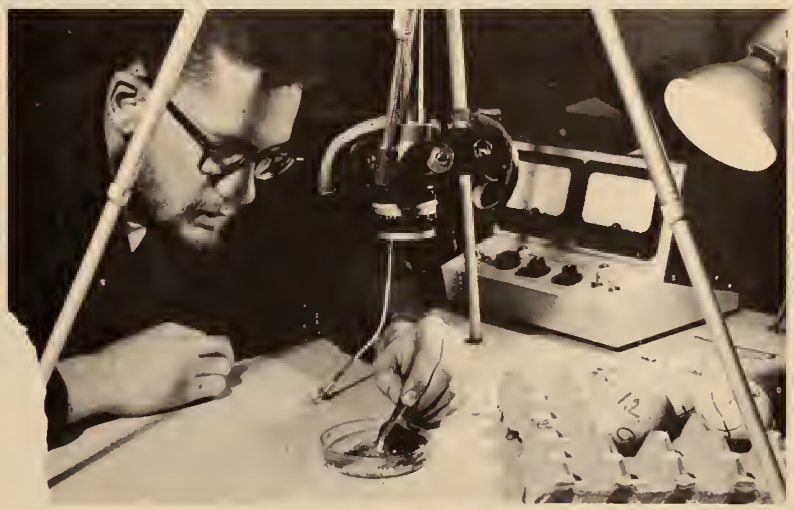
Each summer in the past 10 years, several hundred scientists have joined the U.S. Antarctic Research Program (which is sponsored by the National Science Foundation), and spent October through February doing research in Antarctica. Scientists from New Zealand and the Soviet Union are working with the U.S. scientists in a few of the 60 studies scheduled to be made before winter closes in later this month.

One of the most ambitious projects is to drill a hole 8,000 feet down through the great ice sheet that covers nine-tenths of the continent. When it is completed it will be the deepest hole ever drilled through ice. As samples of the ice at different levels are brought up in the drill *(see photo right)*, scientists study them for clues to weather conditions in the past. Anthony J. Gow, a geologist with the U.S. Army Cold Regions Research and Engineering Laboratory, at Hanover, New Hampshire, believes that he may be able to find out from these samples of ice what the earth's climate was like 30,000 years ago. Information like this might help explain the growth and shrinking of the huge ice sheets that covered much of North America four times in the past million or so years.

The photographs on this and the following pages show some of the ways that scientists are finding out more about the past and present in the world's largest frozen laboratory. BENEDICT A. LEERBURGER, JR.

Richard Peterson, a biologist from Johns Hopkins University in Baltimore, records numbers painted on the breasts and flippers of Adelie penguins so that scientists can tell one bird from another. An adult penguin, however, can recognize its own offspring among a thousand nesting chicks. Scientists at Hallett Station (see *map*) record the chirps of penguin chicks to find out if their parents recognize them by sound, and deafen some parent penguins to find out if they can recognize their offspring by sight alone.





In the biology laboratory at McMurdo Station (see *map*), a three-day-old penguin embryo is dissected by Richard Allison, a graduate student in biology from the University of California, at Davis. He is studying the pre-hatching development of these Antarctic birds.

In a tunnel 40 feet below the surface of the ice at the U.S. Byrd Station (see *map*), two scientists prepare to take a core, or cylinder of ice, out of a drill bit. This sample came from several thousand feet below the surface of the ice cap and was formed of snow that fell more than 2,000 years ago. By studying such cores, the scientists expect to find out such things as: how much snow fell at different times; whether the ice cap was growing or shrinking; how the temperature of the air varied with the seasons at different times; and how much "space dust" (tiny meteorites) fell at different times.

(Continued on the next page)

By collecting samples of ice and melt water from a glacier and finding out what is in the samples, Dr. Carl Bowser (left) and Dr. Robert F. Black, of the University of Wisconsin, in Madison, hope to learn whether the glacier is advancing or retreating. Antarctica has more fresh water, in the form of ice, than any other continent. The water tied up in Antarctica's ice is equal to the water in the North Atlantic Ocean. →

Whales swimming in a channel cut through the sea ice of McMurdo Sound by an icebreaker ship are observed by biologist Arthur L. DeVries, of Stanford University, in Palo Alto, California. The coastal waters of Antarctica are rich in the tiny sea animals (especially shrimp-like *krill*) and plants that whales eat, and scientists are studying the effects of these mammals on their plentiful food supply. ↓

↑ A *microclimate*, or climate of a tiny area, where insects called springtails live under rocks in ice-free areas of Antarctica is being measured by Kelly Rennell (left) and Keith Wise, insect experts from the Bishop Museum, in Hawaii. They are trying to find out how small insects survive in the intense cold. Tiny plants "sleep" through winter temperatures of —40° F. a foot below the surface of the volcanic soil. They come to life only in summer when melt water from the glaciers raises the ground temperature.

← A scuba diver prepares to go down through 16 feet of ice into the crystal-clear waters of McMurdo Sound (see *map on page 13*). The temperature of the salty water is about 29°F., but his insulated rubber suit allows the diver to work in the cold water from 60 to 90 minutes. In summer, these coastal waters are one of the world's richest areas of marine life. The divers placed cages around some areas at the bottom to find out what happens to plants and animals there when they are protected from predators, such as seals and fish.

When someone gives you a push, do you always push back? Whatever your answer may be, you'd better find out about...

THE "LAW" OF *PUSHING*

BY ROBERT GARDNER

■ If you push someone and he pushes you back, it's probably not much of a surprise to you. Would you believe, though, that when you push *anything*—even a lamp post—it pushes you right back?

Your push probably won't move the lamp post, and its push may not move you, but if you push the post by running into it, it may push part of you hard enough to raise a bump. You might think that the return push from someone you have pushed is an attempt to "get back" at you—and that might be partly true. You might even "accuse" the post of trying to "get revenge" for your push. Since the post isn't a living thing, and can't think or feel, that doesn't make much sense. The fact is that anything you push will push you back. It's a "law" that no one or no thing can "break."

Testing the "Law"

The next time you are ice skating or roller skating with a friend, ask him to help you test this "law." Stand behind him and tell him you are going to give him a push. Tell him to try *not* to push back. (He can perform the same test on you next.) Now place your hands at his waist and give him a slight push *(see diagram)*. Who moves? Does the same thing happen when he gives you a push? Find out what happens if you give a post or a fence a push, instead of your friend on skates.

The idea that when something pushes on another object the second object pushes back was developed by the famous British physicist, Sir Isaac Newton, about 300 years ago. This idea is often called Newton's *Third Law of Motion*. You can see it in action when you are pushing or being pushed. What if you are not involved in the pushing?

The friend you pushed on skates probably weighed about the same as you. What would happen if you had pushed someone much heavier or lighter than you? You could try it and see, or you might investigate this way:

Get two toy cars or trucks that are about the same size and weight (two of the same kind would be best). Tape a spring-type clothespin to one truck *(see diagram)*, and tie the ends of the clothespin together with string to hold the jaws of the pin open, so that the spring is stretched.

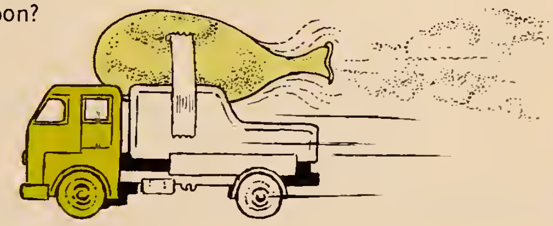
(Continued on the next page)

PROJECT

Blow up a balloon, then let go of it. Can you explain its motion? To see more clearly what is happening, push a long piece of thread or string through a soda straw and tie one end to a hook or doorknob *(see diagram)*. Next, blow up a balloon and attach it to the straw with sticky tape, as shown. Stretch the string out straight and release the balloon with its "mouth" open.

You can see the balloon get smaller as it pushes the air out. Does the air push back on the balloon? How can you tell?

Attach a blown-up balloon to a toy car, as shown in the diagram, and release the neck of the balloon to let the air escape. How does the speed of the car compare with the speed of the air coming out of the balloon?



Place the trucks nose-to-nose, and snip the string with scissors. What happens when the clothespin spring is released? How far does each of the trucks move? Could you say something now about how the push in one direction compares with the push in the other direction?

Find out what will happen if one of the trucks is heavier than the other. (You might fill one with sand, pebbles, or washers, for example.) Which truck travels farther when you release the clothespin spring? Can you tell which truck moves faster? Does it make any difference which truck the clothespin is attached to?

Suppose you replace one truck with something much heavier, say the earth. A wall is attached to a house, which is imbedded in the earth, so you might place the truck with the clothespin (spring stretched) against a wall and snip the string. How does adding weights to the truck change what happens when it pushes against the wall?

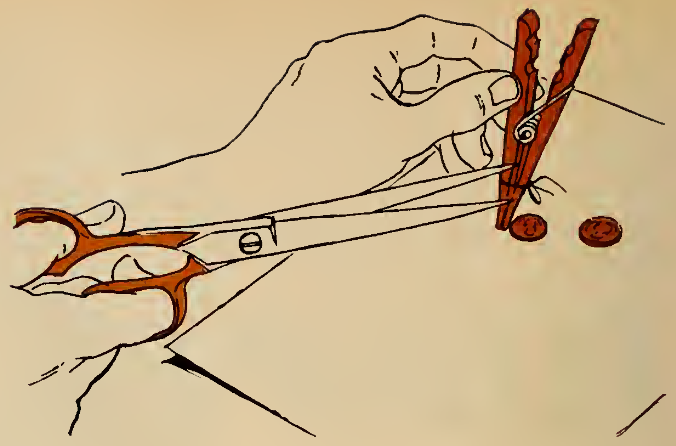
Investigating Collisions

Can you predict what will happen if you give the truck with the clothespin (spring *un*stretched) a push that makes it bump into the other truck? Try to guess how the

push given by the moving truck will affect the one at rest, and what the push given by the truck at rest will do to the moving one.

What will happen if one truck is heavier than the other? Does it make any difference whether it is the moving truck or the stationary one that is heavier? Find out what happens when the moving truck collides with the wall, instead of with an object that can move. *(See "Hitting a light pole," in "What's New?", page 11.)* Can you explain why some automobiles are now made with bumpers of rubber or plastic, and why some cars are being made so that the front of the car will fold up like an accordion bellows when it receives a stiff push? *(See "Crash," in "What's New?",* N&S, *November 13, 1967.)*

You can make similar tests using a dime, penny, nickel, and quarter for "trucks" of different weight. Place a dime and a quarter about an inch apart on a piece of smooth

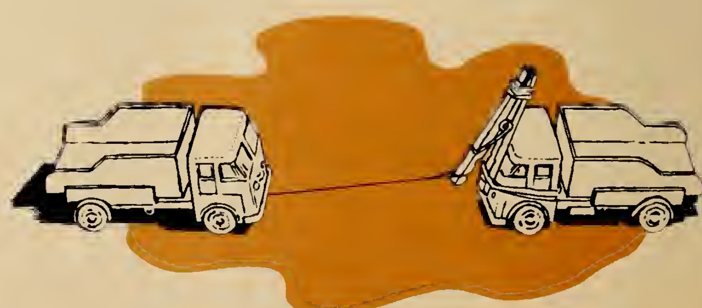


paper and draw a circle around each to mark its starting position. Hold a tied clothespin beside the dime as shown in the diagram and snip the string (this provides an equal push for each test). Measure how far the coins move after the dime strikes the quarter—and which direction. Try pushing the quarter against the dime. What happens if you shoot a dime at a half dollar, or something even heavier?

Walking, Running, and Pulling

To walk or run, you have to push your feet against the earth, which pushes you in the opposite direction *(see diagram).* Do you think that your push moves the earth? Why? What happens when you step onto a dock from a small boat that is not tied or held to the dock? Or when you try to run in soft sand or loose gravel? (If you don't know, try it and see.)

Do you think that Newton's Third Law of Motion applies to pulling as well as to pushing? To find out, attach a spring clothespin to one truck with the jaws down. Tie the jaws open, and attach a short piece of string from the forward jaw to the other truck *(see diagram).* What will the two trucks do when you snip the string to release the clothespin spring? ■



Using This Issue...
(continued from page 2T)

up this investigation. After each pupil has guessed at which cube will melt first, go on to other things while waiting to see. It will take some time before either one melts.

Since air is a very poor conductor of heat, it will tend to insulate the ice and keep it for a much longer time than the water—even cold water—will. Water is capable of conducting a considerable amount of heat.

Can you do it? A simple leveling device consisting entirely of a glass of water can be used to see whether a window next door is higher than your own. Simply place the glass on the window sill and sight over the top of the water. This will work even if the sill is not level, since the water is "self-leveling."

Mountain climbers carry a small level so they can see whether they have reached the highest peak on a mountain.

Fun with numbers and shapes: First let your pupils guess roughly at how many people live in the section of the city shown in the aerial photograph; then ask them to count the number of houses and guess at the average number of people living in each one. You might then show them how they could estimate the number of houses by dividing the photo into 16 or 20 equal spaces, counting the number of houses in one space, and then multiplying.

Since the photo shows about 200 of what are probably small apartment buildings, each housing two or three families (or 10 to 15 people), there are probably 2,000 to 3,000 people living in that section of the city.

Show your pupils how other kinds of large numbers can be approximated by sampling techniques *(see "Quick Counting,"* N&S, *Sept. 19, 1966)*. Emphasize that an exact count is often neither possible nor necessary.

For science experts only: When a full moon is seen from earth, an observer on the moon would see a "new earth." *(See moon cycle diagram in "Keeping Track of the Year,"* N&S, *Jan. 8, 1968.)*

Encourage the children to look for the moon continuously over a period of several months. How do its shape and position change from day to day? Can it ever be seen during the day?

Just for fun: If you set up this demonstration, your pupils will see that the weights keep winding and unwinding for a long time. What would happen if you used two heavier weights? Two objects of different weights? Two strings of different lengths?

ABOUT THE CORRECTION in this issue (page 11) to a Brain-Booster answer in *N&S*, Nov. 13, 1967: The difference in results of an *elastic* and a *non-elastic* collision is too complex to present in the students' edition. Here, however, is what happens. When one object collides with another, the total *momentum* (mass *x* velocity) of the system must be the same before and after the collision.

When a washcloth with a momentum (mv_1) of 2 collides with a heavy door whose momentum (MV_1) is zero, the resulting momentum of the washcloth (mv_2) is zero, so the momentum (MV_2) of the door must be 2. In an elastic collision, however, between a ball with a momentum (mv_1) of 2 and a heavy door with a momentum (MV_1) of zero, the resulting momentum (mv_2) of the ball is nearly -2, since it is moving in the reverse direction with almost the same speed it had before it hit the door. To conserve the momentum in the system, the resulting momentum (MV_2) of the door must then be 4 ($-2 + 4 = 2$).

N&S REVIEWS...
(continued from page 1T)

and contains a chapter on bears of other lands. Habits of bears are told in a story about twin cubs. The author points out the changing status of bears and their dwindling numbers in many places. A most readable book for ages 10 and up. Black and white photos. Indexed.

The Life of the Kangaroo, by Stanley and Kay Breeden (Taplinger Publishing Co., Inc., 80 pp., $4.95). This book, with a large format, lives up to the promise of its strikingly handsome dust jacket. Filled with many large and unusual photographs of kangaroos, it also contains a text which is entertaining and highly informative. The authors spent months on Bribie Island off the Queensland coast of Australia. Here they came to know a number of grey kangaroos well enough to give them names. In addition they have thoroughly researched their subject, so that they provide a wealth of material hard to find elsewhere. It is too bad there is no index. For upper elementary grades.

Wonders of the Monkey World, by Jacquelyn Berrill (Dodd, Mead & Co., 88 pp., $3). This book tells children something about monkeys in their natural world high up in the rain forest trees, far from the zoos where children usually picture them. There are sections on old-world monkeys, new-world monkeys, pre-monkeys, and the great apes. There is information about the behavior of those monkeys and their relatives which have been studied in the field, such as the Japanese monkey, gorilla, and the baboon. The book is indexed and there are striking black and white drawings by the author. Children 8-12 should enjoy it.

Black Jack, by Robert M. McClung (William Morrow & Co., Inc., 64 pp., $2.95). The Okefenokee Swamp is the home of the alligator, Black Jack. The author shows how he fits into the swamp world of cypress trees, egrets, and water moccasins. A great deal of information about alligators, all of it interesting and accurate, is brought into this story of the last of the big ones. The alligator's narrow escapes from poachers are a reminder that they continue to threaten all alligators. This is an easy-to-read book with many excellent illustrations for children 8-12.

Bears Around the World, by Phyllis Osteen (Coward McCann, Inc., 256 pp., $3.49). Anyone looking for information concerning bears, especially about their habits and their relationships with man, will find this a useful book. The author has diligently searched out facts from every possible source. There is a good index and bibliography, fortunately, for this is mainly a research book for the junior high age. Since the prose tends to be a parade of short sentences stating facts, it is not a book many will read all the way through for pleasure. Illustrated with black and white photos.

Fish Hawk, by John Kaufmann (William Morrow & Co., Inc., 64 pp., $2.95). The osprey is presented here as a highly specialized bird that has followed its present way of life for centuries. Its remarkable eyes, its perfectly designed wings, and its feet, so efficient for catching fish, are described and illustrated with the author's clear drawings. It is a matter of concern that the bird is rapidly declining

(Continued on page 4T)

(continued from page 3T)

due to the cumulative effects of DDT; as the author says, "Everyone should see a fish hawk for himself." A factual book containing accurate information with a vocabulary suitable for children 8-12.

Milkweed, by Millicent E. Selsam (William Morrow & Co., Inc., 48 pp., $3.95). This is a deceptively simple book. With its large, handsome photographs on every page, six in color, it seems mainly a picture book, but it is much more than that. With the author's gift for explaining things to children, the short text tells how a milkweed plant grows and blossoms, and how its seeds develop. Since the milkweed has a most involved method of pollination, making this procedure clear to children 7-10 is an accomplishment. And it should stimulate children to observe plants on their own.

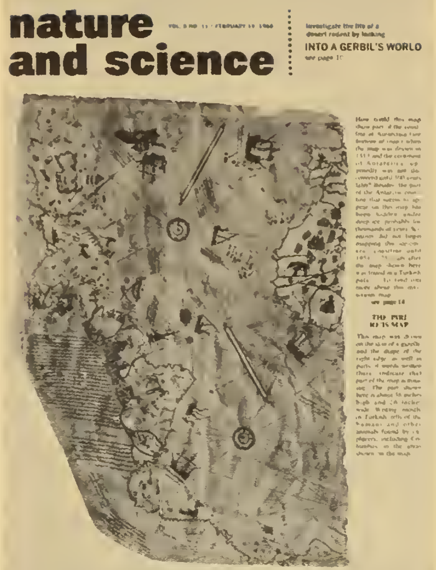
Diving Birds, by Charles L. Ripper (William Morrow & Co., Inc., 64 pp., $2.95). Four species of loons, six species of grebes, four cormorants, and one anhinga are described in this book, several pages being devoted to each, field-guide fashion. The text is accurate, and so are the author's many drawings which are attractive and helpful. The format with its large print suggests a book for the primary grades. The jacket says eight to twelve. However, phrases like, "an accumulation of vegetation," and " distribution is widespread," would make reading difficult for a third grader.

Pond Life, by George K. Reid and Herbert S. Zim (Golden Press, Inc., 160 pp, $1—paperback ed.). Here is another in the Golden Nature Guide series. This subject is difficult because pond life is not only varied, but much of it is small, unfamiliar, and has no common name. One-celled animals, copepods, algae, and diatoms are covered, as well as a great variety of larger plants and animals. The book is surprisingly comprehensive; for example, five species of crayfish are illustrated, 38 species of birds, and 10 snails; there are two pages of sedges and two of ferns. The first 26 pages are devoted to the ecology of ponds and lakes. There is information on observing and collecting, and there is a bibliography and index. Altogether a most attractive and thorough little field guide. Since it was not written especially for children, probably best suited for good readers age 10 and up.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 11 / FEBRUARY 19, 1968 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

"Canned" Electricity

This article introduces your pupils to the concept that an electric current is made up of moving electrical charges; describes how a dry cell produces a current; and shows your pupils how to investigate the use of different materials to make cells that produce electric current.

In the next issue, a SCIENCE WORKSHOP article will explore electrical circuits and conductivity of different materials. A subsequent issue will tell (with projects for your pupils) how the use of magnets to make electric current and put it to work was discovered; a WALL CHART will show how light, radio, and other forms of radiant energy are carried by electromagnetic waves.

Suggestions for Classroom Use

In studying Diagram 4, page 3, your pupils may get the idea that electrons flow through metal much like water flowing through a pipe. Scientists believe they move more like water in buckets being passed along a line of people from hand to hand. For example, in a dry cell when an extra electron is left on an atom of zinc it pushes another one of that atom's electrons along to the next atom, and so on through the zinc, the copper wire, a light bulb, more wire, and back through the carbon rod to the paste in the cell.

Your pupils can find many other materials (solids and liquids) that can be used in different combinations to make "wet" cells. In addition to materials suggested in the Investigation, have them try other fruits and vegetables in place of the lemon; other metals (tin, gold, lead, etc.) and materials such as wood, plastic, glass, and so on; and other liquids (detergents, mouthwash, sugar water, water with more or less salt dissolved in it, and so on).

The earphone suggested for detecting weak currents can be the type that you push into your ear (it can be just held near the ear) or the type used by radio repair men or "ham" radio operators. The rod at the end of the "jack" that plugs into a radio is in two parts, one part connected to each wire of the earphone.

In testing cells, wrap the end of one wire from the cell around one part of the jack rod and touch the end of the other wire from the cell repeatedly to the other part of the jack rod. Test this arrangement first with a dry cell—holding the earphone *near* to your ear.

Activities

• Have your pupils make a cell using a penny, a dime, a small piece of paper towel, and some water with salt dissolved in it. Place the penny over the end of a piece of copper wire, paper towel soaked in salt water on top of the penny, a dime on top of the paper, and tape the end of a copper wire to the dime. Also, try using an iron washer in place of the dime.

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by •, see pages 1T-4T.)

• "Canned" Electricity
Your pupils can find out how a dry cell produces electric current and try making electric cells of various common materials.

• I Climb to Eagles' Nests
In Part 2 of this SCIENCE ADVENTURE, biologist David Hancock tells of his observations of eagles' food-getting and how he climbs to nests in order to band young eagles.

• The Cells in Your Body
A WALL CHART shows several of the different kinds of cells in the human body and tells of the "jobs" of the cells.

• Into a Gerbil's World
How to get, care for, and study gerbils, desert rodents that are newly popular as pets and classroom animals.

Brain-Boosters Contest Winners

The Piri Re'is Map
A history professor tries to unravel the mystery of a map drawn in 1513 that seems to show part of Antarctica—which was supposedly not discovered until much later.

IN THE NEXT ISSUE

Digging for remains of the Northwest Coast Indians' early culture... SCIENCE WORKSHOPS: Electrical circuits, Measuring sap pressure in plants... More adventures with eagles.

Using This Issue...
(continued from page 1T)

• Have your pupils connect a dry cell to a bulb and find out how long it will produce current. After the light goes off, disconnect the cell and let it "rest" for a while. Will it produce current again? For how long? Will a dry cell light a bulb longer if you keep it connected or if you give the cell frequent periods of "rest"?

• Does a cell made with, say, salt water produce a stronger current if the water is warm or cold? (You can detect the strength of the current by the loudness of the sound when you test the cell with an earphone.)

Eagles

As your pupils read about David Hancock's experiences, they may wonder if the adult eagles presented any danger when he climbed to nests. Hancock reports, "Bald eagles are shy creatures. In fact, they not only don't attack when you climb their nest tree but they usually slip silently away as the climber starts up the tree, and are not seen again for several hours."

In this article, the author tells how bald eagles share foods such as seal carcasses and tolerate other eagles near their nests. This is not true for all species of eagles (and may not even be true for all bald eagles). Other biologists, studying the golden eagle in Yellowstone National Park, found that each pair of eagles defended a territory of about 70 square miles in order to have sufficient food. Food is much more abundant in the shoreline environment of the British Columbia eagles. This illustrates the concept that *organisms are adapted to their environment.*

Topics for Class Discussion

• *What do bald eagles eat?* Although eagles have been persecuted as sheepkillers, most of their food is carrion, such as dead fish that wash ashore. Female bald eagles (which are bigger than males) usually weigh between eight and 11 pounds. Even with their great strength they can't lift much more than three pounds, and that only for short distances.

With this in mind, everyone should cast doubt on tales of eagles carrying off babies and lambs. Sheep raisers sometimes claim that eagles kill many lambs. Dave Hancock says, "I have seen dozens of ewes and lambs, some in the stage of giving birth, in a field with more than 30 eagles perched nearby. Never once did I see any sign of predation on the live sheep, nor did the ewes or lambs show any signs of fright when eagles flew close above their heads. Destruction of this great bird on the grounds that it is a predator of sheep is completely unwarranted." The eagle's role on the sheep ranges is the same as that along the coasts—that of a scavenger.

• *What information can be learned by banding birds and other animals?* The banding of birds has enabled biologists to learn a great deal about the migration routes and the winter and summer homes of birds. In addition, data may be gathered about a bird's age and growth rate, and about the effect of hunting seasons on the numbers of a species. The same sort of data can be gathered about nonmigratory species.

Banding usually doesn't yield much information unless great numbers of individuals are marked; only a small percentage of bands are ever returned. Also, the investigator usually knows nothing of the animal's movements between the points of banding and recovery of the band. In recent years this gap has been filled by tracking individual animals by use of radio signals. (An article describing radio-tracking of raccoons will be published in a spring issue of *N&S.*)

Human Cells

Although cells were first detected during the seventeenth century, it wasn't until 1839 that Theodor Schwann suggested that *all* living organisms consist of cells. All of life's processes can be studied in the cell or in groups of cells. Today, many scientists study only cells or parts of cells; they seldom deal with whole animals. The study of cell structure and function is called *cytology.*

The WALL CHART emphasizes the differences between cells. You might point out that cells have many things in common. Each cell is enclosed by a *membrane,* which helps regulate what passes into and out of the cell. (Since plants have no skeletons, plant cells have a rigid cell wall outside of the membrane.)

Inside the membrane of a cell, the most conspicuous part is usually the *nucleus.* It is often in the middle of the cell and is the control center. The nucleus contains *chromosomes,* which are the carriers of the cell's heredity.

Every multicellular organism — horse, tree, man — develops from a single fertilized egg cell. Yet the mature organism contains many different kinds of cells. As the fertilized egg divides and redivides, the new cells begin to *differentiate.* Exactly how this happens is still not known. Remarkably different cells develop, then multiply by dividing. These groups of similar cells are called *tissues.* Tissues of several different kinds form *organs,* and several organs may function together in a *system* (such as the digestive system).

It is estimated that 50 million of our body cells die every second and are replaced by 50 million new cells. Cells multiply by dividing. The splitting of a cell is preceded by division of the nucleus, a process called *mitosis.* For more details about mitosis and more information about cells, look in biology or general science textbooks and in the books listed below.

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531.

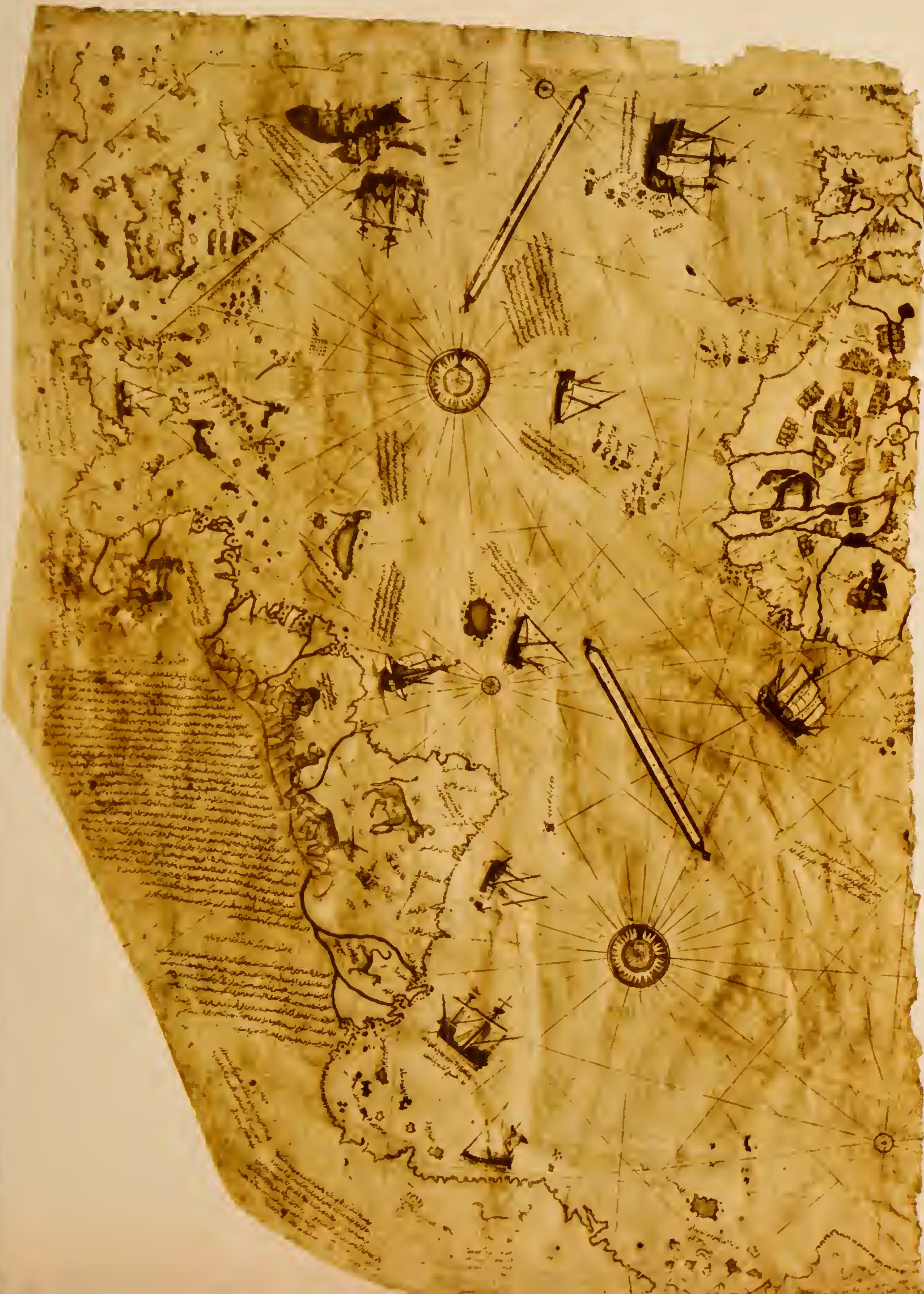
nature and science

VOL. 5 NO. 11 / FEBRUARY 19, 1968

Investigate the life of a desert rodent by looking . . .

INTO A GERBIL'S WORLD

see page 10



How could this map show part of the coastline of Antarctica (*see bottom of map*) when the map was drawn in 1513 and the continent of Antarctica supposedly was not discovered until 300 years later? Besides, the part of the Antarctic coastline that seems to appear on this map has been hidden under deep ice, probably for thousands of years. Scientists did not begin mapping this ice-covered coastline until 1954 — 25 years after the map shown here was found in a Turkish palace. To find out more about this mysterious map,

see page 14

THE PIRI RE'IS MAP

This map was drawn on the skin of a gazelle, and the shape of the right edge, as well as parts of words written there, indicate that part of the map is missing. The part shown here is about 36 inches high and 26 inches wide. Writing, mostly in Turkish, tells of the humans and other animals found by explorers, including Columbus, in the areas shown on the map.

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PICTURE CREDITS: Cover, from David O. True and The American Geographical Society of New York; pp. 2-3, 6-7, 13-15, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 4-6, photos by David Hancock; p. 7, photo from United Press International; pp. 8-9, Robert G. Bryant; pp. 10-11, 13, Education Development Center; p. 16, photo from Dr. Glauboch, Photo Researchers, Inc.

The credits for the photos on pages 8 and 9 of the Dec. 18, 1967 issue were incorrect. Correct credit is: Raccoon by Leonard L. Rue III; cricket and beetle by Charles E. Mohr, fish by Gene Wolfsheimer, bat by Alvin E. Staffan, all from National Audubon Society; crayfish from Photo Researchers, Inc.

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THE AMERICAN MUSEUM OF NATURAL HISTORY
BY THE NATURAL HISTORY PRESS
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"CANNED

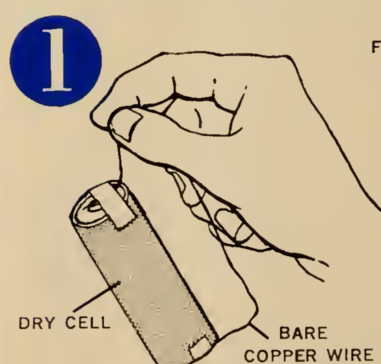
■ Have you bought any cans of "instant electricity" lately? You can get instant electricity from a wall socket, of course, just as you can get instant water from a water faucet. But when you are far from a wall socket, you can get electricity to light a bulb, for example, or make a portable radio work, from handy "cans," called *dry cells*. (Two or more cells working together are called a *battery*.)

A dry cell like those in your flashlight produces electricity whenever you connect the bottom end of the cell with metal to the metal disc in the center of the cell's top. Do this with a cell from your flashlight and a short piece of copper wire, as shown in Diagram 1. You should feel the wire heat up as an electric current flows through it. (Don't keep the wire there long, though—it "wears out" the cell.)

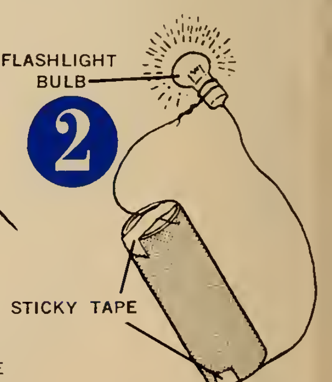
Now use two pieces of wire to connect the cell to a flashlight bulb as shown in Diagram 2. Can you explain why the tiny wire inside a light bulb glows brightly when an electric current flows through it?

How a Dry Cell Makes Electricity

A dry cell is hard to cut open, because beneath the paperboard wrapper is a zinc case. If you cut through this case with a hacksaw, you will find moist black paste surrounding a carbon rod that is attached to the metal disc



You can feel this wire heat up as an electric current flows through it.



Dry cells are connected to a bulb this way in your flashlight.

Instant electricity is made right in the package it comes in. You can find out how it's done and "can" some yourself.

ELECTRICITY

at the top of the cell *(see Diagram 3)*. Sealing wax closes the cell and separates the carbon rod from the zinc case.

Like all things, the substances in a dry cell are made of tiny particles called *atoms*, and the atoms themselves are made of even smaller particles. Two of the particles that make up atoms are called *electrons* and *protons*. 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.

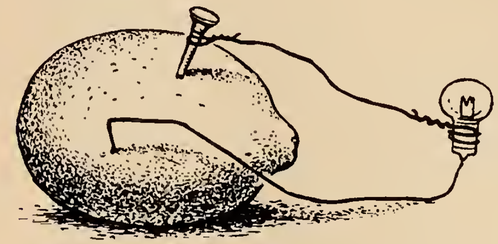
An atom usually has equal numbers of electrons and protons. But an atom that has either some extra electrons or a shortage of electrons is said to be *electrically charged*. (Extra electrons give an atom a *negative* (–) charge, while a shortage of electrons gives an atom a *positive* (+) charge.)

Look on the wrapper of a flashlight cell, and you will probably find a "+" mark near the top and a "–" mark near the bottom. This means that the metal disc attached to the carbon rod has a positive charge, and the zinc case —which is exposed at the bottom of the cell—has a negative charge. Diagram 4 shows how the cell produces these charges.

When you connect the zinc case to the top of the carbon rod with a wire, the extra electrons in the case push electrons in the atoms of the wire toward the carbon rod (which has a shortage of electrons). The movement of these electrons, with their negative charges, is what we call electric current ■

INVESTIGATION

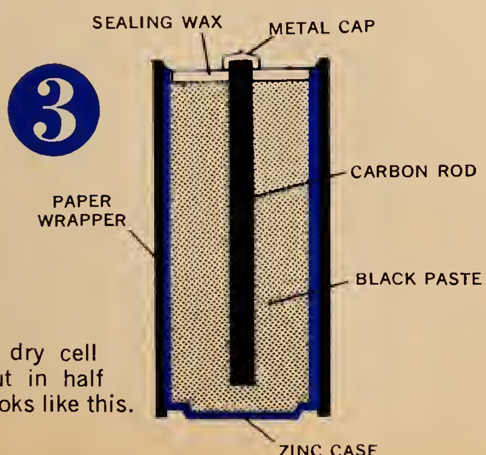
You can make electric cells of many different materials. For example, roll a lemon on a table until it feels soft and juicy. Wrap the end of a copper wire around the head of an iron nail and tape it in place. Use the nail to make two holes in the lemon, about half an inch apart. Stick the nail in one hole and the end of another copper wire into the second hole. Can you make a flashlight bulb light by connecting it to the cell (see diagram)?



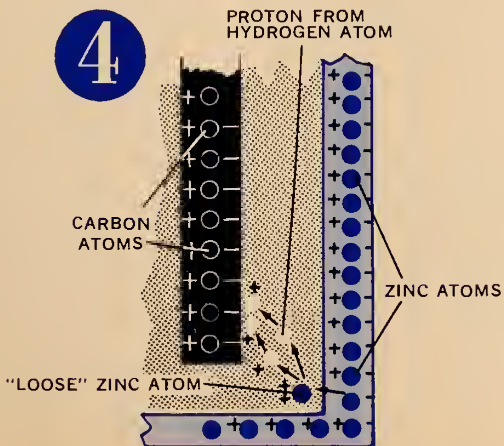
The current will probably be too weak to light a bulb, but here's a way to make sure the cell is producing current. Get an earphone—the kind that you plug into a transistor radio and stick in your ear will do. Wrap the end of one wire from your cell around the metal "jack" that plugs into the radio. When you touch the other wire from the cell to the tip of the jack, you will hear a clicking sound if the cell is producing electricity.

Can you find other substances that will work in place of the iron nail or the copper wire? Try the blade of a steel knife, a stick of pencil "lead" (carbon), a strip of zinc from a dry cell case, an aluminum screw, a dime, a penny, and so on. Which combinations produce the strongest current (making the loudest click)?

Try suspending two different metals in a glass of vinegar, salty water, cooking oil, and so on. (Be sure to wash and dry the metals between trials.) How many liquids can you find that work like the black paste in a dry cell?



A dry cell cut in half looks like this.



The black paste in the cell contains water, hydrogen, oxygen, and other chemicals that break some atoms of zinc away from the case but leave some of their electrons behind. These extra electrons give the case a negative charge. The "loose" zinc atoms are short some electrons, so they have a positive charge, and they push protons from the hydrogen atoms through the paste to the carbon rod, giving it a positive charge.

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A SCIENCE ADVENTURE

Flying with the Eagles, Part 2

I Climb to Eagles' Nests

by David Hancock

In Part 1 of this article, the author told how he uses an airplane to study the lives of bald eagles. In Part 2, David Hancock tells how he and his wife watched eagles feeding, and how he climbed to eagle nests.

■ To learn more about the food of bald eagles, we hid near places where they fed. In one area, there were five pairs of eagles with nests. They fed their young food gathered in a small bay. Each morning, as the tide started to drop, the eel grass beds and tide pools would become exposed. From our hideout we watched. As the tide marched out, so did crows, poking and prying under each newly exposed blade of eel grass and into every crevice of each pool.

When the crows spotted something to eat, they would gulp it down. That is, they would if it was small enough. Often they would surprise fish too big for them to swallow in one gulp. As soon as one of these fish was discovered, down would swoop one of the eagles from the surrounding trees. The eagle grabbed the fish amid croaks of protest from the crows. The eagle would then fly back to its nest with the three-to-six-inch-long fish. This process would continue for the three to four hours of low tide or until all the eaglets and adults had enough food. The remains of these fish were never found in or below the nest. They were eaten whole by the eagles. So, by studying the food leftovers in and under nests, we got only part of the picture. As it turns out, the adults fed their young mostly on small fish that are easily carried back to the nest.

During much of the rest of the day, the eagles watched the water from their perches for herring or other fish that sometimes come to the surface. Then they would dive to the surface and grab a fish with their claws. The eagles couldn't lift a fish weighing over three pounds, however. The weight dragged them into the water. Then the bird would "row" to shore with its wings, dragging the fish along.

When the eagles aren't raising young, they eat any dead food they can find. This might include the carcasses of

3

4

whales, seals, sharks, and sea birds. The bald eagle is a *scavenger,* taking live prey only when very hungry or when live food is easy to get. Even during the breeding season, the adults usually feed on carcasses, while the young eat smaller, freshly caught fish.

In the fall the eagles feast on fish. One of the most spectacular sights on the British Columbia coast is the annual salmon run up the rivers. It is a one way trip for these fish. They die once they have mated (*spawned*) and laid their eggs. The dead fish are a feast for the scavengers. Bears, gulls, and eagles gather in great numbers. In a few hundred yards of river, I have counted over a hundred bald eagles feeding, or resting and waiting to fill up again.

Sharing a Seal

We occasionally put seal carcasses near nests. We wondered what the adults at the nearby nest would do if other eagles came and tried to feed. Most *predatory* (meat-eating) birds defend territories and chase away other birds of their kind. This may be necessary to help insure a food supply around the nest for the birds and their young.

When an eagle catches a fish too heavy to carry, it may drag the fish back to shore, rowing with its huge wings.

1 This moss-lined nest contains three eagle eggs. Compare their size with the matchbox in the photo.

2 This eaglet is seven days old. It is still covered with down and must be kept warm by its parents.

3 By the time an eagle is six weeks old, it has a warm coat of gray down.

4 The feathers of an adult eagle are replacing the gray down on this nine-week-old eagle.

After putting a seal carcass near one nest, we patiently watched from a hiding place. The first eagle to settle on the carcass was the female from the nest immediately above. She had hardly started to eat when three more adults and a three-year-old eagle appeared. Within half an hour, I could see 27 eagles perched nearby. However, only one or two eagles would feed at once. If an eagle came near the carcass, the one that was already eating would threaten it with low guttural calls, a hunched neck, and raised wings. This meant, "Get back!"

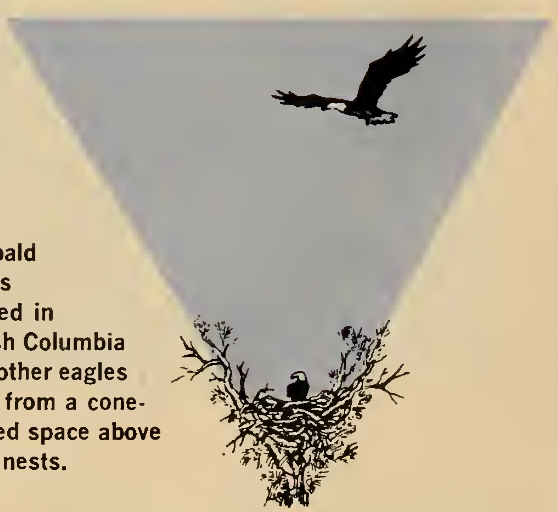
There wasn't a single attempt by the owners of the nest to drive these other eagles away. In fact, there were three other eagles sitting in the nest tree, though they were well below the nest itself.

We observed the same thing near other nests. This showed us that bald eagles only defend a cone-shaped air space immediately above the nest (*see diagram on the next page*). Any eagle flying over a nest might be a threat; it

(Continued on the next page)

might see the eaglets and try to eat them. There is no such threat if eagles fly below the nest.

Sharing a large carcass seems to help the eagles to survive. One eagle family couldn't use a whole carcass before it rotted or went out to sea with the next tide. Besides, the next free and easy meal may be under a neighbor's nest. The bald eagles share these temporary food supplies without wasting a lot of effort fighting about it.



The bald eagles studied in British Columbia kept other eagles away from a cone-shaped space above their nests.

A Band for Each Eaglet

We were able to look into hundreds of eagles' nests from our airplane. Sometimes, however, the nests were hidden by the leaves at the top of the tree. I climb to these nests. To each leg I strap a climbing iron, like the ones telephone linemen use, but with longer spurs to stick into the thick bark. A long rope with a steel core for strength is tied to my belt and looped around the tree. By kicking the spurs into the bark I can "walk" up the tree. The rope, which keeps me from falling, is gradually worked up the trunk.

In order to protect the tree, I didn't want to cut off each branch as I got to it, as a logger does. Instead, I would balance on the spurs, perhaps 100 or 150 feet up, unbuckle the belt and lift the rope over the branch, then resnap the buckle into the belt. Sometimes, I would use two belts, tying the second one above the branch and then undoing the first one.

I can't say I actually enjoy the climb up a tree. It is plain hard work. The most difficult part is when I reach the huge nest. Somehow I have to climb out around it and over into the nest. Once over the overhang, usually all is well.

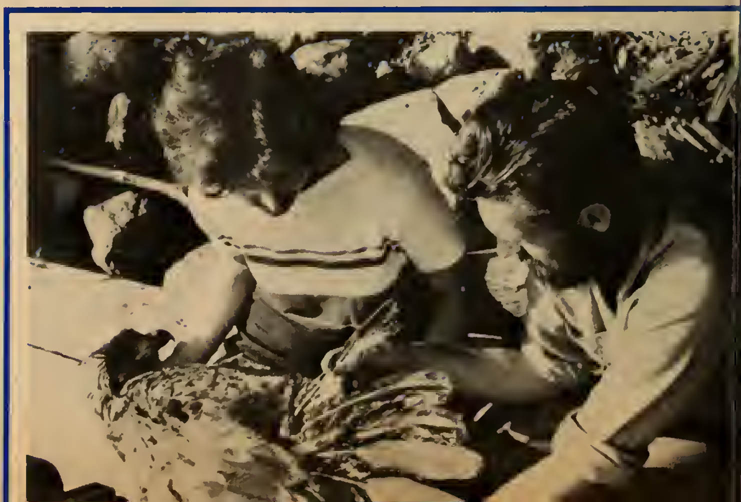
I try not to climb to nests until the young are well feathered and nearly full grown. At five weeks of age, the dark body feathers start to show through the downy feathers of the young. From the sixth week on, the young don't need much warmth from the parents. They don't get chilled when I visit the nest. However, at this size they can be a problem to handle. Balancing on the nest platform, I try to grab their feet before they grab me. They defend themselves very well by flapping their wings. A blow on the side of the head could easily topple me 150 feet to the ground.

I usually take a towel up the tree to wrap around an eaglet. Then I have the bird restrained and my hands free. Using pliers, I put an aluminum band around one leg of each eaglet. Written on the band is its number and the address of the United States Fish and Wildlife Service, Washington, D.C. For each band I place on an eagle I fill out a card with information about the bird, the place where it was banded, the date, and the eagle's estimated age. This card is then filed at the Washington office for any scientist wanting to use the information. At a later date this bird may be captured or found dead. Then the band can be sent to the Fish and Wildlife Service and we learn something of this eagle's travels and its age ■

In the next issue, David Hancock tells how he and his wife, Lyn, were stranded high in an eagle's nest for nine hours.

The photo below shows three eagles wrapped in towels that hold them quietly until they are banded and let go.

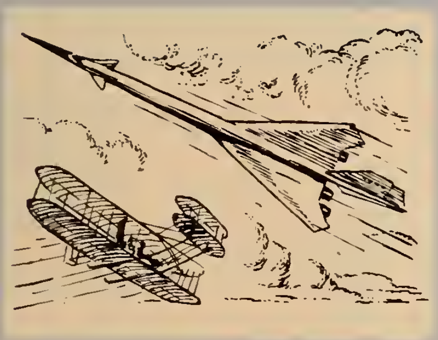
The author and his wife colored the feathers of some eagles so that the birds could later be recognized at a distance.



WHAT'S NEW

By Roger George

One of the newest airplanes is taking an idea from one of the oldest. The borrower is a supersonic jet airliner that will fly at 1,800 miles an hour when completed in 1974. The idea comes from the plane that was flown at 6.8 miles an hour by the Wright brothers at Kitty Hawk, North Carolina, in 1903. The idea is a small wing, called a Canard wing, that is located near the front of a plane (*see diagram*). The Wright biplane had two Canard wings, one above the other. The



airliner's main wing is set far back on its 318-foot body. As first designed, it had no Canard wing. The small forward wing was added recently for better control and to make a smoother ride.

Long times without food may not bother the banded gecko lizard, which lives in our southwestern deserts. This lizard can eat tremendous amounts of food quickly. In fact, it can eat enough in four days to keep it alive for six to nine months.

In tests with captured geckos, H. Robert Bustard, an Australian scientist, found that after five days of eating they weighed 1½ times as much as when they started. But after 75 days without food, they lost only one-seventh of their weight. A gecko stores food as fat throughout its body, especially in its tail.

Some things stay alive in boiling water at Yellowstone National Park in northwestern Wyoming, says Dr. Thomas D. Brock in the journal *Science*. Dr. Brock, who teaches at Indiana University, in Bloomington, is a *microbiologist*. He studies living things that are too small to be seen except through a microscope. Dr. Brock looked for microscopic life in Yellowstone's hot springs.

He found one-celled animals called protozoa living in water at temperatures up to 124° F., one-celled plants called blue-green algae at temperatures up to 167° F., and certain bacteria in underground pools at temperatures up to 204° F. Water boils at 212° F. at sea level, but at Yellowstone's high altitude of 8,000 feet, water's boiling point is lowered to about 198°. So the bacteria are living in water hotter than boiling temperature. What's more, Dr. Brock's studies suggest that these bacteria grow better in such hot water than in cooler water.

"Flying saucers" are getting people excited in Soviet Russia as well as in the United States *(see "What's New," N&S, December 4, 1967)*. A group of Russian scientists who are studying unidentified flying objects (UFOs) has received 200 reports of people seeing saucers. One of the usual type was described as "a luminous orange-colored crescent . . . only a little duller than that of the moon." Jets, sometimes with sparks, were said to be coming from the ends of such crescents. People said the crescents were about 1,700 feet across and that they sped at about 11,000 miles an hour.

Professor Feliks Zigel, an astronomer at the Moscow Aviation Institute, has said scientists all over the world should investigate flying saucers.

Cold beetles remember better than warm beetles. At Northwestern University, in Evanston, Illinois, Thomas M. Alloway and Aryeh Routtenberg placed flour beetles one by one in a small passageway. This passageway branched into two: one branch was a dead end; the other led to the beetles' "home" and food. The beetles soon learned to take the passageway leading home.

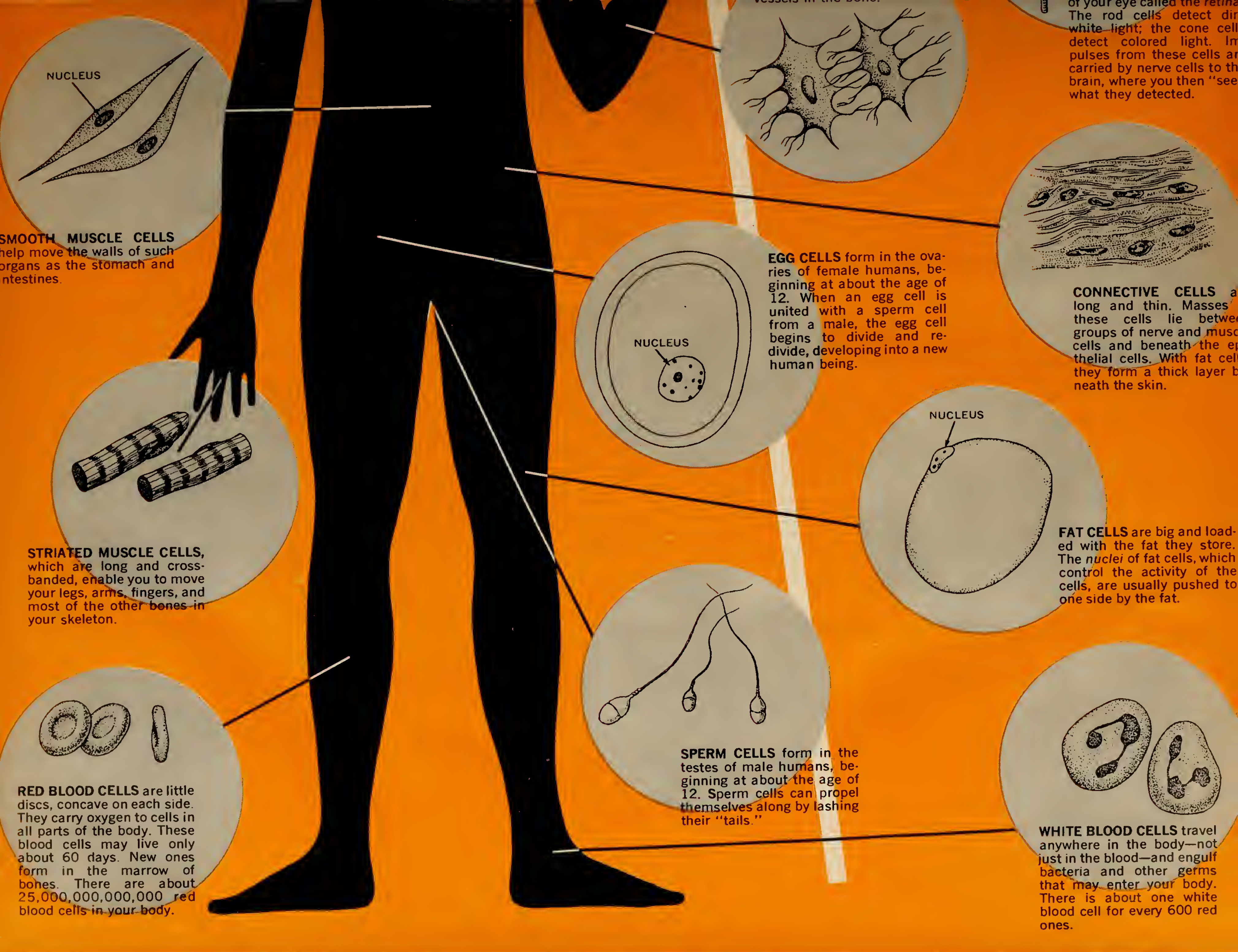
Then some of these beetles were kept at room temperature while others were put in a refrigerator. After one to 10 days they were tested again in the passageway. The cold beetles proved better at remembering the way home. But oddly enough they almost lost their memory at the end of two days. Their memory then improved, becoming almost perfect after five days.

Further experiments may tell why coldness improves a beetle's memory and why cold beetles lost their memory for a while after two days.

Riding on a cushion of air, a French train without wheels has whizzed along at 215 miles an hour—the fastest a train has ever traveled. The "aerotrain" *(see photo)* is an experimental railway car powered by a jet engine and two rockets. It sits on one high concrete rail, much as a rider sits on a horse. Small jets on its underside shoot air downward, lifting the car a tenth of an inch above the rail. This reduces the slowing effect of friction. The car is stopped by brakes that grip the rail and by two small parachutes.

The final version of the aerotrain will be driven by a turboprop, an engine that combines a propeller and a jet. The train is expected to carry 80 passengers at speeds near 250 miles an hour.

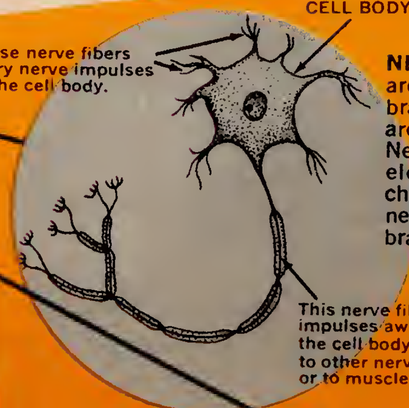
In this test, one of the aerotrain's two parachutes has been opened to slow it down. Its two rockets are shown at the rear, above the jet engine.


vessels in the bone.
of your eye called the retina.
The rod cells detect dir
white light; the cone cell
detect colored light. Im
pulses from these cells ar
carried by nerve cells to th
brain, where you then "see
what they detected.
NUCLEUS
SMOOTH MUSCLE CELLS
help move the walls of such
organs as the stomach and
intestines.
CONNECTIVE CELLS a
long and thin. Masses
these cells lie betwe
groups of nerve and musc
cells and beneath the ep
thelial cells. With fat cel
they form a thick layer b
neath the skin.
NUCLEUS
EGG CELLS form in the ovaries of female humans, beginning at about the age of 12. When an egg cell is united with a sperm cell from a male, the egg cell begins to divide and re-divide, developing into a new human being.
NUCLEUS
STRIATED MUSCLE CELLS, which are long and cross-banded, enable you to move your legs, arms, fingers, and most of the other bones in your skeleton.
FAT CELLS are big and loaded with the fat they store. The nuclei of fat cells, which control the activity of the cells, are usually pushed to one side by the fat.
SPERM CELLS form in the testes of male humans, beginning at about the age of 12. Sperm cells can propel themselves along by lashing their "tails."
RED BLOOD CELLS are little discs, concave on each side. They carry oxygen to cells in all parts of the body. These blood cells may live only about 60 days. New ones form in the marrow of bones. There are about 25,000,000,000,000 red blood cells in your body.
WHITE BLOOD CELLS travel anywhere in the body—not just in the blood—and engulf bacteria and other germs that may enter your body. There is about one white blood cell for every 600 red ones.

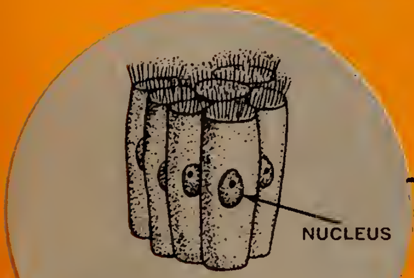
THE CELLS IN YOUR BODY

■ Your body is made up of trillions of tiny building blocks called *cells*. If you were asked to describe one of your cells, you would probably picture it as a round clump. Many cells do look like that, but others are shaped more like barrels, plates, or ribbons. Most cells are so tiny that 250,000 of them will fit on the period at the end of this sentence. A single nerve cell, however, may be a yard long, and the biggest human cell—the egg cell—can be seen without using a magnifying lens.

The diagrams on these pages show some of the different kinds of cells in your body. Most of them are found in great groups, called *tissues*. The captions tell something about the "jobs" of these tissues and the cells that make them up ■

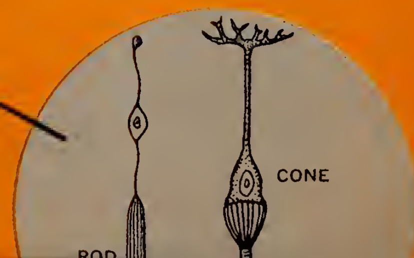


NERVE CELLS, or neurons, are most plentiful in your brain and spinal cord, but are found all over the body. Nerve cells carry pulses of electricity that can be changed into messages at nerve centers such as the brain.



EPITHELIAL CELLS line the inner surface of your nose, throat, mouth, lungs, and stomach. Some kinds are oblong, others look like cubes or plates. The epithelial cells lining the nose and throat have tops covered with hair-like *cilia*. The cilia "sweep" dust and other par-

BONE CELLS have oval bodies and many "branches" that reach out into the hard material around them. One kind of bone cell gives off a hard mineral substance that makes bones rigid. Bone



INTO A GERBIL'S WORLD

BY DAVID WEBSTER

Here is how to care for these active desert rodents, and how to investigate their lives.

The eyes of a young gerbil open at three weeks of age. By then the gerbil has a thick coat of fur.

■ What animal looks like a furry mouse, is very curious, and can be more fun than a monkey? If you haven't guessed, it is a *gerbil.* These little mammals make excellent pets. They are clean and quiet. Perhaps you can buy one or two for pets in your home or classroom.

Taking Care of Gerbils

The first thing you will need for your gerbil is a cage. A fish tank makes a good cage even if it is cracked. You could also use a bird cage, or make a cage from a wooden box, giving it a wire front *(see photo).*

Your gerbil will escape from its cage if it finds an opening. For this reason, keep the cage inside a bathtub for the first few days. Then if the gerbil does get out, it can't get away. The sides of a tub are too slippery for gerbils to climb.

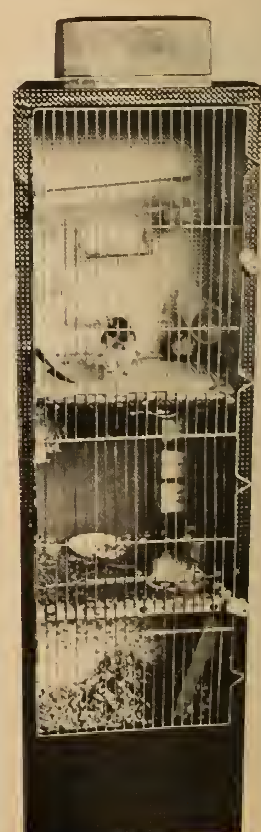
Gerbils are not fussy eaters. They grow well on a regular diet of birdseed. Put in a lot of seed so there is always enough for the gerbil to eat. It won't overeat. Give your gerbil some lettuce and carrots, too.

Gerbils come from China, on the edge of the Gobi Desert. Because there is not much water in the desert, gerbils need only a few drops of water each day *(see "Survival in the Desert,"* N&S, *October 30, 1967).* Your gerbil won't need to drink any water at all if you provide foods that have water in them. Lettuce, carrots, celery, and grapes contain a lot of water. In the desert gerbils eat the roots, seeds, and leaves of desert plants.

A Shredded Paper "Machine"

If you ever want something shredded, give it to your gerbil. It will tear up almost anything. Put some things in the animal's cage to see if it rips them apart. You might

This gerbil "apartment house" was made from an old bookcase. Notice all the things in the cage for gerbils to chew on, hide in, and play with.



This article is adapted from The Curious Gerbils, *developed by Phylis and Philip Morrison. Copyright © 1967 by Education Development Center, Newton, Mass. This booklet was written for the Elementary Science Study of Education Development Center, and has been published by the Webster Division of McGraw-Hill Book Co. ESS is supported by the National Science Foundation.*

try paper towels, colored paper, old socks, cardboard boxes, and spelling tests. Think of some other things to try.

Watch the gerbil as it works. What teeth does it use to shred paper? How does it hold the paper while chewing? Does your gerbil ever tear up things at night in the dark? Does it use some of the shredded paper or cloth to make a fluffy bed?

Gerbils gnaw for hours on cardboard, plastic, and even wire. This doesn't mean they are trying to escape or to get something to eat. They need to gnaw. Like other rodents, gerbils have front teeth that never stop growing. Gnawing wears away the teeth so they keep at the right length.

If you use a fish tank for a cage you can see how gerbils dig tunnels. In the desert gerbils build tunnels in the sand, where they hide from other animals.

Pack about 10 inches of clean soil into the fish tank. Mix water with the soil until it is damp. If the soil becomes too dry, the gerbil's tunnels will fall in, so sprinkle some water on top every day.

Put in your gerbil and see if it starts to dig. Does the gerbil dig with its front feet, like a dog? Does it take a long time to make a tunnel?

Sometimes gerbils dig tunnels right next to the glass. Then you can look in and see what they do underground. A gerbil is more likely to dig near the glass if you cover the glass with a piece of dark paper. Take the paper off only when you want to see inside.

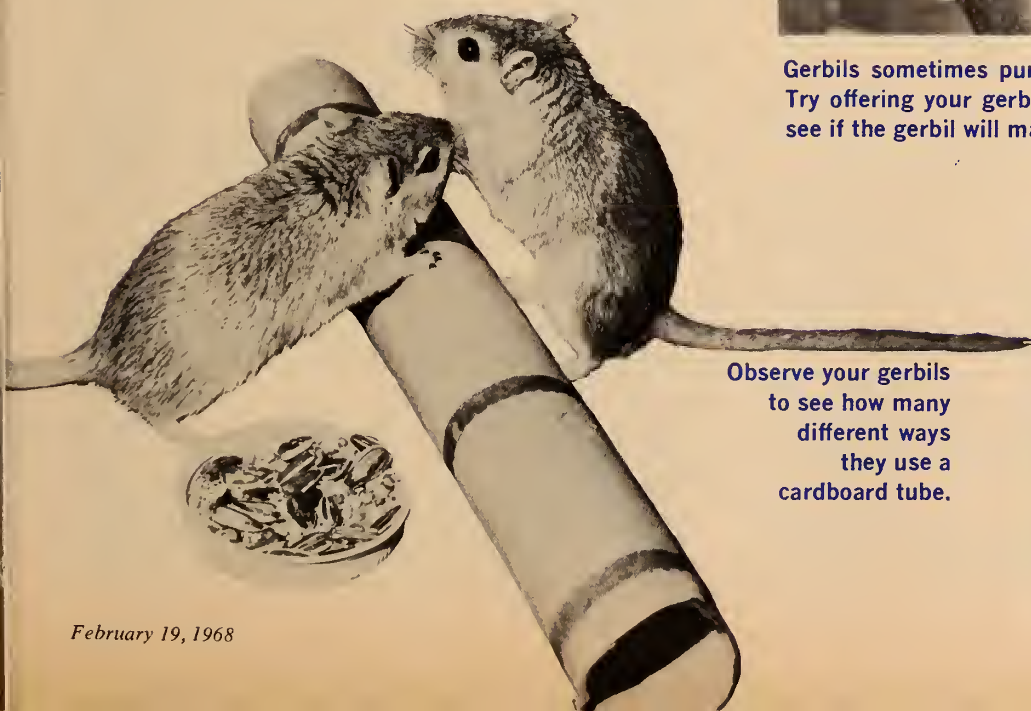
Gerbils need exciting places to explore. They spend hours crawling in and out of cardboard tubes. Give your gerbil a tube from the inside of a paper towel roll. Watch to see what the gerbil does with it.

Maybe you can make a little ladder or sliding board

(Continued on the next page)

If you have more gerbils than you want, give them to a friend or someone else who will give them good care. *Do not let them go.* If you let gerbils go outdoors, they will probably die. If they survive, they could become a serious nuisance *(see "The Animal Movers,"* N&S, *Oct. 2, 1967).*

Gerbils sometimes punch holes in paper with their teeth. Try offering your gerbil the edge of a piece of paper and see if the gerbil will make a lot of little holes.



Observe your gerbils to see how many different ways they use a cardboard tube.

You can now buy gerbils from many pet stores. Or you can order them from SEE, Inc., 3 Bridge Street, Newton, Massachusetts 02160. From SEE, Inc., gerbils cost $9.50 for a male and a female, or $5 for just one. In addition, there is a charge of about $5.50 for air express shipment.

for your gerbil. Gerbils are good climbers and acrobats. They soon become skillful with rear and front claws.

Watch a Gerbil Family

If you have two gerbils, and one is a male and the other a female, you may be lucky enough to get some young. A mother gerbil usually has four or five young at a time. Sometimes, though, a gerbil family has as many as 10 young.

The best way for you to care for young gerbils is to leave them alone. Their mother knows what to do. She feeds and washes them, and keeps them warm in her nest. You can help her only by supplying plenty of food and nest-making material.

At first the new gerbils are very tiny. Their eyes are sealed shut and they have no fur. In a few days they grow their first coat of light brown fur. All they do is wiggle around and make faint *cheeps.*

When the young gerbils are two weeks old, they will have begun walking around the cage. Often they bump into things, because their eyes are still unopened. After three weeks their eyes open. They will soon eat regular gerbil food, instead of drinking their mother's milk. The young gerbils now can be taken away from their mother and put into a home of their own. In three months they will be full-grown adult gerbils ■

INVESTIGATION

What do you think your gerbil likes to eat for a special treat? What would it like best, a dandelion flower, a piece of candy, some ice cream? You can find out by putting three or four foods that you want to test in the gerbil's cage. The food should be in separate dishes so you can tell how much of each one has been eaten. Look in the dishes the next morning. How much of each food was eaten? Which of the foods tested does the gerbil seem to like best?

You can keep trying different foods to find out what the gerbil likes best of all. Does your gerbil prefer cornflakes, dog biscuits, a cactus, toast, popcorn, grapes, or cheese?

These booklets give more information about raising gerbils: **The Curious Gerbils,** available from Webster Division, McGraw-Hill Book Company, Inc., Manchester, Missouri 63011, 95 cents; **How to Raise and Train Gerbils,** T. F. H. Publications, Inc., 245 Cornelison Ave., Jersey City, N.J. 07302, $1; **Beginning with Gerbils,** also from T. F. H. Publications, 50 cents. (For either of the last two booklets, add 25 cents for postage and handling.)

Announcing . . . BRAIN-BOOSTERS CONTEST WINNERS

Mr. Brain-Booster has chosen the winners in the Brain-Boosters Contest announced in the October 16, 1967 issue of *Nature and Science.* The winners were selected on the basis of their answers to all of the contest questions. Each first-prize winner received his choice of a 10-power or a 100-power microscope, or a 10-power telescope, courtesy of Bausch & Lomb Incorporated. Each of the runners-up received a copy of *Crossroad Puzzlers,* the new brain-boosting book by Mr. Brain-Booster himself. Here are the winners:

Fourth grade and below
First prize: Ned Van Embden, Millville, New Jersey.
Runners-up: Jeffrey Silber, Yonkers, New York; Vincent Cook, Juniata, Nebraska; Samuel Eisenpress, White Plains, New York.

Fifth grade
First prize: Fifth Grade Class, Room 23, Randolph Central School, Randolph, New York.
Runners-up: Buck Webb, Ithaca, New York; Kurt Eakle, New Berlin, Wisconsin; Caroline Smith, Springfield, Virginia.

Sixth grade
First prize: Stan Curry, Tempe, Arizona.
Runners-up: Nina Hanenson, Cincinnati, Ohio; Warren Siska, Bohemia, New York; Richard Seelinger, Pittsburg, California.

Seventh grade and above
First prize: Nedra Noll, Winchester, Kansas
Runners-up: Eugene Lesser, Albuquerque, New Mexico; Andrew Levin, Weston, Massachusetts; Bess Ward, Auburn, Alabama.

Teachers and other adults
First prize: Clifton A. Dukes, Jr., Atlanta, Georgia.
Runners-up: Gerald Lauber, Nyack, New York; David Philips, San Juan Capistrano, California; Mrs. Marna Goddard, West Grove, Pennsylvania.

HERE ARE THE WINNING ANSWERS:

Mystery Photo: The wavy track in the sand was made by the ridges on a tire of some vehicle driving across the sand. **—Stan Curry**

What will happen if? The ice cubes will melt in the following order: on top of a car, on the street, on a rock, and on some dirt. They don't all melt at the same time because the various surfaces mentioned lose heat to the ice at different rates.
—Room 23, Grade 5, Randolph Central School

Can you do it? To make one balloon float in a bathtub and another one sink, merely fill the bathtub with hot water. Fill one balloon with hot water and the other with cold. Put them in the tub of hot water. The one with hot water floats, and the one with cold water sinks. **—Nedra Noll**

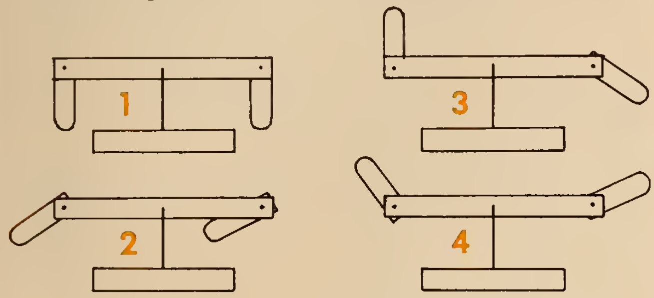
Fun with numbers and shapes: The piece of paper in the shape of "A" is the one used to make a pointed paper cup. "B" and "D" are not suitable at all, and if "C" were used there would be no practical way to seal the point of wrap-around as there would be no fold for sealing purposes.
—Clifton A. Dukes, Jr.

For science experts only: Catsup gets stuck in a bottle that is held straight up and down because air can't get in the place where the catsup was supposed to come out. The air has to get in to fill up the place the catsup leaves. If you tilt the bottle, the catsup running out doesn't take up all the room, so the air runs in. **—Ned Van Embden**

BRAIN-BOOSTERS

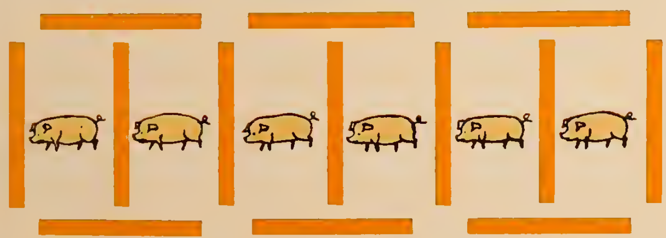
prepared by DAVID WEBSTER

What would happen if?
The sketch shows a wooden stick balanced on a stand. At each end of the big stick is a shorter stick that can be turned up or down. What will happen when the shorter sticks are turned as shown? Will the big stick still balance, or will it drop down on its left or right end?

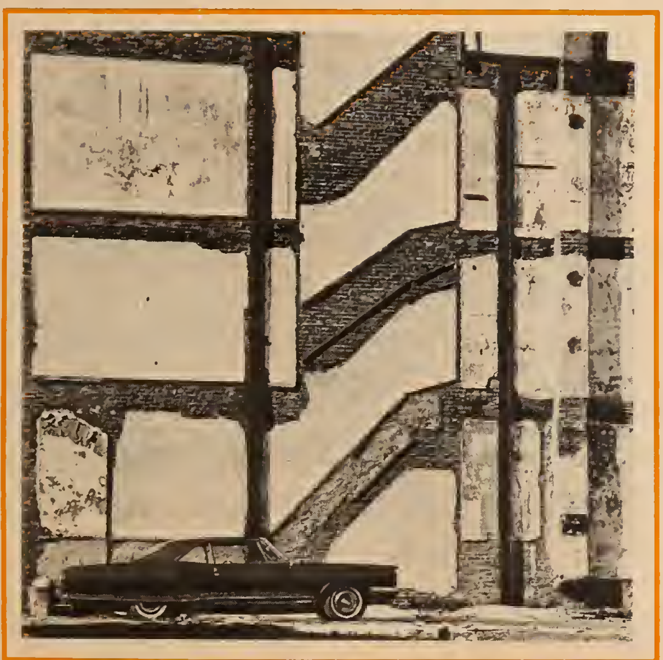


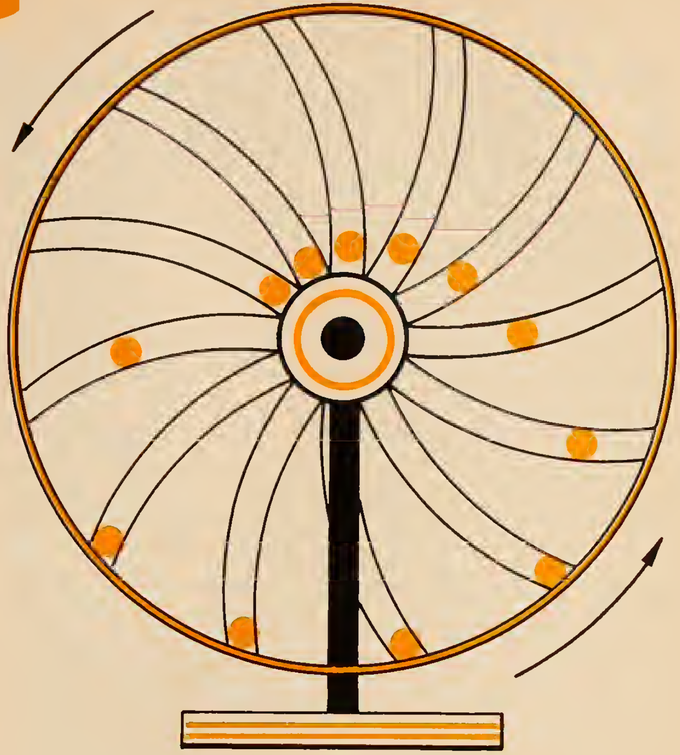
Fun with numbers and shapes
The 13 sections of fence have been arranged to make separate pens for six pigs. Can you find a way to make six pig pens with only 12 sections of fence?

Submitted by Jean Dedier, Salem, Oregon



Mystery Photo
Can you explain the unusual patterns on the wall?





For science experts only
A long time ago, scientists spent a lot of time trying to invent perpetual motion machines. Once started, such a machine would run forever without the need for any fuel, electricity, or other source of power. One idea that was tried is pictured. Can you see why some people thought it would turn by itself? Do you know why it doesn't?

Can you do it?
Can you make an ice cube that is completely clear, without any air bubbles inside?

For calendar experts only
How many Presidents of the United States have been elected in a year that was not a Leap Year?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The photo was taken looking straight down into a porcelain light socket.

What will happen if? An ice cube in a glass of cold water will melt faster than an ice cube in an empty glass. Will an ice cube in an empty glass last overnight in your refrigerator (not the freezer)?

Can you do it? A glass of water can be used to see if your bedroom window is higher or lower than a window in another house. Set it on the window sill and sight across the top of the water.

Fun with numbers and shapes: About 2,000 people live in the part of the city shown in the aerial photograph. There are about 200 small apartment houses, which would average about 10 residents each.

For science experts only: When the moon is full, there would be a "new earth" seen from the moon. How would the earth look when there is a new moon?

THE PIRI RE'IS MAP

How could a map showing part of the outline of Antarctica have been drawn centuries before modern scientists found the edges of that ice-covered continent with electronic instruments?

by Diane Sherman

■ Captain Arlington Mallery, a retired sea captain, was examining an old Turkish map in 1956 when he made a startling discovery. Part of the map's outline seemed to show islands and bays along the Queen Maud Land coast of Antarctica (*see cover photo and maps on these pages*).

What made this so extraordinary is that the Antarctic coast is under a thick covering of ice. Since 1954, scientists have been mapping the shape of Antarctic bays and islands by bouncing echoes off the ground below the ice. But the Turkish map was dated 1513. It seemed that someone before that time had either mapped the coast through hundreds of feet of ice, or else had drawn the map *before* there was any ice.

How could this be? Most scientists think that ice has covered Antarctica for thousands of years. Yet the map, called the Piri Re'is map (pronounced Pee-ree Ry-iss) for the name of the Turkish admiral who drew it, appears to be genuine. It was found in the Imperial Palace in Istanbul, Turkey (*see photo, page 16*), in 1929, and has been seen by many scientists. One scientist has pointed out that the map could not have been forged, because even in 1929 no one knew the shape of the land covered by Antarctic ice.

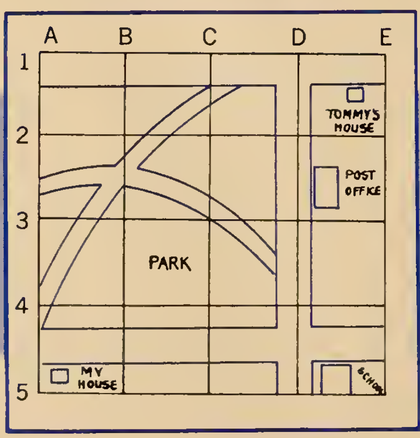
What University Students Learned from the Map

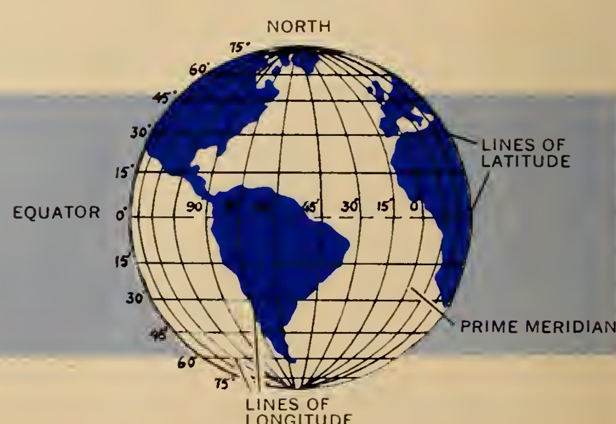
In 1956, Charles Hapgood, then Professor of History at Keene State College, in Keene, New Hampshire, heard about the map. He decided to study it as a project in his classes. For almost ten years he and his students worked on the problem. They studied the map carefully, and looked over other old maps as well.

The first thing they did was try to discover what kind of geographical *grid* was used to make the old map. A grid is a system of lines drawn on a map to help the map-maker and the map user locate places on the map (*see diagrams*). On a modern world map or globe, the grid is formed of certain lines of *latitude* (running east and west) and *longitude* (running north and south). The latitude lines are numbered north and south from the *Equator* (0° Lat.)—a line drawn around the earth halfway between the North and South Geographical Poles. The longitude lines are numbered east and west from the *Prime Meridian* (0° Long.)—a longitude line drawn through Greenwich, England. You can locate any place on the map if you know which lines of latitude and longitude cross at that place.

The Piri Re'is map did not use the same longitude and latitude lines that our maps use. It took many tries before Professor Hapgood and his students could figure out the grid system of the Piri Re'is map. But gradually they began to reach some startling conclusions.

They found that the ancient Egyptian city of Alexandria was located on the map's central line of longitude (0° Long.). Maps drawn by ancient Greeks all used the longitude line of Alexandria as the central longitude line for their maps. It began to look as though the Piri Re'is





The black lines in this map of a small neighborhood form a *grid* that helps you locate places on the map. On a modern world map or globe, the grid is formed of certain lines of latitude and longitude *(see text)* drawn on the globe.

The map at the left is an outline of the land areas shown on the Piri Re'is map *(see cover photo)*, with the modern names of many of the places on the map. By comparing this outline map with the modern map at the right, you can see that the land in the upper left corner of the Piri Re'is map is turned around somewhat, and parts of the coastline of South America are missing, as well as the ocean between Antarctica and the tip of South America.

map might go back to the time of the ancient Greeks. Piri Re'is himself had written that his map was mainly copied from other maps dating as far back as 356 B.C., but no one had yet been able to find any evidence of this.

The Mathematics of the Map-Makers

Finding the central line of longitude helped Professor Hapgood and his students to figure out the whole grid system of the map. Once they could do this, they could transfer places on the Piri Re'is map to the positions they would occupy on a modern map grid. To everyone's astonishment, most places were located at just about the same latitude and longitude as on a modern map (*see outline of map*).

This accuracy was surprising because it is very difficult for a sea-captain exploring strange waters to find his location without modern instruments. A way of figuring out latitude was found nearly 30 years before Piri Re'is drew his map, but no way of measuring longitude is known to have been discovered until the 1700s. It seems almost impossible for explorers before then—even at the time of Piri Re'is—to have measured the longitudes of islands they discovered in the middle of the ocean. Yet the Piri Re'is map shows the correct positions of the Caribbean islands and many others. Some of the islands shown are not even supposed to have been discovered by 1513!

Antarctica itself was supposedly not discovered by 1513! Yet the Rev. Daniel L. Linehan, director of the Weston College Observatory in Weston, Massachusetts, and a scientist who took part in measuring Antarctic ice, agrees that the map seems to show part of Antarctica.

If the original map was drawn not in 1513, but 1,500 years or so before, the knowledge shown by the map-makers is even more surprising. Their familiarity with the world's geography would be amazing all by itself. In addition, however, they must have had some way of measuring latitude and longitude, *and* they must also have known some advanced mathematics. Only then could they have shown places in just about their correct positions.

(Continued on the next page)

The Piri Re'is Map (continued)

The mathematics used in the map-making told Professor Hapgood and his students something else, too. To draw the map accurately, the map-makers had to know the distance around the earth, or its *circumference*. When the ancient Greeks figured this out, they made an error which shows up in all their calculations. Yet the Piri Re'is map was drawn without the mistake. So it would seem that the Greeks could not have drawn the original map.

"Ancient Sea Kings"

Greek civilization dates back to before 1000 B.C. We know from writings passed down to us that mathematics was not used again in mapmaking until the late 1500s. Professor Hapgood began to wonder. Could the map have been drawn *before* Greek civilization?

Perhaps there was some ancient people of whom we have no record. If so, they must have been highly advanced. Their ships must have sailed oceans and charted shores not visited by European explorers until the 1500s and later. These people must have had complex instruments and known difficult mathematics. Professor Hapgood thinks that these "ancient sea kings," as he likes to call them, must have lived at least 5,000 years ago.

Even if these ancient people did exist, it is hard to see how they could have mapped Antarctica through its covering of ice. So we might ask whether Antarctic shores could have been ice-free when these people may have lived, so they could see its shape. Scientists do not yet completely understand what caused the large amounts of ice that once covered much of the continents. They have different opinions about the length of time Antarctica may have been icebound. There is evidence, however, that its shores may have been ice-free for a long period until about 6,000 years ago. So an ancient people might have had a better opportunity to map Antarctica than we do.

There is other evidence, too, showing that some ancient unknown people might have been able to draw accurate maps. From the 1300s to the 1500s, maps called "portolanos" were used by navigators. There were more than 400 of these, but they all seem to have been copied from the same original map. What is surprising is that the earliest portolanos are by far the best maps. It seems as though errors began to creep in when the maps were copied.

Islands That May Have Disappeared or "Shrunk"

Professor Hapgood and his students have studied these old maps, including one that is a reasonably accurate map of the entire coastline of Antarctica, showing rivers, valleys, and bays. Taken all together, the Piri Re'is and portolano maps contain many other signs that they may have been drawn very long ago.

The Piri Re'is map was found in the library of what was formerly the Imperial Palace of Constantinople, in Turkey. Constantinople is now called Istanbul, and the building—now called Topkapi Palace—is used as a museum.

The Piri Re'is map shows island groups where none now exist in the North Atlantic (*see maps on pages 14 and 15*). One island appears on the map where today only rocks jut above the sea. One of the portolanos shows many more islands in the Aegean Sea than there are today. And the islands that do still exist are shown larger than they are today. On another map, some areas that are now islands are shown connected to land.

All this could be explained if there had been a change in the sea level since the map was drawn. A rise in the level of the ocean would cover many islands, make others appear smaller, and cut some islands off from the mainland. We know that 10,000 years ago much of North America was covered by ice. So much water was "locked up" in the ice that the sea level was probably more than 200 feet lower than it is today. When the ice melted, the oceans rose to their present height, undoubtedly covering up some land areas. We do know, for example, that a feature shown on one old map—a bridge of land connecting Alaska with Siberia—existed during the last ice age.

There is still one more sign that the maps may have been drawn several thousand years ago. As a river flows, its waters gradually carry sand and soil down to the river's mouth. In time, the sand and soil are built into a large deposit called a *delta*. On the portolano maps, some rivers are drawn without the deltas they have today—deltas that must have taken thousands of years to build up.

All this, of course, is not *proof* that the maps are really so old. What looks like evidence may be just bad map-making. Perhaps the map-makers drew some things incorrectly. Maybe they left some things out and added others that didn't belong. Some day, perhaps, we will know whether there was a great prehistoric civilization whose sailors roamed the world. In the meantime, the hunt for clues will go on ■

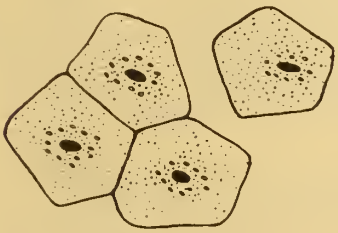
Using This Issue . . .
(continued from page 2T)

Activities

Your pupils can see cells, including some from their bodies, by using a microscope that magnifies at least 100 times.

• Plant cells can be seen easily in a tiny, thin layer of onion skin. Put the onion skin on a microscope slide, add a drop of water, and cover the onion skin with a cover slip. With a sufficiently thin piece in focus you should be able to see rectangular or brick-shaped cells. By adding a stain made of iodine diluted with water you should be able to see the round nucleus inside the cells.

• To see epithelial cells, gently scrape the inner lining of the cheek with the flat end of a toothpick. Then transfer these scrapings to a slide and stir the material to spread the cells around. Stain the cells with diluted iodine and apply a coverslip. Under high power you should be able to see irregular pentagonal-shaped cells *(see diagram)*. You may also be able to borrow prepared slides of blood cells or other human cells from a biology teacher or school nurse.



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• *Teaching Elementary Science: A Sourcebook for Elementary Science*, by E. Hone, A. Joseph, E. Victor, and P. Brandwein, Harcourt, Brace & World, Inc., New York, 1962, $7.50.

Male gerbils (right) have large, dark-colored sacs (containing the testes) near the base of their tails. Males are also smaller than females (left).

Gerbils

Gerbils (pronounced JUR-bils) were first introduced to North America in 1954 for use in medical research. They are especially useful in studies of heart and kidney diseases. Just recently it has been discovered that gerbils may become important in the study of epilepsy. Until now, no laboratory animal had been found that suffered from epileptic-like seizures.

If you keep gerbils in an aquarium tank, don't set the container in direct sunlight. The temperature inside the glass container might rise high enough to kill the gerbils.

Gerbils are adapted for life in the desert, and need very little water. Their body wastes are relatively dry, so gerbils do not present the odor and cleaning problems of many other small mammals. (Remind your pupils of the adaptations of desert animals that were described in "Survival in the Desert," *N&S*, Oct. 30, 1967.)

Gerbils become sexually mature at age nine to 12 weeks, but you may be able to tell the sexes apart by the time the mammals are three weeks old *(see photo)*. The *gestation* period (time between conception and birth) is about 24 days.

Brain-Boosters

Mystery Photo: The patterns on the wall were left when the building that once adjoined it was torn down. The broad diagonal lines show where the stairs were.

If you teach in a city, your pupils may be able to find another example of a wall like this. From a photo or sketch of the wall, the whole class could guess at the significance of the marks left on it.

What would happen if? You could make a device like the one shown on page 13 out of cardboard, and let your students test the various arrangements. Only in position 1 of the arrangements shown will the system remain in balance. You might encourage your students to try to find other arrangements of the system in which the beam would balance.

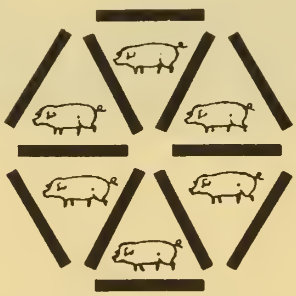
Can you do it? As water freezes, air that is dissolved in the water is forced from the solidifying ice into the still-liquid water. Thus, the air is caught in the last part of the ice cube to freeze, giving it a cloudy white appearance.

Clear ice cubes that you find in restaurants are made by special ma-
(Continued on page 4T)

(continued from page 3T)

chines that remove the air from the water as it freezes. You can make a clearer ice cube by boiling the water (to remove most of the dissolved air) before putting it into the freezer.

Fun with numbers and shapes: When you have a few spare moments, you might pass out toothpicks or matchsticks to help your pupils solve this problem. The diagram below shows one way to make six pigpens with 12 sections of fence. Perhaps your pupils may find other ways.



For science experts only: The weight of the spheres at the outer ends of their channels was supposed to overbalance the spheres at the inner ends, turning the wheel of the "perpetual motion" machine counter-clockwise. As the wheel turned, the weights at the inner ends would fall to the outer ends of their channels, presumably providing enough leverage to keep the process going. But there were never enough weights at the left-hand rim of the wheel to turn it.

If you have the October 3, 1966 issue of *N&S,* you might use the article *"Perpetual Motion Machines – Are They Possible?"* to launch a discussion of these machines and why they cannot work.

For calendar experts only: George Washington was elected in 1789 and took office the same year. Thomas Jefferson was elected in 1800 and William McKinley in 1900—neither of which were Leap Years. In the Gregorian calendar *(see "Keeping Track of the Year,"* N&S, *January 8, 1968)* years ending in two zeroes are only Leap Years if they can be evenly divided by 400. The year 2000, for example, will be a Leap Year.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 12 / MARCH 4, 1968 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

The Sap Is Rising

At one time it was believed that root pressure alone forced water to the tops of plants. Then botanists inserted pressure gauges into the bases of tree trunks and found that the high level of root pressure occurred just after sunrise. Root pressure was lowest just when the plant needed water most, in the heat of the day.

Some other process or processes must bring the water to the highest parts of plants. One theory is that the process of *transpiration*—the giving off of water from leaves—has an effect on water movement to the tops of plants. As water molecules leave a leaf and escape into the air, a force is created that pulls other water molecules upward into the leaf.

The results of some experiments, however, do not support this theory (called the "transpiration-tension" theory). Sap movement in plants still puzzles botanists.

The amount of root pressure depends on the kind of plant being used, the amount of water in the soil, the soil temperature, and the amount of salts in the soil. The next-to-last paragraph of the article suggests some ideas for investigating these factors, using the same simple pressure gauges.

The Earliest Indians . . .

If you asked your pupils to draw a picture of an Indian you would probably get drawings of a feathered warrior riding across a prairie or a sheepherder in the sandstone canyons of Arizona. Add the word "prehistoric" and they may think of the cliff dwellers of Mesa Verde, Colorado.

Point out that North America's deserts, mountains, coasts, plains, swamps, and forests have been the home of many groups of Indians. Ask how the lives of these groups may have differed. Most of your pupils probably picture Indians in relation to the early American settlers. Point out that Indians all over North America had developed cultures of their own thousands of years before the first Europeans came.

Such old or vanished civilizations challenge scientists who want to piece together the jig-saw puzzle of man's social development over the past two million years. What these scientists find may help increase understanding of today's societies. A scientist may ask, why did an old society make war? What effects did wars have on the people's life? What kind of family life did different groups have? Did it strengthen or weaken the group?

Using his imagination and logic, the archeologist tries to find answers in the things he uncovers. Scientists who studied the remains of one Indian village where women used to live in the same dwelling with their daughters decided that the continuing strong influence of elders was a big reason why pottery made there was almost all the same.

The archeologist tries to learn from

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 1T-4T.)

IN THE NEXT ISSUE

Electromagnetism, motors, and generators . . . WALL CHART on the electromagnetic spectrum . . . Why eagles are declining in numbers and what can be done about it . . . Investigating respiration and exercise with goldfish.

Using This Issue . . .
(continued from page 1T)

the physical remains of a people what habits and customs they used for adapting to their environment. Pots, arrowheads, house walls, and axes can reflect the political system, language, religious beliefs, and the attitude of the people toward their ancestors *(see "The Mystery of the Mayas,"* N&S, *Nov. 13 and Dec. 4, 1967)*. Ask your pupils what difference it would make to them if they uncovered a carefully made bowl in a grave, rather than in a house or on the altar of a temple.

• *What should students do with an archeological "find"?* They should not dig into it. Rather, report it to a scientist at a nearby university. When a site is dug it is gone forever. If the digging is done by scientists, they will make a report that others can learn from. There will be a record of the age and location of things found. Archeological sites belong to the whole nation, and in many places amateur digging in public land is illegal.

Activities

• When a building is torn down, it leaves signs that may tell something about its structure and use *(see mystery photo in "Brain-Boosters,"* N&S, *Feb. 19, 1968)*. Have your pupils survey vacant lots in their neighborhood and give a brief report. Was there a building there? How long ago? How big was it? Was it a house, garage, office building? What was it made of? Besides a foundation, were any other clues left that reveal something about the building's use?

• Ask your students to predict what scientists 2,000 years from now will be able to tell from the land where their own house now stands. Have them make lists of what might still be left. What would have disappeared?

Today's Indians

"There goes the neighborhood," said an Indian in disgust as the Pilgrims landed. At least this is the way one cartoonist pictured it. And from the viewpoint of the Indians—the first Americans—the "neighborhood" and Indian life was ruined by aliens from Europe.

Many teachers in the middle elementary grades teach units on the history of Indians in North America, and textbooks record some of the sad history of broken treaties and neglect by the United States government. The study of present-day Indians and their problems may make the subject more meaningful for your pupils.

There are more than 550,000 American Indians in the United States today. About 3 out of 5 Indians still live on or near the 250 reservations set aside for their use. Many of the reservations are on land of poor quality, in depressed areas where job opportunities are limited. Schools provided for the Indian children have often been inadequate.

After reading the text and captions of this article, your pupils can probably sympathize with the older Indians, trying to teach the young the old skills and customs and the history of their tribe. Ask your pupils if any of them has experienced (or is experiencing) the pressures that bear on the young Indians. Are they being taught any customs or skills that will be of no practical use later in life? Thoughts like this may spark some lively discussion. Try to bring out the values of old customs, traditions, etc. to a group of people.

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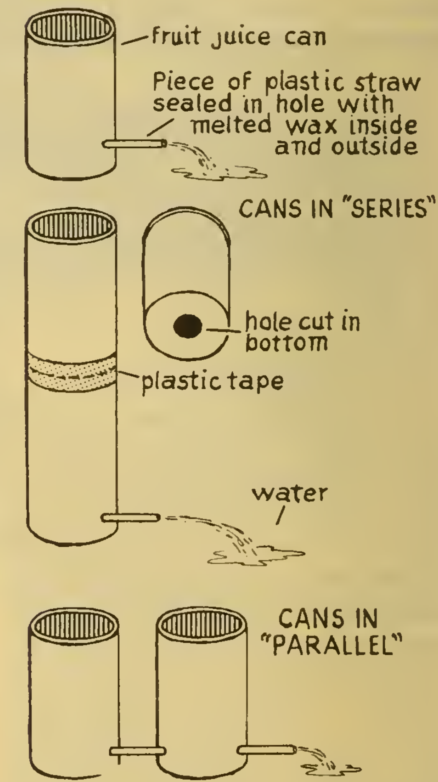
• *The North American Indians,* by Ernest Berke, Doubleday & Company, Inc., New York, 1963, $3.75.

Bulbs and Batteries

If you plan to have small groups of pupils make these investigations in class, it might be helpful to provide No. 6 dry cells, 3-volt bulbs and porcelain sockets (two or three of each), and a few feet of bell wire for each group. (You may be able to borrow these materials from a high school physics lab.) The No. 6 cells have screw-on terminals that make it easier to connect wires and keep the contacts tight (the taped and springwire contacts suggested for penlight cells and bulbs tend to get loose in handling).



• You can use three fruit-juice cans of ‘he same size to demonstrate what happens when cells are connected in series and in parallel *(see diagram)*. With an ice pick or awl, punch a hole in the side of one can near the bottom.

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

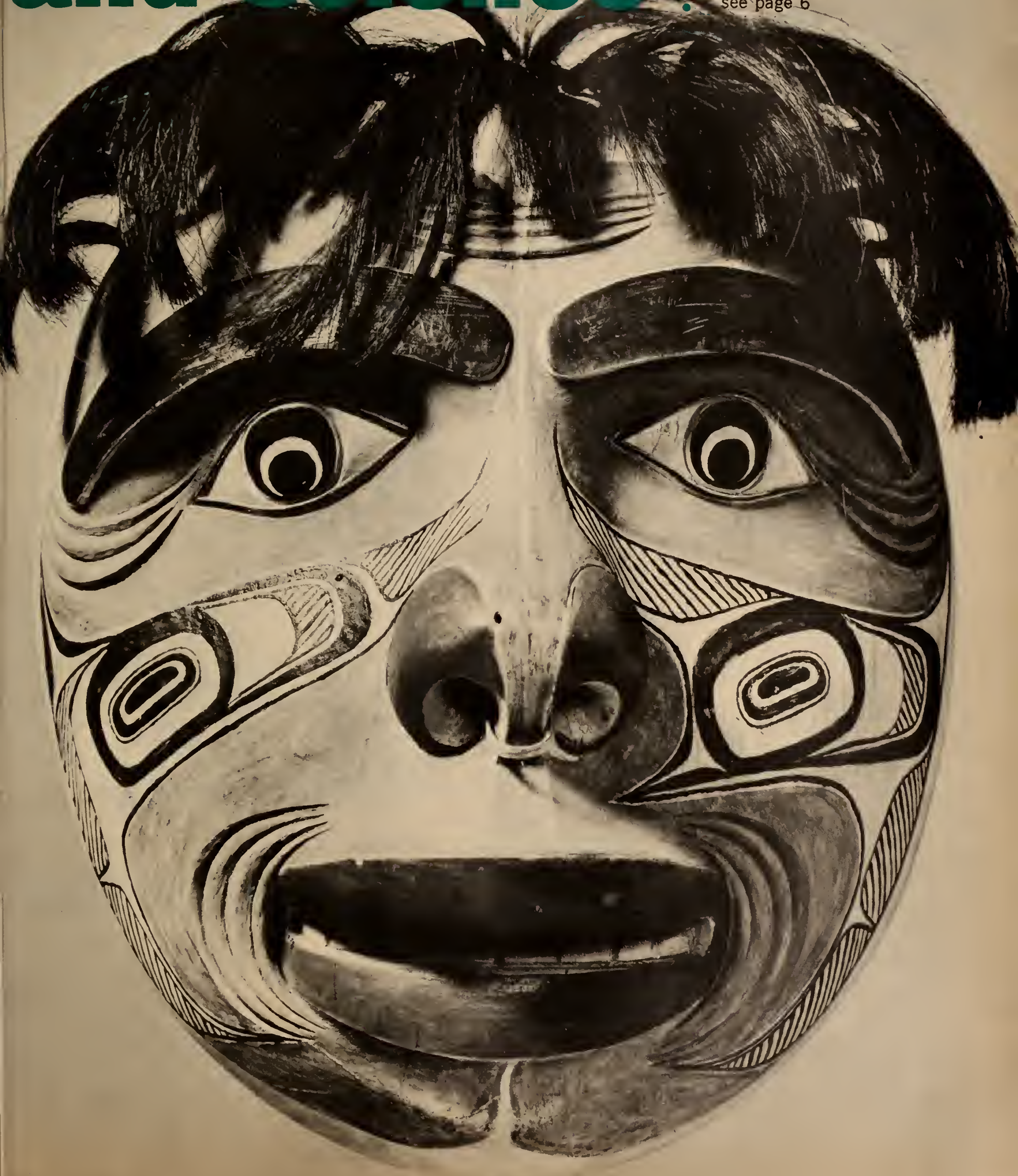
nature and science

VOL. 5 NO. 12 / MARCH 4, 1968

Scientists and college students are digging and sifting soil to find out more about...

THE EARLIEST INDIANS OF THE NORTHWEST COAST

see page 6



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PICTURE CREDITS: Cover, The American Museum of Natural History; pp. 2, 7, 14-15, drawings by Graphic Arts Department, AMNH; pp. 4-5, David Hancock; pp. 6, 8-11, Ruth Kirk; p. 12, Thomas McAvoy, Life Magazine, Time, Inc.; p. 13, David Webster; p. 16, The New York Times.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** R. J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen
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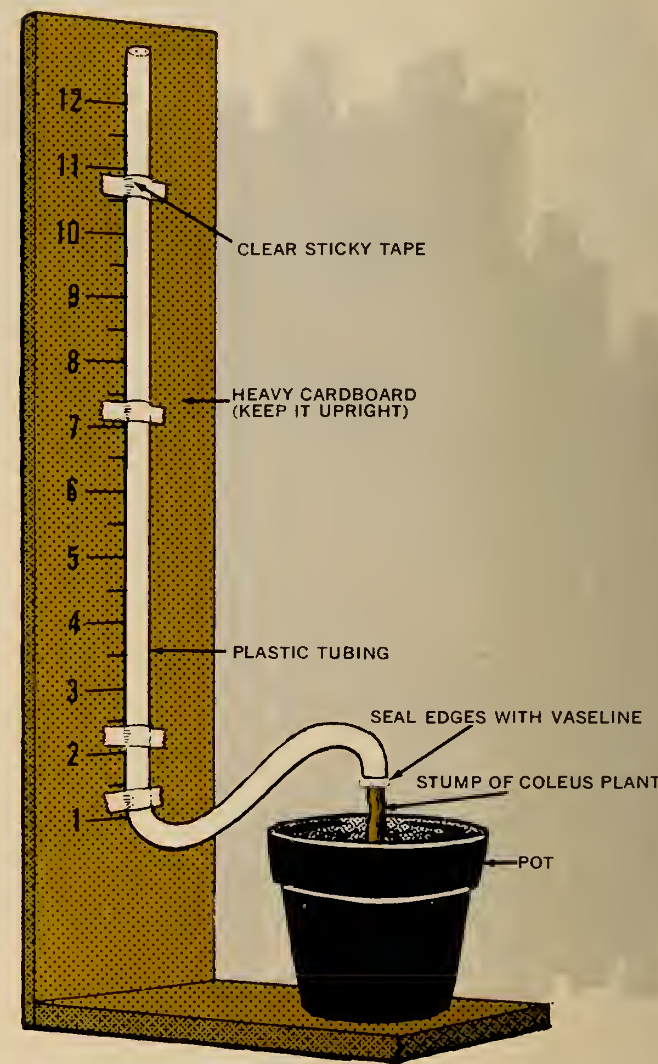
SCIENCE WORKSHOP

THE

In the spring, sap begins to move up the trunks and limbs of trees. With some simple equipment and six house plants, you can measure the pressure that pushes this liquid upward.



SOIL CONDITIONS IN POT	POT #1 WET 35-40°F	POT #2 WET 65-75°F	POT #3 WET 85-95°F	POT #4 DRY 35-40°F	POT #5 DRY 65-75°F	POT #6 DRY 85-95°F
HEIGHT OF WATER—FIRST HOUR						
HEIGHT OF WATER—SECOND HOUR						

Dr. Richard M. Klein is Professor of Botany at the University of Vermont, in Burlington, and Dr. Deana T. Klein is Associate Professor of Biology at St. Michael's College, in Winooski, Vermont.

SAP IS RISING

by
Richard M. Klein
and Deana T. Klein

■ Each spring, new leaves and flowers begin to grow on trees. For the leaves and flowers to develop properly, water and minerals from the soil must rise in the plant all the way to the topmost branches and twigs. For many years, plant scientists have been trying to find out how this watery *sap,* as it is called, can get to the top of a really tall tree.

People once thought that a tree had some hidden "pump," but this has been shown to be false. Scientists now believe that water moves from soil to tree top by a series of steps, with one or more processes in each step. This Science Workshop suggests a way for you to study the second step—the movement of water from the roots to the stem.

Make a Simple Pressure Gauge

Studying water movements in large forest trees is a complicated business; it is even harder to bring whole trees into a laboratory. Fortunately, you can study the flow of sap by using small plants. The Coleus plant is excellent for this purpose. For these experiments, you will need six Coleus plants. You can buy them in "dime" stores or a florist's shop. Each plant should be about 8 to 10 inches tall, about the same size, and should have the same color markings on the leaves.

You will also need some Vaseline; six pieces of transparent, flexible plastic tubing; six strips of heavy cardboard; a thermometer; and some clear sticky tape. Buy the plants first and then the plastic tubing because you will need tubing just big enough to slip tightly over the cut-off stems of the plants. (You can get plastic tubing from a drugstore.)

When you have all the material, you can make *pressure gauges* to measure the sap or root pressure. The diagram shows how to make a simple pressure gauge.

Wet and Dry, Hot and Cold

Before setting up your experiment, think about the conditions that might exist in the soil around trees in the early spring. The soil can be wet or dry. The weather might be sunny and warm and the soil will quickly warm up. Or the weather might be cold, and the soil will also be cold. These, then, are the conditions you should try to have for the different Coleus plants.

You can control "wet" or "dry" soil simply by watering or not watering the plants. You can control temperature by placing the plants in the refrigerator (about 35°-40°F), leaving them at room temperature (about 65°-75°F), and by placing them on either a radiator or a thin wooden board held just above two 100-watt electric lights (about 85°-95°F). You can measure soil temperature during the experiment by pushing a thermometer into the pot. With six plants, you can have one "wet" and one "dry" plant at each of the three temperatures *(see table).*

When you get the plants, keep them in a warm sunny place for about four days, watering only three of them. Leave the other three dry. Make six pressure gauges during the four-day wait. Then put two plants in the refrigerator, two on a radiator, and leave two at room temperature *(see table).* Next, use a single-edged razor blade and cut a plant off about one inch above the soil line. Immediately put the lower, free end of the plastic tubing over the plant's stump. Seal the edges with Vaseline so that water does not leak out around the tubing. (Leaking can spoil your experiment.) Mark down the time that you cut off the plant and attached the pressure gauge. Then repeat this process with the other five plants.

As the water in the soil is taken up by the roots and moves up to the stem, it builds up quite a bit of pressure. This root or sap pressure is measured by your pressure gauge. The greater the pressure, the faster and farther the water will move up the tube of the pressure gauge.

To measure the pressure read the scale marked on the board of the gauge *(see diagram).* Make readings every hour for several hours, beginning at the time when you cut off the plant. Keep a record of the pressure in the different plants (use a table like the one on page 2).

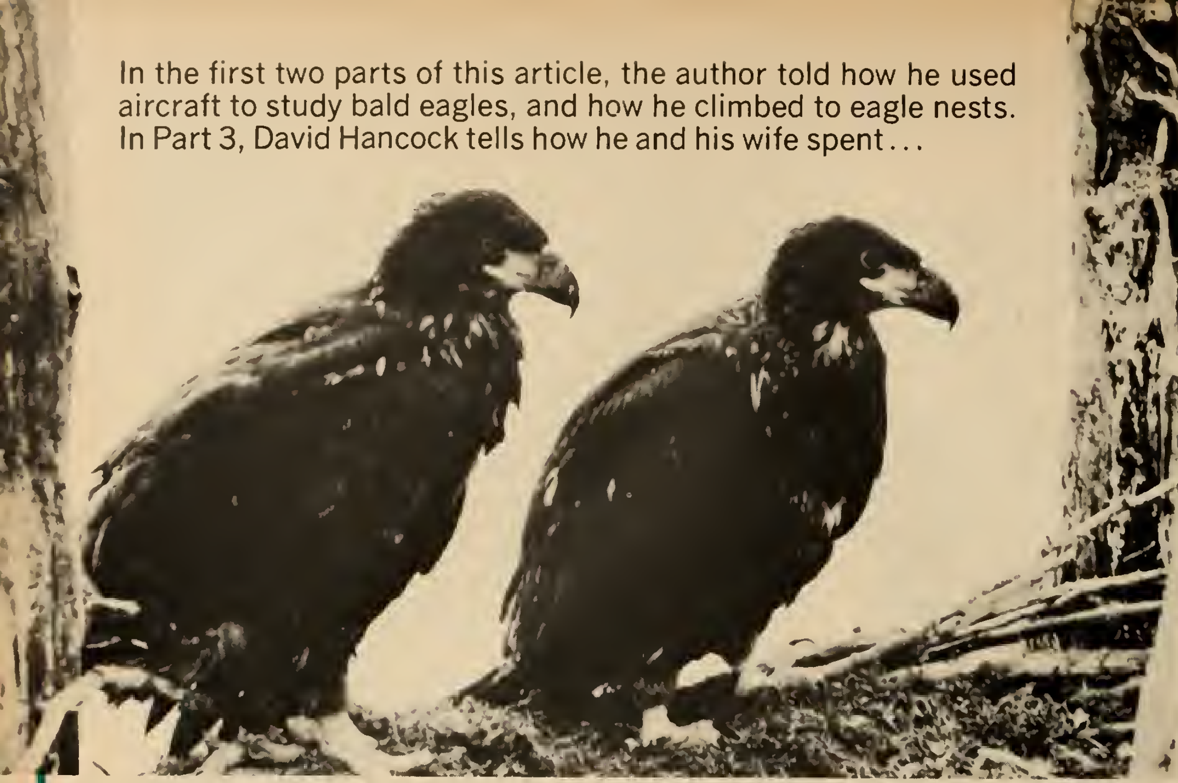
What Affects Sap Pressure?

Are there differences in the heights of the water columns with different amounts of moisture in the soil? Does the temperature of the soil have any effect on the pressure? What sort of spring weather do you think would make sap rise quickly in trees?

You can use your pressure gauges for many other investigations. You can compare sap pressure in Coleus with the pressure in other plants, such as geraniums. Suppose you overwatered plants for a week or two before running the experiments. Would the sap pressure be greater or less than normal? Try adding a tablespoon of salt to each cup of water used to wet the soil. How does this affect the sap pressure? Do you think that removing part of the root system would change the pressure?

If you test any of these ideas, be sure to have a *control* on your investigation. If you water plants with salty water, for example, be sure to compare them with similar plants that have been watered with unsalted water ■

In the first two parts of this article, the author told how he used aircraft to study bald eagles, and how he climbed to eagle nests. In Part 3, David Hancock tells how he and his wife spent...



A year after his all-day stay in this nest, David Hancock returned and took this photograph. The young eagles shown here are not the ones mentioned in the article, but were born the following summer. The author discovered that his visits to some nests had a harmful effect on the number of young that were raised *(see text).*

Nine Hours in an Eagle's Nest

by David Hancock

■ "Another wet drizzling morning with the clouds hanging on the tree tops," I scribbled in my notebook as we headed by boat for nest Number 137. When we reached the island where the nest was, I dropped off my assistant, Lionel Hughes-Games, and my wife, Lyn. Then I circled the island in the boat, observing the beaches and taking notes on what I saw. This sort of information may help us learn why one area of coastline has more eagles than another area.

In 20 minutes I headed back toward the nest tree. I looked up at the nest—135 feet above the water—and saw my wife gleefully waving from the nest platform. I was so startled I drove the boat right up onto the beach!

I fought my way over the rocks and through the dense brush to the base of the tree. It was a massive red cedar, about seven feet in diameter. On the ground lay my wife's jacket. A rope dangled down from the lowest branch. Somewhere up through the snarl of branches was my wife. Before I had time to catch my breath and yell, the rope started to jump. A foot, then two legs, then a backside appeared through the branches. Then the rest of Lionel appeared. He had a silly grin on his face.

"Well," he said, "she thought that, since this tree leaned at an angle out over the water and had so many branches to hang on to, she would have a try at it.

"Unfortunately," he continued, "I left the bands for the eagles on the window sill of the cabin and I'm going back now for them. Besides, now that Lyn has climbed to her first eagle's nest, she wants a picture of it, so I'll bring back the camera."

Sharing a Nest with Eagles

Cautiously, I worked my way up, over, under, and through the often slippery branches.

"Surely my wife isn't up this tree," I told myself. Then I broke through the canopy of leaves. Lyn beamed a proud smile at me from the four-foot-wide nest. Perched on either side of her—as though humans visited the nest every day—were two full-grown eaglets.

Just then, the wind blew some of the clouds away. It was a marvelous picture; if only Lionel would hurry back with the camera. The nest was cradled by three cedar limbs. Unfortunately, it was a small nest, with barely enough room for two eagles, let alone two people.

We weighed the eagles and measured their wingspan, body length, foot width, and feather length. This information helps us figure out an eaglet's age and sex. Half an hour passed. There was still no sign of Lionel returning in the boat. All that remained to do was put identity bands on the birds.

"Much as I like to see that sun, I hope the wind doesn't get stronger," Lyn said.

Carefully, we rearranged our positions. My legs hung over the nest edge, dangling 135 feet above the sea. Lyn, more cautious, sat in the center of the nest, holding one eaglet on her lap while the other sat between us.

Two, then three hours passed. Surely, Lionel must have had motor trouble. We hoped for his safety. By the end of four hours, we were hungry and nibbled at our only two chocolate bars. Our concern for Lionel grew. Was he stranded on some island? (And us on another?) Had he met a worse fate on a now white-capped sea? We decided to wait in the vantage point of the nest. Lyn said she didn't want to try climbing this tree a second time.

Between our thoughts of Lionel and our growing worries about what to do when night came, we talked about our life before we were married. This was the first time we'd ever been in one place long enough to talk much about it. Our first date had been on an eagle survey, and our wedding took place three weeks after that.

The eaglets were so used to our company that they went to sleep. One had its huge beak and head propped over my leg. The sun was getting lower on the horizon and the wind was dropping.

Both eagles suddenly looked up—overhead was their mother carrying the evening meal. They both stood up, stretched their wings and nearly fell off the crowded nest. I knew they must have their dinner. We decided to climb down the tree and prepare a fire and lean-to for the evening.

Before I had the fire started, the adult eagle had brought food to the nest for her young. Just as our makeshift camp was ready, we heard a motor. Lionel arrived with the bands and camera. As we feared, he had had trouble with the boat's motor.

In the last rays of sunlight, I climbed the tree again and put bands on the young eagles. My only regret, now that Lionel was safe, was that I did not get a picture of Lyn in "her" eagle's nest.

Passing by the nest three days later, we saw both parent eagles circling the nest. Then we saw the young male launch himself into the air on his first flight. Out toward our boat he came. Right above us he turned left, then headed for the shore 100 yards away. Awkwardly, he approached the trees, his wings back-paddling furiously to help slow himself. *Thump . . . shuffle . . . shuffle* — he landed. He folded his 6½-foot span of wings. He was bigger than his father but still wearing the brown feathers of a juvenile. His sister stayed in the nest. She might not fly for another day or two. The female's growth is usually slower than the male's.

Lyn and I kept staring at the eaglets. She was wondering, just as I was: Where would the young eagles be going? Would they survive careless hunters with guns? Would they find enough food? Would they be back here again in five years, wearing the white head and tail feathers of adult bald eagles, ready to rear their own young? We wondered and we wished them well.

A Sad But Important Discovery

It is difficult not to feel personally attached and concerned for the creatures you have studied. The life of the biologist has many rewards, but it also can produce heartbreaks.

My goal was to study the bald eagle so that with greater understanding of its ways we could better protect this bird from being wiped out. Several months after my helicopter flights over the nests to count eggs, however, I realized I had caused great harm to some of the nests. I discovered that the close helicopter flights and my climbs to eagle nests had a harmful effect on the number of young that were raised in those nests. Unintentionally, I had hurt the chances for survival of the very birds I was trying to help.

Apparently, bald eagles (and maybe other birds as well) don't feel safe if their nests have been discovered by a climber or a hovering helicopter. When they don't feel safe, they more easily lose their eggs to crows, or abandon their nests. The result: My banding work and helicopter flights near nests resulted in only half the normal number of young being raised in those nests the following year.

But some good may come from this sad discovery. No one had suspected that close observation of nests would have such an effect on the number of young produced in the following years. It is discouraging to think that I somehow reduced, at least temporarily, the number of young eagles produced in my study area. But this information will help other biologists avoid the same problem in their studies of the bald eagle, and perhaps of other birds ■

The bald eagle has disappeared from many parts of North America. In the next issue, David Hancock tells why the number of bald eagles is getting smaller, and what must be done to save the eagle.

David Hancock and his wife, Lyn, used boats, airplanes, and helicopters to study eagles along the coast of British Columbia. They first met on a "flying date," when Lyn took notes as they observed eagle nests from the air.

A SCIENCE ADVENTURE

Digging and sifting the earth on a point that juts out into the Pacific Ocean, scientists are searching for—and finding—tell-tale remains of . . .

THE EARLIEST INDIANS OF THE NORTHWEST COAST

by Ruth Kirk

Students dug this trench into a beach near the Ozette Indian Reservation *(see map)*. Each shovelful of dirt was thrown onto a table where a student searched through it for bones, old tools, charcoal, or other leftovers from when Indians lived there.

■ Richard Daugherty and Harvey Rice stood beneath a dripping spruce tree, looking into the four-foot hole cut into the black mud at their feet. Beyond them, waves lapped the beach and a seal bobbed in the ocean swells a little way out. It was an August day in 1966, gray with rain, but neither man noticed the waves, the seal, or the raindrops spattering off their rubber parkas. What held their eyes were the bits of charred wood and bones they had just uncovered at the bottom of the pit.

This scene took place near the Ozette Indian Reservation in the state of Washington *(see map on next page)*. Dr. Daugherty is a Professor of Anthropology (the study of man) at Washington State University, in Pullman. Harvey Rice is an archeologist—a scientist who studies how people lived in the past. The two scientists knew that the fossil fragments in the pit were the remains of a campfire where men had once roasted meat and left the bones in the embers of the fire.

ABOUT THE COVER: Masks like the one shown on the cover were carved and painted by the Northwest Coast Indians to look like people, animals, or "spirits." *Shamans* (people who were supposed to have "magic" powers) and members of secret groups and certain families wore these masks when they danced in ceremonies.

From the location of the remains, they guessed that the fireplace had been used by men who lived there thousands of years ago. But not until months later, when the charred wood was "dated" at the university laboratory *(see "Dating Fossils by Radioactivity")* did they learn that the fireplace was probably about 6,000 years old!

This is centuries older than any other remains of early man's life that have been found so far on the Northwest Coast. Before they can be certain that men lived there 6,000 years ago, however, the scientists will collect many more samples of such remains and compare the ages recorded by their measuring instruments.

Last summer a team of scientists directed by Dr. Daugherty returned to Ozette to continue digging. "In summer we excavate the site," Dr. Daugherty explained, "and the rest of the year we analyze what we have found. Archeology is like a puzzle. You find the pieces, and then you fit them together and you can begin to understand what you are looking at."

Why Dig at Ozette?

For a long time experts have known that the Northwest Coast Indians had developed an advanced *culture,* or way of life, before the arrival of white men in the late 1700s. In fact, this early people's culture was one of the most advanced in North America. They have not been studied much, however, except in Alaska.

"We actually know more about prehistoric men along the Nile River in Egypt than we do about early-day Indians living on our own Pacific coast," said Dr. Daugherty. "It is past time that we studied where they came from, and when, and how they lived."

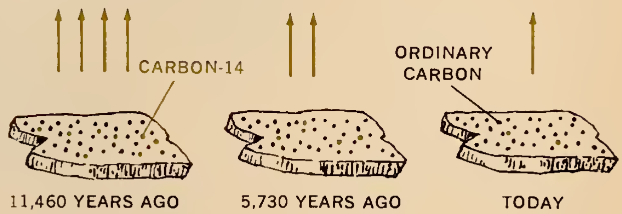
Part of the reason for the delay in studying the remains of these people is that archeologists in the Northwest have barely been able to stay ahead of the power shovels and bulldozers building dams and highways. They have to study places where Indians are known to have lived before the sites are destroyed forever. Dr. Daugherty did this kind of work in the eastern part of Washington, but he longed to get back to the west coast. He lived there as a boy, and when he was a college student, he helped the present-day Indians fish for salmon while he studied their culture and beliefs *(see "Today's Northwest Coast Indians," page 8).*

He knew that from Alaska to the Channel Islands of California, early men hunted sea mammals such as whales and seals, depending more on the ocean than on the land for food. These Indians paddled their canoes eight or ten miles out to sea to harpoon whales. After sinking a harpoon point deep into a whale, they prayed that the great animal would swim for the beach and not pull them to sea.

DATING FOSSILS BY RADIOACTIVITY

A living plant or animal takes in carbon from the earth's atmosphere, and a tiny part of that carbon is a kind called *carbon-14.* Because it is *radioactive,* carbon-14 is slowly but constantly changing into another element, called nitrogen-14. As the carbon-14 in a living plant or animal disappears in this way, it is constantly replaced by 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. The amount of carbon-14 in the remains of the plant or animal gets smaller and smaller as it steadily changes into nitrogen-14. It takes 5,730 years, though, for half of the carbon-14 to disappear. (This period of time is called the *half-life* of carbon-14.) Then it takes 5,730 years longer for half the remaining carbon-14 to disappear, and so on *(see diagram).* By measuring the carbon-14 in a piece of fossil wood or bone and comparing it with the amount that was in the plant or animal when it was alive, scientists can tell how long ago the plant or animal was alive.



If their prayers went unanswered, the hunters might spend a week or more in their wave-tossed canoes rather than cut the line holding them to the whale.

Most Indian tribes that developed an advanced culture raised their own food plants. Indians who depended on hunting, fishing, and gathering wild plants for food usually had time to develop only a simple culture. But this was not true for the Northwest Coast Indians.

From cedar trees they got bark for clothes, wood for

(Continued on page 10)

THE CUSTOMS OF THEIR ANCESTORS MAY DISAPPEAR WITH

TODAY'S NORTHWEST COAST INDIANS

■ Young Indians along the northwest coast of the state of Washington lead two kinds of lives. They ride yellow buses to school and study the same arithmetic and history that everyone else in the United States does. They play Little League baseball and watch television.

But they also help their fathers pull salmon and smelt into dugout canoes. They go into the forest with their families to gather material for making baskets. Occasionally they hear the *THUMP-thump-thump-THUMP-thump* of deerskin drums as a village elder announces a *potlatch,* the special type of party of the Northwest Coast Indians.

Sometimes the party is to celebrate a wedding or to wish a serviceman well as he is sent to Vietnam. Once a year it is to celebrate the birthday of the young chief of the Quileute Indians, David Hudson, who will be 14 years old this June. Indians come to the party from as far as Oregon and British Columbia, Canada.

The photographs on these pages show some of the Indian ways that have been passed down through the centuries. How long the old customs continue will soon be up to David and the others in his generation. They must learn about the old, passing world as they train for the modern world—and that is a big job. Five or six tribal elders, including David's grandfather, still know how to hollow logs into canoes. A few of the boys help. Perhaps they will learn enough to carry on the art.

Girls watch their mothers and grandmothers make baskets and some of them are learning how. But only the older women know exactly what time of year to gather and prepare the bark and wild grasses used in the baskets. None of the young people are learning the complicated Indian languages. Each village has its own language, and the elders prefer the old languages to English. But they know that the words soon will die forever.

—Ruth Kirk

The leaders of the Makah tribe have set up classes to teach the young Indians the Makah customs. Each year, they hold a "Makahs Study Makahs" day, when older Indians tell the youngsters the legends of their tribe (right). The boys wear Makah costumes and perform the tribal dances they have learned (above).

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'etails and photographs about the oast Indians today, look in your li- okstore for: **David, Young Chief of** *s, by Ruth Kirk, Harcourt,Brace & New York, 1967, $3.25.*

An Indian boy (far left) uses an axe to loosen a strip of bark from a cedar tree. He will then pull off a 30 or 40-foot strip of bark. His grandmother (left) uses the bark and the stems of bear grass to make a basket.

←

For thousands of years, Indians have fished the rivers and ocean along the northwest coast of North America. They used canoes hollowed from single cedar logs. Today only a few of the older Indians know how to make such canoes. Here, Charles Howeattle uses an adze to finish the bow of a canoe. The cutting edge of the adze is an old axe blade; the handle is made of whalebone. Today's canoes will last 40 or 50 years if they are cared for. Then there will be no more— unless Indian boys learn the art of canoe-making.

David Hudson (far left) and his brother Dennis listen as their great-grandfather, Charles Howeattle, tells how he used to paddle to sea in a canoe and hunt seals with spear-like harpoons. He is showing the boys his cedar bark bag used to store harpoon points. The Indians no longer hunt seals. David Hudson, 11 years old when this photo was taken, is now nearly 14. He is chief of the Quileute tribe.

An Indian of the Quileute tribe beats a drum while making announcements at a potlatch (party). The drum is made of deerskin and painted with a thunderbird design. Thunderbird was one of the most important spirits in the old tribal days and the Indians still tell stories about him.

houses, and logs to hollow out for canoes. Salmon came up the rivers from the sea to mate; deer and elk roamed the forests; seals, sea lions, and whales swam along the coast as they migrated northward in the spring and southward in the fall. At each low tide, clams, barnacles, sea snails, and other tasty sea animals could be gathered on the beaches. Food and shelter were so easy to obtain that these people had time to develop advanced ways of living, and to create works of art.

Finding the Pieces

Dr. Daugherty knew that the Ozette coast was a promising place to look for remains of these prehistoric ocean-going people. He had hiked the entire northern coast of Washington, about 80 miles of wilderness that still is little touched by modern life. He knew that the land at Ozette juts farther to the west than any other point on the coast, bringing it closer to the migration routes of the sea mammals; this was a great convenience for early hunters. Also, at Ozette Dr. Daugherty had found deep deposits of *midden* (bits of shell and bone and charcoal from long-ago dinners). He had seen photographs from the 1890s showing a village lining the beach, and he had talked with Indians who remembered living there as children.

He decided that the old *terraces*—flat areas shaped by waves thousands of years ago when the ocean was higher than it is now—would be good places to look for ancient remains. And from the fallen-down houses of the now-abandoned village, as well as from the living Indians, much could be learned about the last days of the Ozette people.

The work began in June 1966, supported by the National Science Foundation and Washington State University. Fifty students and professors arrived at the beach. A few flew in by plane and landed on wet sand at the edge of the waves, but most walked 3½ miles through the forest from the end of the nearest road, and then another half mile up the beach. United States Coast Guard helicopters lifted in three tons of equipment: cook stoves, butane gas, tents, shovels, drills, and food.

The students came from 14 colleges and universities to learn the basic methods of field archeology. The professors were mostly from Washington State University, but not all were anthropologists or archeologists. (This dig was to be a new sort; Dr. Daugherty wanted experts in many different fields to help with the dig and interpret the findings.)

At the main site, students dug a trench 70 meters (about 228 feet) long and two meters wide *(see photo on page 6)*. It cut through five beach terraces, each one shaped by the waves when the ocean was at a different level in the last 10,000 to 13,000 years. The walls of the trench were marked off in two-meter squares with string. Each student drew a diagram showing the layers of earth, the rocks, the fine sand, the ancient fireplaces, the filled-in holes where house posts had been, the whale bones he found. He numbered each object he took from the trench. Back at the laboratory the diagrams would be fitted together and redrawn into a seven-meter-long record of the centuries *(see photos)*.

Each shovelful of earth was tossed onto a table, and

The tags in the trench wall *(left photo)* show where a student has removed objects. At right, Dr. Richard Daugherty checks part of a drawing of the trench against a student's sketch of the section he worked in.

students looked through it carefully for shell or scraps of bone or stone tools. Often workers in the trench used small hand tools or brushes to gently free an old fireplace from the centuries-old "junk" and earth that was piled on top of it—or to uncover a whale's skull, a clam shell, or a seal bone. The trench was four meters deep before the students stopped finding evidence of man's presence.

Each week as the digging went on a small airplane brought groceries from the town 30 miles away. When it left it was loaded with paper bags of bones and ancient tools. The searchers sent 80,000 animal bones back for study, plus hundreds of harpoons, fish points, hammers, wedges, whetstones, hair combs, pieces of jewelry, and gambling pieces. Never before have so many bones been collected from a Northwest Coast dig, nor has such a detailed drawing been made. But bones and tools are not enough to give a clear picture of the Indian life.

"To understand the people's culture," Dr. Daugherty said, "we must know about their surroundings."

Fitting the Pieces Together

One of the scientists who investigated the surroundings was Roald Fryxell, a geologist. By figuring out the age of each layer in the pit, he could make a good guess at the age of a bone, say, that was found in that layer. By studying the soil, he could tell how close to the beach the people were living at a certain time. He could even suggest where people might have beached their canoes, built their houses, and cooked their food centuries ago when the present shore was under the ocean.

Carl Gustafson, a bone scientist, had the job of sorting the 80,000 bones that were brought back to the laboratory and identifying what kind *(species)* of animals they came from. There were more bones from fur seals than from any other animal, and they were found in all layers of the dig. This indicated that fur seals have always been a part of the Indians' life. Only two or three bones out of each hundred were from land mammals such as elk or bear.

In the lower, older parts of the trench, the bones of sea otter and elephant seal were found. These mammals were all killed off along the Washington coast soon after the arrival of white men. Two types of dog bones were found. One was from a dog almost as big as a collie. This dog was like the dogs the Indians of the area have today. The other dog was much smaller. It may have been the "wool dog" that the first explorers from Europe reported seeing. The dog disappeared long ago, but the explorers wrote that it was about the size of a Pomeranian, and was bred especially for its fur, which hung to the ground. The Indians wove the fur into blankets.

Two plant specialists worked at the dig. One was an

Geologist Roald Fryxell cleans a set of *toggles*, or pins, which Indians used to wrap harpoon lines around when they hunted for whales.

ecologist who studies how plants, soil, water, climate, and other living things affect each other. The other was a *palynologist,* who studies plant pollen. The pollen of different plants found in layers of the dig enabled them to guess what the climate may have been like at the times those plants were growing on the site.

They could also tell whether cedar trees were around for Indians to make canoes, when nettles became available for the Indians to make thread and rope, and when there were salmonberries and huckleberries for the Indians to eat. Nettles grow best in soil with a lot of calcium in it, and in places where the Indians threw clam shells and bones away for years the soil became rich in calcium. The scientists think that by digging where nettles grow, they may be able to find the remains of other old villages.

An *icthyologist* examined the fish bones to find out which kinds of fishes early Indians caught. Knowing the habits of these fishes, the scientists could guess how far to sea the Indians must have been able to paddle to catch them. And from the depth in the pit where the fish bones were found, Dr. Daugherty could tell how long ago Indians built canoes that could go far out in the ocean.

From these scientists' first year of work at Ozette came the outline of 6,000 years of Northwest Coast Indian life. The search is scheduled to last several years. After it is over we may understand much more about the Northwest Coast Indian of thousands of years ago—how he worked and lived, what he liked, and what he believed ■

adopting a "mother"

When these young geese were only a few hours old, they saw Dr. Konrad Lorenz instead of their own mother. From then on they followed Dr. Lorenz as if he were their mother.

■ Can you imagine a boat or floating log on a river becoming a "mother"? It could happen. For example, if a newly-hatched duck saw such a moving object before it saw its real mother, it might adopt the strange thing as "mother" and follow it everywhere.

A newborn seal once followed a skin diver onto dry land. The seal was then taken to a zoo. For the rest of its life it seemed to prefer human beings and to ignore other seals.

How do some kinds of newborn animals "adopt" a non-living object or an animal of a different kind *(species)* as their parent? An answer was discovered more than 30 years ago in Austria. A biologist named Dr. Konrad Lorenz found that young geese would choose him as their parent under certain conditions. If the geese saw Dr. Lorenz instead of their mother when they were only a few hours old, they would follow him as they would an adult goose *(see photo)*. From then on, the birds seemed to regard Dr. Lorenz as their mother, and preferred him to their real mother.

This bond of the young to a "parent" is called *imprinting*. For many birds, the bond must be formed very soon after hatching. In one experiment, scientists found that baby chickens could be imprinted to sounds while still in their eggs. The scientists played a certain sound in the room where the eggs were kept. When the chicks hatched, they were attracted to a loudspeaker that produced that sound, but not to a loudspeaker that produced a somewhat different sound.

Imprinting may occur in many kinds of animals, including humans. Some scientists suspect that human babies are imprinted to the sound of their mother's voice, even before birth.

How Imprinting "Works"

Imprinting is a form of learning. But it differs in some important ways from what we usually call learning. For example, an animal usually learns to stay away from an object that has caused it pain. Yet a baby chicken or duck may move closer to an object that has caused it pain if the object has been imprinted as its mother.

Many things that an animal learns may be forgotten if the animal doesn't have a chance to "use" what it has learned. But an animal is less likely to forget an object that has been imprinted as its mother, even if the animal doesn't see the object for some time. Also, while most kinds of learning can take place at almost any time, imprinting can only happen during a brief "imprinting period," while an animal is very young.

Until recently, scientists believed that imprinting is produced by the movement of the "parent." Now scientists are not sure that this is the key in all cases. The imprinting bond may be created, or at least strengthened, by the color or sound of an object, as well as by its movement.

Imprinting on the wrong "parent" can sometimes lead to the death of a young animal, or it may keep the animal from ever living a normal life with its own kind. For example, if a duckling became imprinted on a log, the log couldn't care for the duckling, or teach it how to behave among other ducks. But cases like this are unusual. Normally baby ducks and other animals see and follow their own mother first. In this way, imprinting usually helps a species of animal to survive ■

Brain Boosters

prepared by DAVID WEBSTER

What would happen if...

...all the air inside a fully-inflated basketball were released into a large plastic bag? How much would the bag be blown up—just a little, about half-way, or all the way?

Mystery Photo

Why should a "walkie-talkie" or automobile radio transmitter be turned off near places where dynamiting is being done?

Can you do it?

Can you blow up one balloon inside another?

For science experts only

Which planet has canals, ice caps, and an atmosphere?

Just for fun

Tie a balloon to a piece of string and hold it against a stream of water from the faucet. You will probably be surprised at what happens.

Fun with numbers and shapes

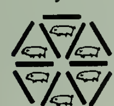
How long will it take a train that is one-half mile long and is traveling 60 miles per hour to pass through a tunnel that is one-half mile long?

ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

What would happen if? The stick will still balance only when the shorter sticks are arranged as in position 1. Would it be possible to balance the stick if one of the shorter sticks were removed?

Can you do it? Clear ice cubes are made by special machines that remove air from the water as it freezes. Can you figure out a way to remove some of the air from water so you can make clear ice cubes in your freezer?

For science experts only: The round weights at the ends of their arms were supposed to turn the wheel of the "perpetual motion" machine. As the wheel turned, the weights at the center of the machine would fall to the ends of their arms, providing leverage to keep the process going. The machine did not work because there were never enough weights at the left-hand rim of the wheel to turn it. Could the machine work if the arms were arranged differently?



Fun with numbers and shapes: Here is how to make six pig pens with 12 fence sections.

Mystery Photo: The patterns on the wall were left when the building that once adjoined it was torn down. The diagonal lines show where the stairs were.

For calendar experts only: George Washington was elected in 1789 and took office the same year. Thomas Jefferson was elected in 1800 and William McKinley in 1900—neither of which were Leap Years. Do you know why not?

BULBS AND BATTERIES

By experimenting with flashlight bulbs, dry cells, copper wire, and sticky tape, you can discover some "rules" about how an electric current behaves.

■ Suppose that you reached for a flashlight in the dark, pushed the switch, and got no light. Can you think of six possible explanations?

A flashlight won't light, of course, if it has no bulb; if it has no battery; if the bulb is burned out; or if both of the cells that make up the battery are worn out. Will it light if the bulb is loose in its socket? What if there is only one cell in a flashlight that holds two? Or if there are two cells, but they are arranged so that their *negative poles* (zinc cases) are touching each other, or their *positive poles* (the metal caps on top) are touching? Will a two-cell battery light a bulb if one of its two cells is worn out?

You can find the answers to these questions by experimenting with your flashlight. With two or three dry cells (penlight cells will do), two or three bulbs, some sticky tape, and some copper wire, you can find out many more things about how an electric current behaves. (Since a few dry cells won't make a strong enough current to give you a shock, you can use bare copper wire. Otherwise you will have to cut or scrape the coating off the wire ends. Don't let the bare wires touch each other, though.)

> **PROJECT**
>
> The switch on a flashlight acts as a valve, or "faucet," for turning the flow of current on or off. When you push the switch to turn on the light, it moves something inside the flashlight to "close" the circuit so that current can flow through it. Look inside your flashlight with the cells removed and see if you can find where the switch opens and closes the circuit.

If you experimented with electric cells as suggested in " 'Canned' Electricity," (N&S, *February 19, 1968*), you found that a cell will make current only when its negative and positive poles are connected by wire or something else that electrons can move through (*see "What Carries an Electric Current?"*). The things that electrons move through on this trip make up an electrical *circuit*.

How a Flashlight Works

Your flashlight, for example, is a circuit—a sort of pipeline to carry electrons from the negative (−) pole of the battery to its positive (+) pole. When the switch is on, the electrons move from the bottom of the battery to the end of the metal flashlight case. The case serves as a "wire" to carry the electrons to the socket touching the side of the bulb. The electrons then go through the wire in the bulb and out the bottom of the bulb to the positive pole of the battery. The wire in the bulb is so thin that the electrons going through it heat the wire and make it glow.

The parts of a flashlight circuit are arranged one after the other, in a *series*, so it is called a *series circuit*. Most flashlights have a battery of two cells connected in series. You can see why by connecting a bulb first to one cell, then to two cells in series (*see Diagram 1*). What would happen if you connected three cells this way?

Think of a cell as a pump that pushes electrons through

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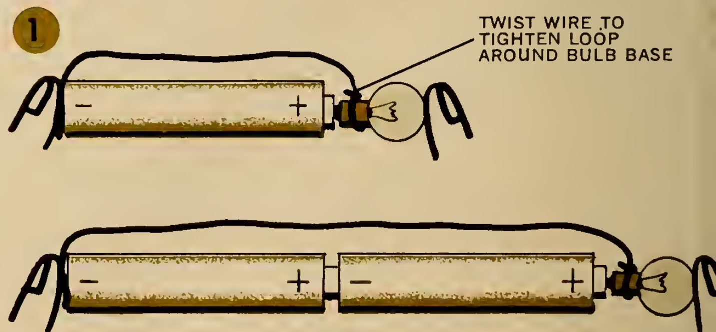

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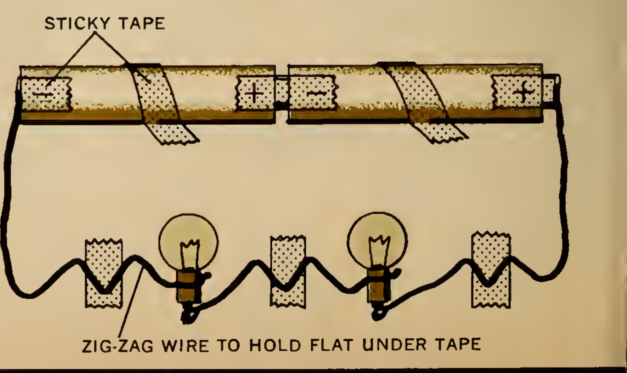


a circuit. A battery of two cells in series makes a pump twice as powerful as a single cell; it pushes twice as many electrons through the circuit in each second, increasing the flow of current.

You can get an idea of what this does to the wire in the bulb by pulling a rope (the current) through your fist (the wire in the bulb) with your other hand. Give the rope an easy pull first, then give it a hard pull. Which moves more of the rope through your fist in the same fraction of a second? Which heats up your fist more?

Like your fist gripping the rope, each part of a circuit—a wire, a bulb, or a motor, for example—offers some *resistance* to the flow of current through it. Do you think the wire inside a bulb resists the flow of current more than the wire that brings current to the bulb? How can you tell?

If you increase the resistance in the circuit by connecting one or two more bulbs in series with the battery (*see Diagram 2*), can you predict what will happen? Try it and see. Can you explain your findings?

Another Kind of Circuit

Diagram 3 shows another way to connect two or more cells in a circuit. Notice that the negative poles of the cells are connected together at one end of the circuit and the positive poles are connected together at the other end. This is called a *parallel* circuit. (Can you see why?)

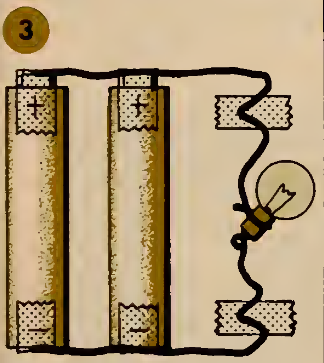
Do you think that cells connected in parallel push as much current through a circuit as when they are connected in series? How can you tell?

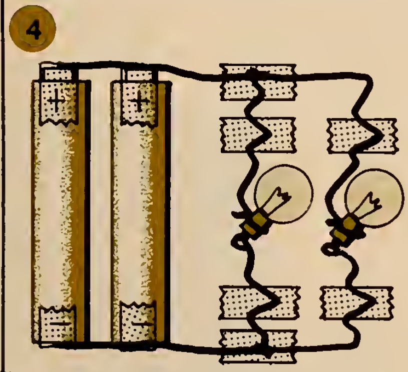
Try connecting two or three bulbs in series (*see Diagram 2*) to the cells connected in parallel. What does this extra resistance do to the current? Take one of the bulbs out of its "socket" and see what happens.

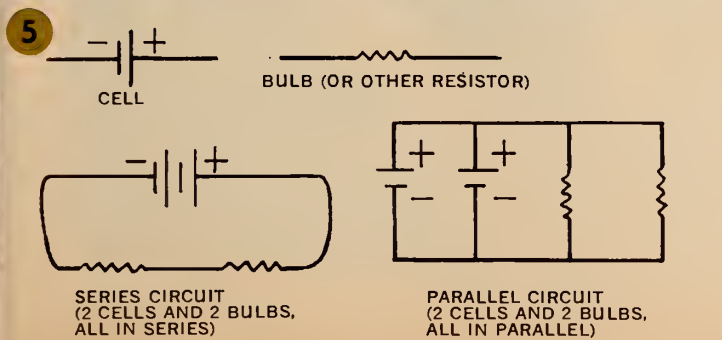
Now connect two or three bulbs in parallel (*see Diagram 4*) in a circuit with cells connected first in series, then in parallel. (Can you guess what will happen if you take one of these bulbs out of its socket?)

By experimenting this way, you should be able to work out some "rules" about how electric currents behave. It will help if you draw a diagram of each circuit you try, as shown in Diagram 5, and write down what happens to the light in each case.

You know already that adding cells in series gives more push to the charges and increases the flow of current through a circuit. What happens to the current when you add more resistance (more bulbs connected in series) to the circuit without changing the number or arrangement of cells?—F.K.L.



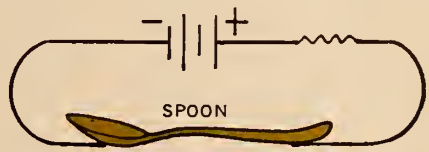




INVESTIGATION

What Carries an Electric Current?

You can test different materials to find out which ones let an electric current flow through them easily, which ones offer more resistance and slow down the current, and which ones stop the flow of current altogether. Set up a circuit of two or three dry cells connected in series with one bulb (see *diagram*). When you get the bulb lighted so you know the circuit is complete, cut one of the wires between the battery and bulb. Separate the ends of this wire, then touch them to the ends of another piece of metal—say a nail or screw.



If the bulb lights at all, you know that the metal the nail or screw is made of is a *conductor*—that is, an electric current can flow through it. If the bulb lights about as brightly as it did without the nail in the circuit, you can say the nail metal (iron?) is a "good" conductor. If the bulb light is noticeably weaker, you know that the metal is resisting the flow of the current, so you might call it a "bad" conductor or a *resistor*. If the bulb does not light at all, you know that the nail resists the flow of current so much that it is stopped completely; a material that does this is called an *insulator*.

In place of the nail, try a wooden pencil or ruler, a plastic comb, a piece of pencil "lead" (carbon), an aluminum pan, a human hair, and so on. Dip the ends of the circuit wire into a glass of water—plain, and with sugar, salt, or something else dissolved in it. You can probably think of many other materials to test.

Before you test a material, write down what it is and whether you think it is a good conductor, a resistor, or an insulator. Then check your guess and keep a record of your findings.

Does a thin copper wire resist the flow of current more than thicker copper wire of the same length? Can you think of a way to find out?

WHAT'S NEW

by Roger George

Heating the ocean may put more lobsters on the dinner table. The state of Maine is famous for its lobsters, but in recent years fewer lobsters have been caught there. The smaller catch is blamed on a slight cooling of the waters along Maine's coast, caused by a shift in wind patterns. The cooler water makes lobsters grow more slowly, and since the law forbids catching those smaller than a certain size, there aren't as many lobsters legally large enough to be caught.

Scientists of Maine's Department of Sea and Shore Fisheries want to pour hot water into ocean coves to raise the water's temperature just enough to make the lobsters grow faster. The hot water will come from local power plants. Water used in the cooling systems of such plants gets hot just as water in a car's radiator does as it cools (takes heat from) the engine.

Hot dogs with mustard are easier to digest than hot dogs without. The reason, says German food expert Hans Glatzel, is that mustard makes the stomach produce more digestive juices.

Mustard affects the body in other ways, too, he told chemists at a meeting in Berlin. Its smell and taste make the heart beat more slowly. As a result, doctors may find mustard helpful for people with heart trouble. Some other spices promote the flow of blood through the small vessels of the skin. This might benefit people with poor blood circulation.

A chimpanzee has learned to talk in sign language, as deaf people do. The chimp, named Washoe, uses her fingers to make signs that stand for words. Washoe, who is about two years old, knows such words as "eat," "hurt," "go out," "please," and others that a two-year-old child might use. Washoe is the first chimp to learn a language. People have tried in the past to teach chimps a language by training them to talk (*see "Teaching a Chimp to 'Speak',"* N&S, *January 22, 1968*). But they have failed, probably because chimps cannot make the sounds of human speech.

Washoe was taught by husband-and-wife psychologists, Drs. R. Allen and Beatrice T. Gardner of the University of Nevada, in Reno. They say that Washoe is even putting words together by herself. When she asks the Gardners to open a door and they don't do it right away, for example, she gives the sign to "hurry."

Sounds too high for the human ear to hear are being used by doctors to examine the human heart. This "silent sound" is produced by a device called a *transducer* and is beamed through the chest into the heart. Some of the sound bounces back in the form of echoes. These are picked up by another transducer and changed into a pattern drawn on a piece of paper. The pattern of a diseased heart differs from the pattern of a healthy heart.

The method was first worked out by Dr. Inge Edler and Professor C. H. Hertz in the University Hospital at Lund, Sweden. They used it to check the valves that open and close to control blood's movement through the heart. Now doctors in Sweden and elsewhere are finding ways of using silent sound to check other parts of the heart and even to take a "picture" of the whole heart.

Honeybees can make money for a farmer—especially if he grows the kind of cucumber used in making pickles. Honeybees gather nectar from the flowers of these cucumber plants, and in doing so, carry pollen from flower to flower. This pollination makes the plants produce better cucumbers.

A recent study by plant scientist P. H. Williams of the University of Wisconsin, in Madison, shows just how important honeybees are. Of two cucumber fields studied, one had no bee colonies within two miles, and the second had many colonies living on it. When the cucumbers were sold, the farmer made $134 an acre from the first field and $442 an acre from the second. The bees tripled his income.

Lift a stone or a log and you may find several salamanders huddled under it. We know that many *warm-blooded* animals, whose bodies may produce a lot of heat to stay at their normal temperature, crowd together to avoid wasting heat. But salamanders are *cold-blooded* animals. Their bodies can't regulate their own temperature. They do not produce enough heat to make crowding together an advantage. Why, then, do they huddle?

Dr. R. H. Alvarado of Oregon State University, in Corvallis, thinks he has the answer. Salamanders gain or lose water easily through their thin, moist skin. They usually live in damp places where their body can absorb the water it needs. But when their surroundings dry up, water leaves their body through their skin and evaporates into the air. If the animals lose too much water, they will die. When salamanders huddle, Dr. Alvarado has found, they lose water more slowly because each salamander exposes a smaller part of its skin to the air.

This cylinder of ice was dug from deep in the Antarctic ice cap (see "The World's Largest Frozen Laboratory," N&S, February 5, 1968). Such a core, brought up recently from about 3,500 feet below the surface of the glacier at Byrd Station, in Antarctica, is being studied for information about atmosphere and climate of 10,000 years ago when the ice at that level was formed.

Using This Issue . . .
(continued from page 2T)

Insert a short piece of plastic straw and seal it in place with melted wax inside and outside the can. Hold your finger over the outer end of the straw and fill the can with water. Have your pupils measure the pressure of the emerging water by the distance the water spouts out from the straw before dropping straight down. Have them measure the current by finding out how much water flows from the can into a measuring cup in, say, 10 seconds.

By taking these measurements when the can is full and when it is nearly empty, your pupils can see that as the pressure drops, the amount of water flowing out per second also decreases. (The longer a dry cell is used to supply current, the more its voltage drops and the less current it puts out per second.)

Now, use a can opener to cut a hole in the center of the bottom of another can, tape it with plastic tape to the top of the first can, block the end of the straw with your finger and pour water into the top can until both cans are filled. (This is analogous to two cells connected in series.) By measuring the pressure and current flow as before, your pupils can see that both are about double what they were with one can.

In much the same way, two cells in series produce twice as much voltage as one, so they push twice as much current through a circuit per second. And more current flowing through a bulb wire per second is what makes it glow brighter.

(Be careful not to carry the analogy too far, though. The height of the water in a can determines its pressure at the bottom, but the size of a dry cell has nothing to do with its voltage *(see "Topics," below).*

Now punch two holes in opposite sides of the third can, the same size and at the same distance from the bottom as the one in the first can. Seal a length of straw into one hole, and seal the end of the straw from the first can into the other hole. Hold your finger over the end of the open straw and fill both cans with water. (This simulates two cells in parallel.) Your pupils can see that the water flows out of the spout with the same pressure and in the same amount per second as from a single can. But it takes twice as long for all the water to flow out, because there is twice as much in two cans as in one.

Topics for Class Discussion

- *Can your pupils guess where cells in parallel might be useful?* A bulb that lights with current from a single cell will stay lighted longer with current from two or more cells in parallel.
- *Why is it better to connect several bulbs in parallel, rather than in series, to the same battery?* Each bulb in the series circuit resists the flow of current and cuts down the amount of current reaching the next bulb each second, so none of the bulbs lights as brightly as if it were the only one getting current from the battery. Connected in parallel *(see Diagram 4, page 3)*, each bulb gets the same amount of current per second as the others. Also, if one of several parallel bulbs burns out, it does not open the circuit, so the others stay lighted.
- *Does the size of a dry cell have anything to do with its voltage, or how much current it will produce?* By testing single cells of different sizes in a circuit with a bulb, your pupils can see that every dry cell, when fresh, produces the same voltage (1½ volts). And by timing how long different-size cells will keep a bulb lighted, they can see that a large cell will produce current for a longer time than a small cell. A 45-volt "B" battery used in some portable radios is made of 30 1½-volt dry cells in series. Have your pupils find out how many volts an automobile "storage" battery produces (6 or 12 volts).
- *Why do you think the electric current that comes into your home from the power station is under such high "pressure"—110 volts or so?* The miles of wires that carry the current from the station to your home and back to the station offer a great deal of resistance to the flow of current, so it takes a lot of voltage to move the current through them. In fact, the current travels under much higher voltage from the station to a transformer somewhere near your home, where the voltage is lowered before the current gets to your home.
- *What happens when a fuse burns out or a circuit-breaker stops the flow of current in one circuit in your home?* If two wires in the circuit accidentally touch each other, the current flows through this "short" circuit instead of through the bulb or other appliance to which the wires are connected. Without that resistor to hold it back, the current surges through the circuit, heating the wires (which can cause a fire). A fuse is a piece of metal that melts at a low temperature. When too much current flows through it at one time, the metal heats up and melts, breaking the circuit. A circuit breaker does the same thing, but you can just push it back in place to close the circuit, instead of screwing another fuse into the fuse socket.

If there are too many resistors—too many bulbs, toasters, irons, and so on —in the same circuit at one time, they may also "draw" too much current and cause a fuse to "blow."

Activity

Have your pupils investigate whether fresh dry cells of the same size will light a bulb for a longer period if the cell is connected to the bulb continuously or if it is given a "rest" now and then. Does the length of "rests" you give the cell make any difference in the total amount of current it can supply?

Brain-Boosters

Mystery Photo. Perhaps some of your students have seen a sign like this along the highway. If so, find out how many think the sign was there because the noise of a blast could damage a car radio that was "on." That, however, is not the reason. Nor is it necessary, as some may think, to turn off a radio *receiver*.

The warning is there because dynamite charges are set off electrically, and there is a slight possibility that radio waves from a car or "walkie-talkie" *transmitter* could accidentally discharge a blasting cap.

What would happen if? After your pupils have discussed the various possibilities, you can demonstrate what
(Continued on page 4T)

(continued from page 3T)

will happen with a large plastic bag of the kind that a dry cleaner puts over a suit or dress.

Seal one end of the bag with tape, then release the air from a basketball into it, using the needle that is normally used to inflate the ball. Since the ball is not very big, and is not inflated to very high pressure, the air it contains will not blow up the bag very much. An automobile tire, which contains a greater volume of air than a basketball, and at greater pressure, could be used to inflate the plastic bag a good deal more.

Can you do it? Mr. Brain Booster can't. If you or any of your pupils can, he would be interested to know how. (Write Mr. Brain Booster, Bedford Lane, RFD #2, Lincoln, Massachusetts 01773.)

Fun with numbers and shapes. At the instant that the front of the train enters the half-mile-long tunnel, the *back end* of the train is one-half mile farther down the track, or one full mile from the far end of the tunnel. Since the train is traveling at one mile per minute (60 mph), it will take one minute for the back end of the train to emerge from the tunnel.

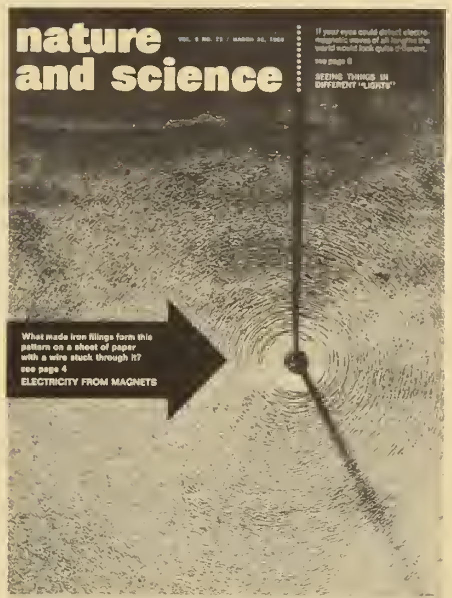
For science experts only. Mars is believed to have polar ice caps (if only a few centimeters thick), and does have an atmosphere (mainly carbon dioxide). But the "canals" for which the planet is so well known are probably nothing more than separate spots and patches on the planet's surface that appear as lines when viewed from a great distance. The earth, of course, has all three features.

Just for fun. The balloon will cling to the stream of water once it has been touched to it. This is caused by the Bernoulli effect: As the speed of a fluid increases, there is a decrease in its pressure outward at right angles to the direction of flow. The fluid is the air immediately surrounding the water and moving with it. When its outward pressure decreases, atmospheric pressure pushes the balloon toward the stream of water. The same effect can be seen when water is run on a small ball floating in the bathtub.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 13 / MARCH 18, 1968 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Moose Malady

In describing the search for the cause of "moose disease," this article reveals the intricate life cycle of a roundworm parasite. This presents an opportunity for you to point out the concept that *living things are adapted in structure and function to their environment.*

If a *parasite* were defined as anything that lives at the expense of other organisms, all animals—including man—would be called parasites. Biologists usually define a parasite as an organism that (1) lives on or in another living organism for a considerable part of its life, (2) derives its food from its host, and (3) is more or less harmful or, at best, is not beneficial to the host.

Few living things are free of parasites. As Swift wrote, "A flea hath smaller fleas that on him prey, and these have smaller still to bite 'em, and so proceed *ad infinitum.*" Most parasites are small—even microscopic—but extremely numerous. Some biologists believe that most of all organisms living are parasites.

Some parasites have intricate life cycles. In the diagram on page 3, for example, point out to your pupils the effect of chance on the roundworm's life cycle. For a new generation to begin, a snail must eat the larvae, then a deer must eat that snail. The chances for success are increased because the adult roundworms produce many young.

This life cycle with one intermediate host (the snail) is something like that of tapeworms that have human hosts. The commonest tapeworms in humans are two species that have livestock as intermediate hosts — one in cattle, the other in hogs. (The tapeworm gets in humans when a person eats uncooked or rare beef or pork.) Another human parasite—the liver fluke—has *two* intermediate hosts: snail and fish.

Electricity from Magnets

This article tells the fascinating story of how Michael Faraday discovered the relationship between electricity and magnetism and put it to work to make electric current by moving a coil of wire through the lines of force around a magnet. With the articles on electric cells and circuits (*"'Canned' Electricity" and "Bulbs and Batteries,"* N&S, *Feb. 19 and March 4)* as background, your pupils should have no difficulty following Faraday's experiments and testing some of them as shown in the projects. (A SCIENCE WORKSHOP in making an electric motor of simple materials and investigating how it works will appear in *N&S* April 15.)

Suggestions for Classroom Use

- Your pupils may be interested to learn that Michael Faraday, the son of a poor blacksmith, had to leave school at 13 and go to work. As an apprentice bookbinder, he read many books, especially those on experimental science, and he tried many of the experiments himself. At 19 he persuaded the eminent British scientist Sir Humphrey

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 1T-4T.)

● **The Mysterious Moose Malady**
It took scientists about 50 years to trace the complex development of a roundworm that causes "moose disease."

● **Electricity from Magnets**
Your pupils can test some of Faraday's discoveries that led to the invention of electric motors and generators. Sending radio signals with a dry cell and wire will introduce them to electromagnetic waves.

● **Seeing in Different "Lights"**
This WALL CHART shows your pupils the variety of waves in the electromagnetic spectrum and how things would appear if their eyes could detect waves other than those of visible light.

● **Brain-Boosters**

● **Gulp, Gulp Goes the Goldfish**
Your pupils can investigate some of the things that affect the respiration rate of fish.

● **Can We Save the Eagles?**
Bald eagles are becoming rare in most of North America because humans are destroying their habitat, disturbing their nests, and indirectly putting poison in their food.

IN THE NEXT ISSUE

Special-topic issue: Spaceship Earth ...The growing problem of waste disposal...How Lake Erie is being killed...City of the future?...Plight of the National Parks...Prospects for reducing pollution from autos...How high school students studied water pollution in a community stream.

Using This Issue...
(continued from page 1T)

Davy to hire him as a laboratory assistant at the Royal Institution in London, a scientific organization Faraday was later to serve as Director.

Faraday refused to believe anything until he had tried it himself, which may account for his discoveries in electromagnetism and also in chemistry. Some of your more advanced pupils will enjoy reading his delightfully informative book, *The Chemical History of a Candle* (Thomas Y. Crowell Co., New York, 1957, $2.75, paper 95 cents). So, probably, will you.

- If your pupils have not yet "mapped" the lines of force around a magnet, this is a good time to do it. (You can get iron filings from a machine shop or make some by using a metal file on some large nails.) Place a stiff sheet of white paper (or clear plastic) over a bar magnet and sprinkle filings over the paper. If the magnet is not very strong, you may have to tap the edge of the sheet several times before the filings line up with the lines of force.

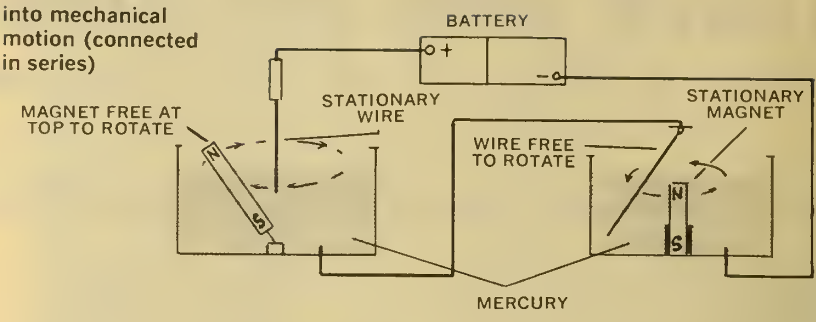
Have your pupils move a compass along the lines of filings, just above them, and watch how the needle moves. Then move the compass from one pole of the magnet through the air in a low arc to the other pole. This will show that the lines of force form a magnetic field all around the magnet.

- The device Faraday made to move a magnet with electric current

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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

Faraday's two devices for changing electric current into mechanical motion (connected in series)



could not *do any useful work,* so it was not really a *motor.* From the diagram of that device and the description of the one in which the wire moved around the magnet (page 5), have your pupils try to diagram the second device. Then compare their sketches with the diagram on this page.

Different "Lights"

The project "Send Signals by Radio," on page 7, explains how *electromagnetic waves* are produced by rapid pulses of electric current (instead of by a steady flow).

Your pupils are probably familiar with the *spectrum* of visible light, running from violet (the shortest waves of visible light) to red (the longest visible light waves). As the diagram in this WALL CHART shows, the visible light spectrum is only a small part of the *spectrum of electromagnetic waves,* which runs off the page at both sides.

Suggestions for Classroom Use

- To clarify the concept that the earth gets its energy originally from the sun, see the WALL CHART, "The Spirit That Moves Things," *N&S,* April 8, 1967.
- You might point out that visible light and infrared are the only waves of electromagnetic radiation that the human senses can detect directly. (Infrared is *radiant heat,* which heats up your body in the sun.)
- For effects of ultraviolet radiation on humans' skin color, see "How Did People Get Different Colored Skin?", *N&S,* Dec. 4, 1967.
- Point out that astronomers can only learn about objects and areas in space by recording and studying the kinds of electromagnetic radiations received from them through both optical and radio telescopes.

Can We Save the Eagles?

In the long history of life on the earth, many kinds of plants and animals have evolved, thrived for a time, and then become extinct. This is a natural process. Among the causes for extinction is the inability of a species to adapt to changes in its environment.

The pace of extinction has speeded up, however, with the rise of the human species and the development of technology. More than 400 species of birds and mammals alone have become extinct within the last 100 years. Humans have destroyed or altered many environments, introduced organisms into new habitats *(see "The Animal Movers,"* N&S, *Oct. 2, 1967),* and spread pollution around the world.

This article tells how human activities have reduced the available eagle range, through either destruction of habitat or disturbances that have the same effect. As the article points out, however, protecting nests and keeping people from disturbing eagles may not be enough to save the species from disappearing from most of its former range. Some form of pollution, probably biocides, is also affecting eagles and their reproductive success.

Topics for Class Discussion

- *What other animals are threatened with extinction in the United States?* The endangered species include such animals as the California condor, timber wolf, alligator, whooping crane, and black-footed ferret. Destruction or alteration of habitat has lowered the numbers of all these ani-

(Continued on page 3T)

nature and science

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If your eyes could detect electromagnetic waves of all lengths the world would look quite different.

see page 8

SEEING THINGS IN DIFFERENT "LIGHTS"

What made iron filings form this pattern on a sheet of paper with a wire stuck through it?

see page 4

ELECTRICITY FROM MAGNETS

nature and science VOL. 5 NO. 13 / MARCH 18, 1968

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

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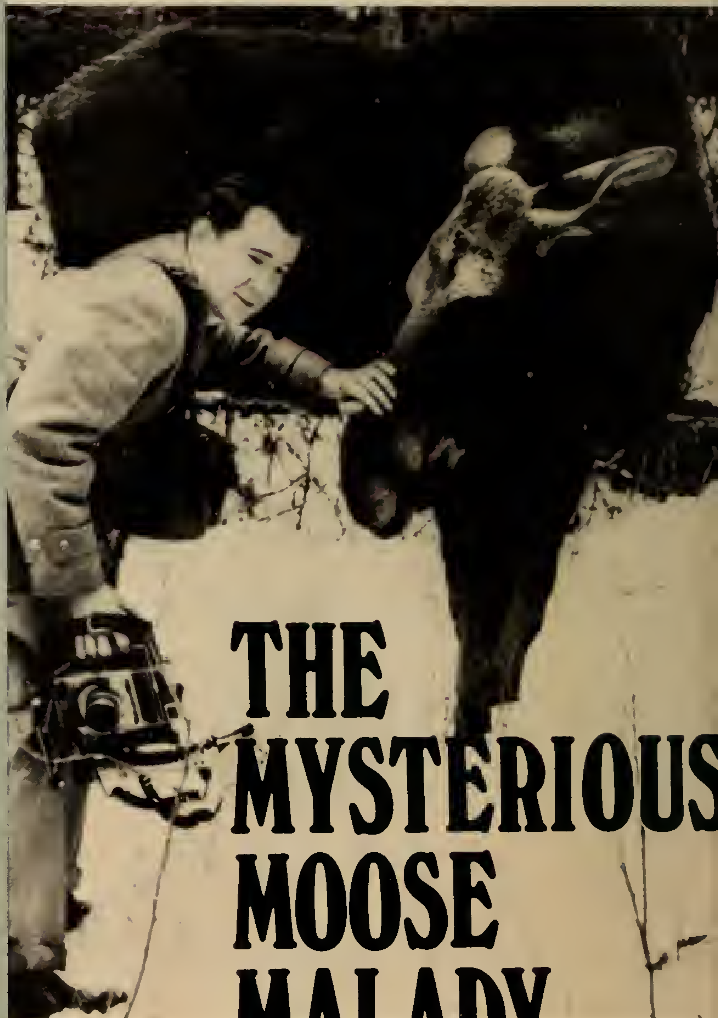
NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly October, December through April; monthly September, November, May and July (July special issue). Second Class postage paid at Garden City, N Y 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, N Y. 10024.

SUBSCRIPTION PRICES: In U S A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1 85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition. $5 75 per school year. Single subscriptions per calendar year $4. two years $7. ADDRESS SUBSCRIPTION correspondence to NATURE AND SCIENCE, The Natural History Press, Garden City, N Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

Scientists were puzzled for many years about a disease that killed moose. Finally, using clues from such animals as deer and snails, they have found the cause of...



THE MYSTERIOUS MOOSE MALADY

by Dave Mec

■ Often the work of a scientist is like that of a detective As part of their jobs, both may need to look for as man clues as they can find, put them together, and think abou them until the mystery is solved. Sometimes this take many years and the help of several people. Such was th situation in "The Case of the Mysterious Moose Malady.

The case "opened" over 50 years ago near the borde between Minnesota and Ontario, Canada. People ther began noticing certain moose that acted very strangely Instead of running away when somebody approached such a moose just walked around in tight circles. It woul stay in one small spot for many days. It didn't eat, and i grew weaker and weaker. People soon found that the could walk right up to the moose and touch it *(see photo)* The animal appeared to be both blind and deaf. Afte many days of this behavior, it would die.

In the 1920s and 1930s, many moose died of this mysterious sickness, which was simply called "moose disease." Several scientists then began trying to find the cause. They cut open and examined moose that had died from the disease. Because of the *symptoms* (the ways that these moose had differed from normal moose in their actions), the scientists suspected that something was wrong with the brains of the sick moose. But what could it be?

From Deer to Snail, and Back

Scientists who study diseases in animals *(veterinary pathologists)* investigated several possible causes of the strange sickness. Some even thought they had solved the mystery. Germs such as viruses and bacteria were blamed at first. Then ticks and poisons were suspected. Eventually some scientists thought that the lack of a certain chemical in the food of the moose was the cause of the disease. But all these leads turned out to be false.

Many years went by, and "The Case of the Mysterious Moose Malady" remained unsolved. Then Dr. Roy Anderson, a Canadian scientist, got an idea about the disease. Dr. Anderson is a *parasitologist,* a scientist who studies *parasites,* which are animals (such as tapeworms and fleas) that live on or inside other animals.

Dr. Anderson had been studying a tiny roundworm parasite that lives inside deer. The adult worms, called *Pneumostrongylus tenuis,* live near the brain and spinal cord of the deer and lay their eggs there. The eggs hatch into larvae small enough to bore into veins and travel with the blood to the deer's lungs. From there they are coughed up and swallowed by the animal. Eventually they pass out of the deer's body with its wastes *(see diagram).*

A few of these larvae may then be picked up by certain kinds of snails as the snails feed. If so, the larvae live in the snail and undergo some changes. If the snail is then accidentally swallowed by a deer as it eats grass where the snails live, the worms travel to the animal's brain and spinal cord. There they develop into adults, and the cycle begins all over again. The worms usually do not seem to hurt the deer.

From Snail to Moose

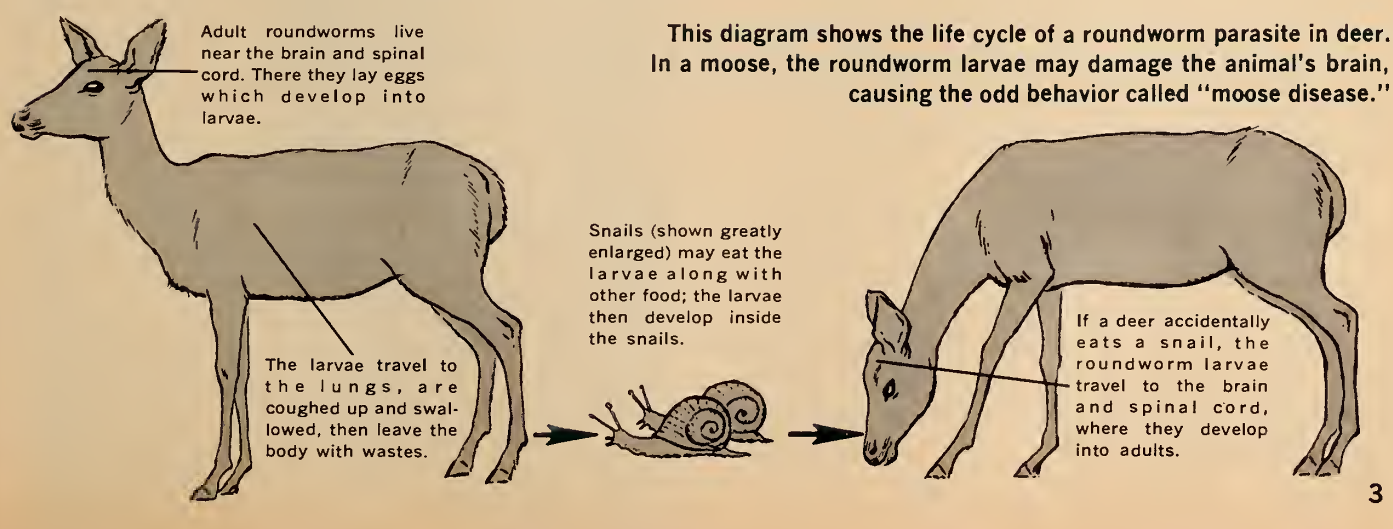
"But what if these worms get into moose?," wondered Dr. Anderson. He knew of other, similar kinds of worms that caused sickness in cattle, horses, and goats in Asia; the sickness was much like moose disease. Here was a new clue.

Dr. Anderson took some worm larvae from deer that he knew were infected. He put them into snails to allow them to develop there as they usually do. Then he fed the snails to some moose calves that he was sure had not yet picked up any worms by themselves. Within three weeks, the calves began acting the same way as animals with moose disease. When Dr. Anderson examined their brains and spinal cords he found what he had suspected —the same kind of worm that usually lives in deer.

In deer, these worms usually stay on the surface of the brain. In the moose calves, they had been boring right through it. This could account for the strange actions of sick moose, thought Dr. Anderson. With part of their brains damaged, the moose could not act normally. It looked like Dr. Anderson had solved the mystery.

In science, however, a theory must be supported by a lot of evidence before it is considered a fact. During the past few years, Dr. Anderson and other scientists have looked for the worms in wild moose that were suffering from the disease. Time and time again they found the parasites. The scientists even looked at brains that had been preserved from moose found sick in the 1930s. There again was the same culprit—the roundworm called *Pneumostrongylus tenuis.* Unfortunately, it seems that nothing can be done to keep some moose from getting the "moose disease." But, more than 50 years after it was opened, "The Case of the Mysterious Moose Malady" was closed ■

This diagram shows the life cycle of a roundworm parasite in deer. In a moose, the roundworm larvae may damage the animal's brain, causing the odd behavior called "moose disease."



ELECTRICITY *from*

A young scientist who educated himself discovered how to make electric current do work—and how to change work into electric current. You can try some of his investigations with simple materials such as he used.

■ All of the electric lights, motors, and heating devices (toasters, and so on) in your home *could* be made to work with current from electric cells (*see " 'Canned' Electricity,"* N&S, *February 19, 1968*). The trouble is, though, that it would take a houseful of cells to supply enough current to make all these things work—and you would have to replace worn-out cells at least several times a day.

Take the bulb in your desk lamp, for example. To make its wire *filament* glow white hot, current has to be pushed through the filament under about 115 *volts* of electrical "pressure." A single dry cell—no matter what size—produces no more than 1½ volts of pressure. So it would take a battery of about 76 dry cells connected in series to light that bulb *(see "Bulbs and Batteries,"* N&S, *March 4, 1968).* Even if your battery were made of large cells it wouldn't supply current very long before the cells "wore out." And you have to have another source of electric current to *recharge* a partly worn-out battery.

Theories about Electricity

Less than 150 years ago, batteries of cells were the only things people had to make a steady flow of electric current. But then there were no electric motors, lights, heaters, or electromagnets that needed current to work. In fact, in the early 1800s electricity was still a "toy" being investigated by scientists who were more concerned with what electricity *is* than with what it can *do*.

Some of those scientists thought that electricity was made up of two fluids—"positive" and "negative"—that attracted each other. No one could explain, though, how fluids of opposite charge could pass each other along a wire.

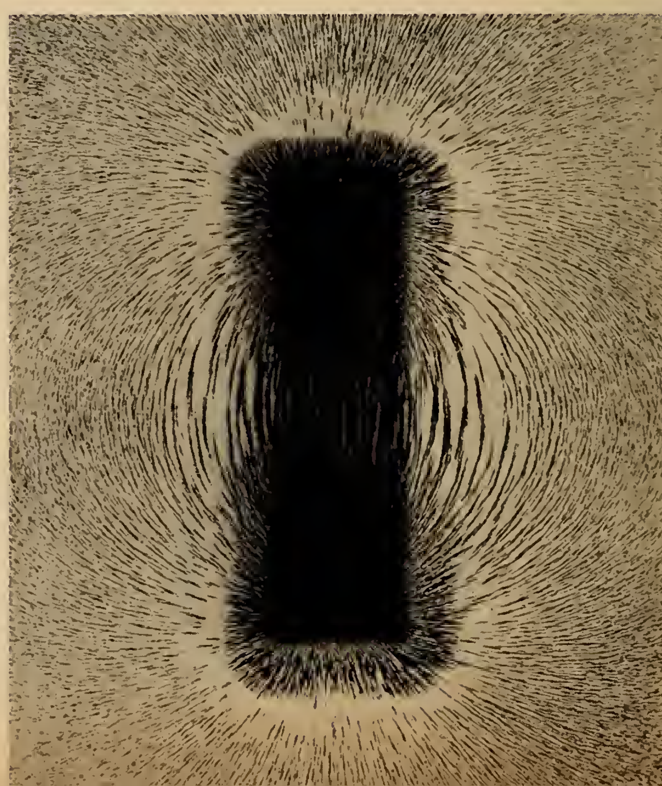
The great American statesman and scientist, Benjamin Franklin, thought electricity was a single fluid. He thought that it flowed through a wire from the positive pole of a cell to the negative pole. Most people still think of electric current as flowing in that direction, even though it is now fairly certain that current is a flow of electrons from the negative pole of a cell through a wire to the positive pole *(see " 'Canned' Electricity").*

Neither of these theories was backed up by enough evidence to convince a brilliant young English scientist named Michael Faraday. Perhaps because he had educated himself, Faraday was not troubled by the conflicting ideas about how electricity moves along a wire. He accepted the fact that it does move along a wire, and wanted to find out more about what happens.

Faraday was also interested in magnets. He knew that when you sprinkle iron filings on a sheet of paper (or glass) with a bar magnet beneath it, the filings are pulled into a pattern of lines that run from one pole of the magnet to the other pole *(see photo).*

Since the filings form the same kind of pattern however the magnet is turned, Faraday thought of the magnet as

When iron filings are sprinkled onto a sheet of plastic (or paper) over a bar magnet, they form a "map" of the lines of magnetic force in that slice of space around the magnet. What would happen to the filings if you turned the magnet end-for-end? Around its length?



MAGNETS

by Robert Gardner

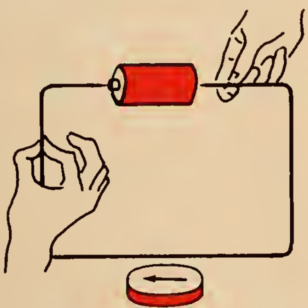
being surrounded by *lines of magnetic force*—even when there are no iron filings to show where the lines are. He pointed out that the force of a magnet is strongest where many of these lines of force are close together (at the poles of the magnet), and weaker where the lines are farther apart. Faraday thought of these lines of force as making up a *field* of force surrounding a magnet.

Making Magnets with Electricity

Until 1819, people thought that electricity and magnetism were unrelated. But in that year a Danish physicist, Hans Christian Oersted, discovered that when you place a compass near a wire with current flowing through it, the compass needle (a small magnet) is turned, or *deflected* *(see Project 1)*.

PROJECT 1

Place a long wire over a pocket compass so that the wire runs in the same direction as the compass needle (see *diagram*). Connect the ends of the wire to a flashlight cell. (Don't leave the wire connected to the cell very long. Do you know why?) What happens to the compass needle when an electric current flows through the wire?

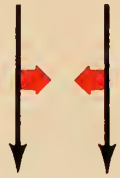


See what happens if you place the wire *below* the compass. Try turning the cell around. Will the current change the compass needle if you place the wire across, or *perpendicular* to, the needle before you connect the wires to the cell? Turn the battery around again and watch what the needle does. How close to the needle must the wire be for the current to affect the needle? If you use two cells in series, will the current affect the needle from farther away? Can you explain why?

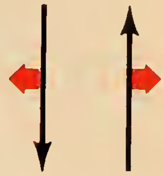
Oersted's discovery showed that a magnetic field surrounds an electric current. You can see in the photo on the cover of this issue how iron filings, acting like tiny compass needles, follow the magnetic lines of force around a wire carrying an electric current. The lines form a series of circles around the wire. (How would a compass needle turn if you moved it around the wire?)

A French scientist, André Ampère, suggested that since an electric current produces a magnetic field, then two wires carrying electric currents should act on each other like two magnets. He found this to be true *(see diagram)*.

Two parallel wires carrying currents in the same direction attract each other.

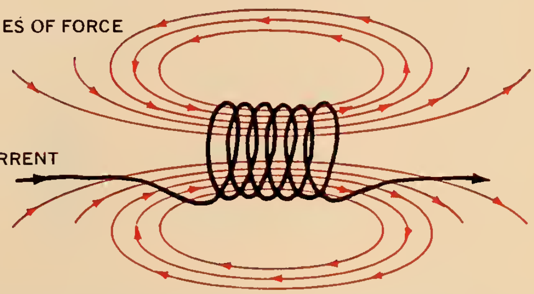


Two parallel wires carrying currents in opposite directions repel each other.



(The forces are quite small, though, unless large currents are used.)

Ampère and other scientists of his time found that when you coil a wire (like a bedspring) and send an electric current through it, the lines of force around the coil take the same shape as the lines of force around a bar magnet *(see diagram)*. When the current stops flowing, the mag-



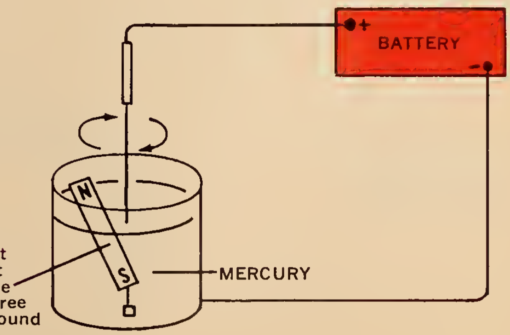
netic field around the coil is no longer there.

To make one of these *electromagnetic* coils, another English scientist, William Sturgeon, wrapped wire around an iron bar. He discovered (perhaps by accident) that this makes a much stronger electromagnet than the coil alone *(see Project 2)*.

Faraday knew of all these discoveries, and in 1821 he decided to see whether the lines of force around a current-carrying wire would push the pole of a bar magnet in a circle around the wire. He attached one end of a magnet to the bottom of a container so the other end of the magnet could move around freely *(see diagram)*.

He poured mercury—a liquid metal that is a good conductor of electricity—into the container. Then he dipped a stiff wire into the mercury at the center of the container

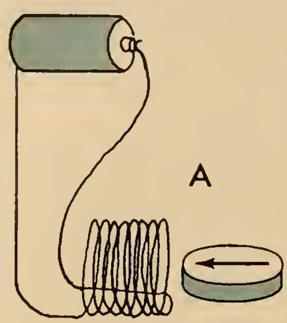
(Continued on the next page)



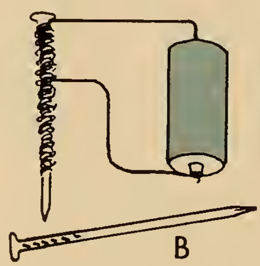
PROJECT 2

MAKING AN ELECTROMAGNET

Wrap about 20 loops of insulated wire (bell wire or enameled copper wire will do) around a dry cell to make a coil. Slide the coil off the cell (some pieces of sticky tape will keep the coils together), and hold the coil near a compass (see *Diagram A*). Connect the ends to a dry cell. (You have a short circuit, so don't keep it connected very long.) Which end of the coil is a north pole? Which end is a south pole? Does the direction in which you wrapped the wire to make the coil make a difference in its poles? Will the poles change if you turn the cell around? Is the coil magnetic when there is no current flowing through it?



You can make a stronger electromagnet by winding insulated wire on a 3- or 4-inch nail. Wind the wire in the same direction up and down the nail until you have two or three layers of wire (see *Diagram B*). Use your electromagnet to pick up another nail. What happens when you open the circuit? How can you make your electromagnet even stronger? Would the nail still be magnetic if you removed it from the coil?



and connected its other end to a battery. When the mercury was also wired to the battery, a current flowed through the mercury and the wire. The lines of force around the wire pushed the end of the magnet in circles around the wire.

This device was a forerunner of the electric *motor*, which uses the magnetic force around a current-carrying wire to turn a shaft and do work. (In the April 15, 1968, issue of *Nature and Science* we will show you how to make a little electric motor and investigate the way it works.)

Faraday made a second device like the first except that the magnet was fixed in the center of the container and the wire was free to move around the pole of the magnet through the mercury. When both of these "motors" were connected in series with a battery, the magnet moved around the wire in one, while the wire moved around the magnet in the other. (Can you draw a diagram of how this might appear?)

Making Electricity with Magnets

The work of Oersted, Ampère, and Faraday showed that magnetism and electricity are related, but part of the puzzle seemed to be missing. If an electric current makes a magnetic field, shouldn't a magnet be able to make current flow in a wire? Faraday thought so. He placed very strong magnets near wires, but he was not able to make any electric current flow through the wires in this way.

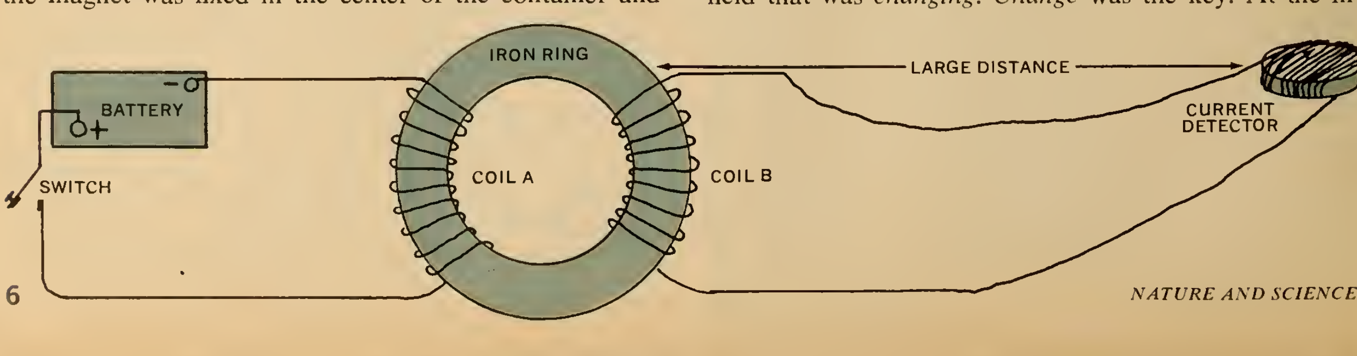
We know today that this cannot be done. If it *could*, we would be able to light our homes and drive our electric motors without doing any work *(see "Can You Work Like a Horse?"*, N&S, *January 8, 1968)*. We could get something for nothing by simply placing magnets near wires. Faraday did not know that this is impossible, so he kept trying.

Faraday experimented with electromagnets of different sizes and shapes, and in 1831 he found the answer to the "electricity from magnets" puzzle. He had set up the apparatus shown in the diagram below.

A wire was coiled around one side of an iron ring, and its ends were connected to the poles of a battery, with a switch for closing and opening the circuit. Another wire was coiled around the opposite side of the iron ring; one of its ends was wrapped around a compass, then joined to the other end of the coil. (The compass needle would be deflected by any current flowing through the second coil. Why do you think it was placed so far away from the coils?)

Faraday found that when he closed the switch to make current flow in coil A, a current was *induced*, or "coaxed," to flow in coil B—but just for an instant. When he opened the switch, current again flowed for an instant in coil B, moving the compass needle in the opposite direction. He found that a current flowed in coil B *only when the switch was being opened or closed*. A steady current in coil A had no effect on coil B.

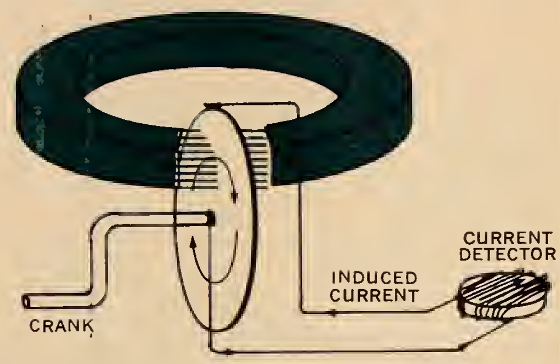
Faraday realized now why he hadn't succeeded before. What was needed was not just a magnet, but a magnetic field that was *changing*. *Change* was the key. At the in-



stant he closed the switch, magnetic lines of force formed around the coils. At the instant the switch was opened, magnetic lines of force were destroyed. A current was "induced" in coil B only when magnetic fields were either forming or disappearing—that is, only when the magnetic field was *changing.*

Faraday tried to "induce" a current by moving a strong magnet in a coil of wire *(see Project 3).* He was rewarded by seeing the needle of his current detector move. Whenever the magnet was moved, current was induced. When the magnet was at rest, no current flowed.

Faraday found that whenever a wire is "cutting across" magnetic lines of force, *or* whenever magnetic lines of force are "cutting across" a wire, a current is induced in the wire. Using this principle he designed the first *dynamo* for



making, or *generating,* electric current *(see diagram).* With a hand crank, he rotated a copper disc in a strong magnetic field. Part of the disc was constantly cutting magnetic lines of force, and a current was produced.

Today's electric motors and generators are much larger and more complicated than Faraday's, but they work on the principle of *electromagnetic force* that he discovered ■

PROJECT 3

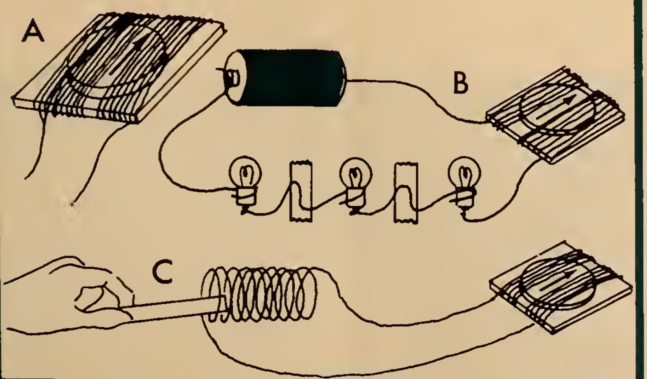
You can make electric current with a magnet just as Faraday first did. The currents you make will be very small, so you will need a sensitive current detector, called a *galvanometer.* You can make one with a pocket compass and some No. 24 enameled or cotton-covered copper wire. In a small square of stiff cardboard, cut a hole just large enough to hold the compass snugly. Turn the cardboard until the compass needle points to opposite sides of the square, then wind about 50 turns of wire around the center of the compass, in line with the needle (see *Diagram A*). Leave a few inches of wire at each end, and cut or scrape about an inch of insulation off the wire at each end.

To test your galvanometer, connect enough flashlight bulbs in series with a single dry cell so that they get too little current to glow (see *"Bulbs and Batteries"*). Now connect your galvanometer in the circuit (see *Diagram B*). Can you detect a current?

Now make a coil by wrapping 50 turns of wire around a flashlight cell. Leave several feet of wire at each end of the coil, and remove an inch of insulation at each end. Some pieces of sticky tape will help you hold the coil together as you slip it off the cell. Connect the ends of the coil to your galvanometer.

If you have a strong bar magnet, try moving it in and out of the coil (*Diagram C*). (Or you can use the electromagnet you made in Project 2.) When is a current induced: when the magnet is not moving? when it is going into the coil? when it is coming out of the coil? Is the induced current always flowing in the same direction? (How can you tell?) What happens if you turn the magnet around?

Would a current be induced if you moved the coil above the magnet? Try it and see. Do you think the speed with which the magnet is moved makes any difference?



With a flashlight cell and a piece of wire, you can...

SEND SIGNALS BY RADIO

Turn a small portable radio on loud, then "tune out" the station, so you can't hear talk or music. Hold a flashlight cell near the radio, pressing one end of a wire against the cell's negative pole. Brush the other end of the wire across the positive pole of the cell and listen to the radio to detect signals from your transmitter.

Remember that each time you close your cell-and-wire circuit, a magnetic field forms around the wire; as you open the circuit, the field is "turned off." At the instant the field changes, a weak current is induced in the antenna wire of the radio set. The radio strengthens the current and changes it into the sound signal that you hear.

The English physicist Clerk Maxwell explained how this happens. He showed that a current that is rapidly changing in strength makes a magnetic field around itself, and the magnetic field makes an electrical field, which makes another magnetic field, and so on. He said that this chain of "disturbances" would flow across space until it reached another piece of matter, where it would induce an electric current like the one that started the chain.

When Maxwell figured out that these "waves" of electromagnetic force must travel through space at the speed of light, he realized that light itself must be a form of electromagnetic waves (see *next page*).

Seeing things in different "Lights"

■ Nearly all of our sources of energy on earth begin in the sun. The sun **radiates**, or sends out in all directions, energy in the form of **electromagnetic waves** (see "Send Signals by Radio," page 7).

These waves travel through space at the speed of about 186,000 miles per second, and they reach us in many forms of energy—as heat, as light that you can see, as ultra-violet rays (which can cause sunburn even on a hazy day), and in still other forms. The main difference in these forms of energy is the length of the waves that carry them.

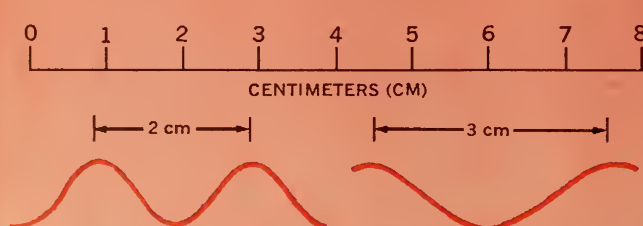
Some forms of radiant energy, such as **gamma rays**, travel in waves so short that it would take a million million or more to measure one centimeter (see diagram). Some, such as radio and infrared (heat) energy, have much longer wavelengths—even as long as a mile! Other kinds, such as visible light, have wavelengths somewhere in between.

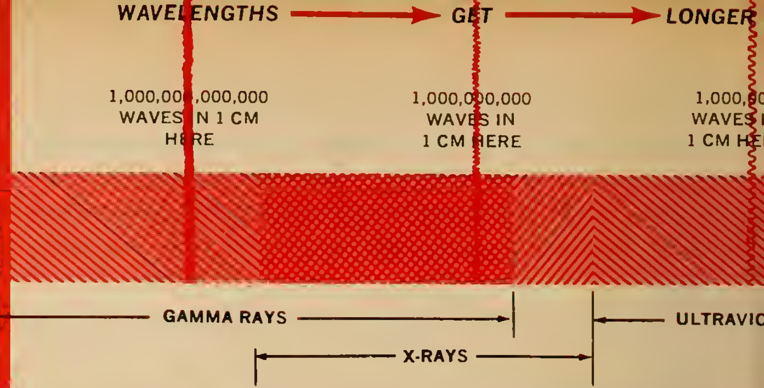
As the diagram shows, when we arrange the different kinds of radiant energy from shorter wavelengths (on the left) to longer wavelengths, we have what the physicist calls the **electromagnetic spectrum.**

Of all the radiant energy reaching us from the sun and other objects in space, visible light is only a very small part. The photographs on these pages were made with films that were sensitive only to radiations of certain wavelengths. They show what the world is like when we view it in different kinds of "light" ■

MEET LAMBDA: λ

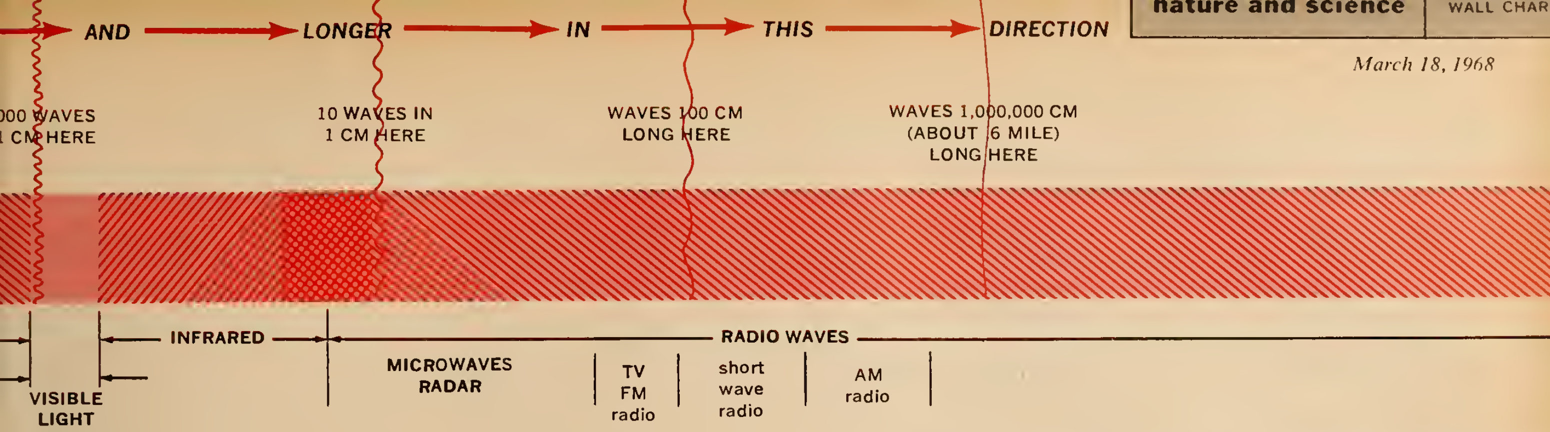
The length of a wave—usually called by the Greek letter λ *(lambda)*—is measured from, say, the crest of one wave to the crest of the next wave *(see diagrams)*. The number of waves that pass a given point in one second is called the *frequency* of the waves. Since electromagnetic waves all travel at the speed of light, you can see that short waves have a higher frequency than longer waves.

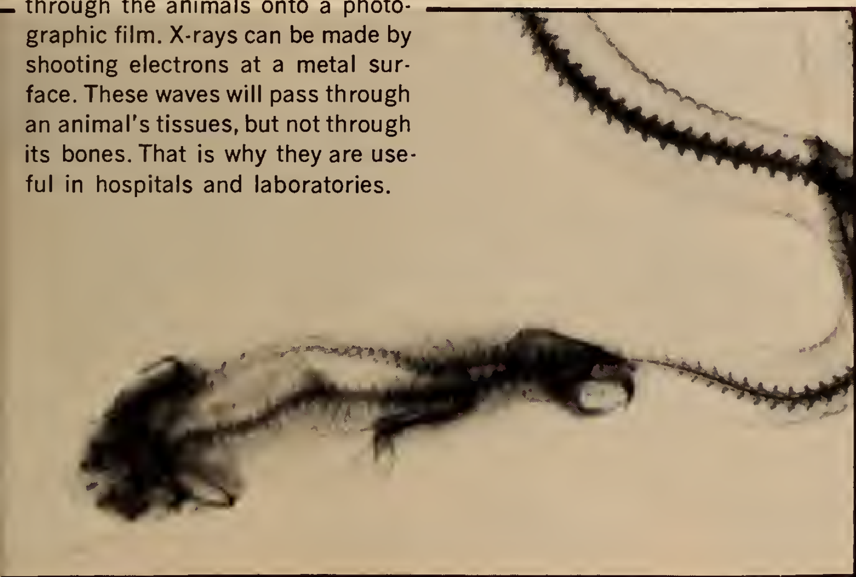




This photo was made recently by sending gamma radiation fro a radioactive substance called iridium 192 through a bronze hors to a photographic film. (Gamma waves can pass through man objects that block x-rays.) The horse, supposedly made abou 470 B.C., was bought in 1923 by the Metropolitan Museum of Ar in New York. This photo showed that iron wires *(see light lines i photo)* were used to support the mold—a process not invented unt the 1300s.

This aerial photo of a residential section in Concord, Californi made with a film that is sensitive to ultraviolet waves. Leaves and *absorb*, or soak up, most of the ultraviolet waves from the su reach them, so they are dark gray or black in the picture. Some ro reflect a lot of ultraviolet radiation, so they appear bright in the



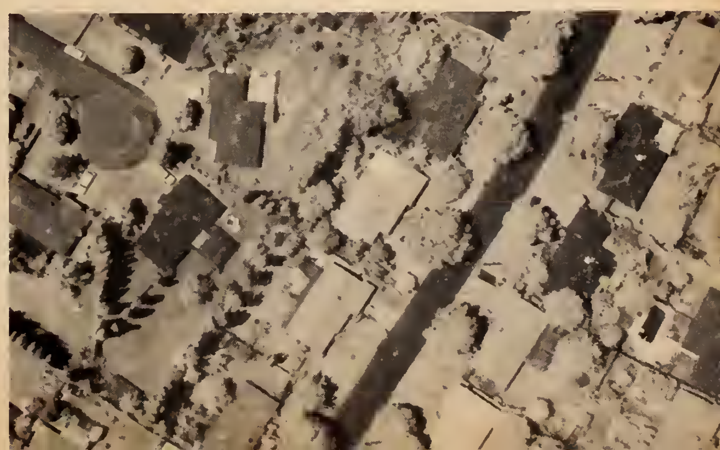


You can see the bones of a snake and the hamster it is swallowing in this picture made by sending x-rays through the animals onto a photographic film. X-rays can be made by shooting electrons at a metal surface. These waves will pass through an animal's tissues, but not through its bones. That is why they are useful in hospitals and laboratories.

This aerial view of the harbor at San Diego, California, was made by sending radar waves out from the plane. The waves that bounced back formed this picture on a radar screen (something like a TV screen), and the picture was recorded on photographic film. The photo shows the topography (height and shape) of the land. The light blur at the tip of the land is a bed of kelp—a sea plant—that sometimes can't be seen in photos made with visible light.

This photo of the same residential area was made with film like the kind you use in your camera. It records the different colors (different wavelengths) of visible light in shades of black and white. Compare objects in this photo with the same objects in the other two photos to find out which materials reflect ultraviolet, visible, and infrared radiations about equally and which reflect one kind of radiation more than another.

This photo of the same area was made with film that records infrared waves. Can you tell from the lightness or darkness of their rooftops which houses are likely to be cooler than others? Most objects, living or nonliving, absorb some infrared radiation from the sun. At night they radiate some of this heat into the atmosphere, and that is why you can see many objects in the dark through telescopes that are designed to detect infrared waves.



FUN WITH NUMBERS AND SHAPES

What number should be next in each series?

Ⓐ 1→2→4→8→16→32→64→?

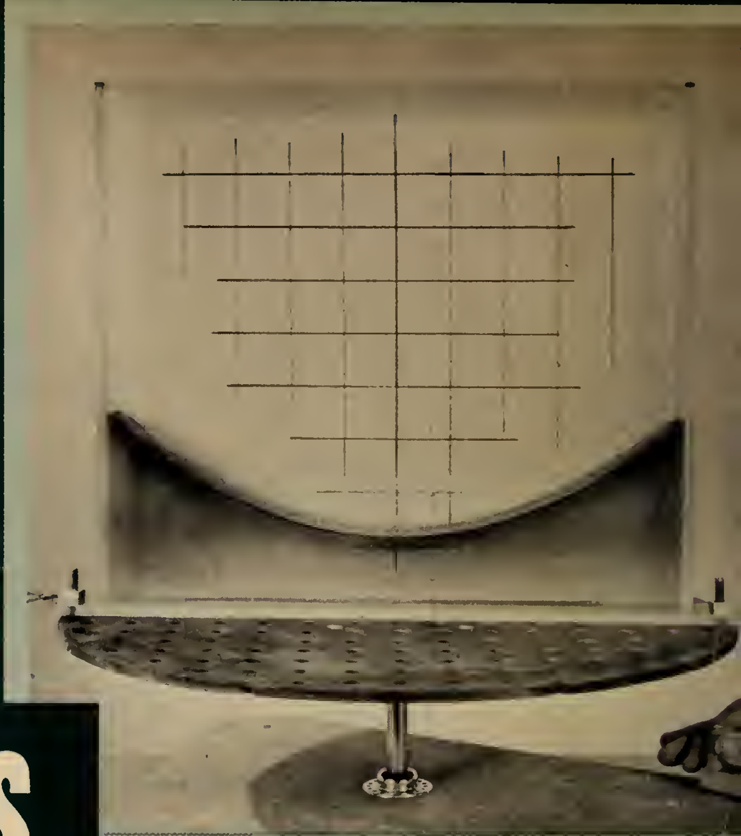
Ⓑ 1→4→9→16→25→36→?

Ⓒ 1→2→3→5→7→11→13→17→19→?

Ⓓ 1→2→4→7→11→16→22→?

FOR SCIENCE EXPERTS ONLY

Can you explain this science puzzle? Campers sometimes keep their food cold by putting it in a hole in the ground; yet the temperature in a deep gold mine in South Africa is more than 120°F.

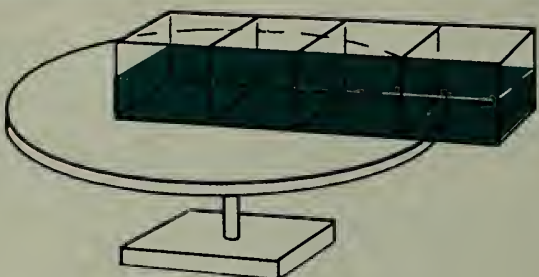


BRAIN-BOOSTERS

prepared by DAVID WEBSTER

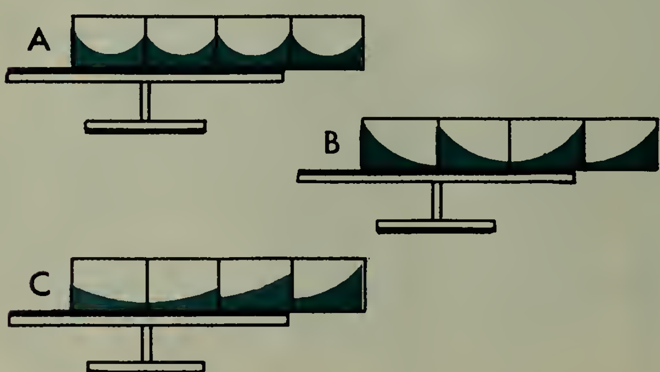
MYSTERY PHOTO

What is making the surface of the water in the tank curve?



WHAT WOULD HAPPEN IF?

The drawing shows a plastic box divided into four parts, each half-filled with water. Which of the three diagrams shows best what would happen to the water in each compartment if you spun the turntable on which the box is resting? (Don't try this on your phonograph at home. If water spilled out of the box, it could damage the phonograph.)



CAN YOU DO IT?

Can you burn some steel?

Submitted by Bonnie Mosier, Newport Beach, California

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: Blasting caps for dynamite charges are set off electrically. There is a slight possibility that radio waves from a "walkie-talkie" or automobile transmitter could accidentally set off a blasting cap.

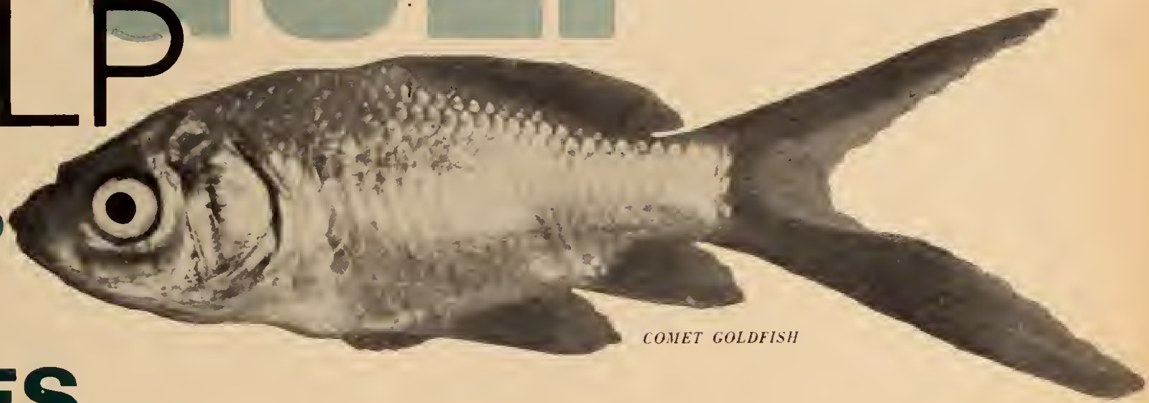
What would happen if? The air in a basketball would blow up a large plastic bag just a little. Would the air from an automobile tire blow up the bag all the way?

Can you do it? I was not able to blow up one balloon inside another. If you can, please let me know how you did it.

Fun with numbers and shapes: A train that is one-half mile long and is traveling at 60 miles per hour would take one minute to pass through a tunnel that is one-half mile long.

For science experts only: The only planet that we can be sure has canals, ice caps, and an atmosphere is the earth.

GULP GULP GULP GOES THE GOLDFISH



COMET GOLDFISH

Water is a fish's "breath of life." You can investigate why he gulps it faster at some times and slower at others.

■ Watch a fish continually gulping water as it swims around, and you might think it should drown. But "drowning" means not being able to get oxygen because your lungs are full of water, or some other liquid. Without lungs, a fish can't drown. Do you think it can suffocate for lack of oxygen?

The water that a fish gulps in passes over, under, and around its *gills*—tiny *filaments,* or folds of thin skin, under the flaps just behind the fish's head. Oxygen that is dissolved in the water passes through the walls of these filaments into the fish's blood stream, just as oxygen from the air passes through the thin walls of tiny tubes that carry blood through your lungs.

The oxygen is combined with carbon in the fish's body cells to make carbon dioxide and release energy to the cells. The carbon dioxide, a waste, is carried in the blood stream back to the gills. There it passes back into the water and out the fish's *gill slits,* while the flaps are open.

The process of taking in oxygen (from the atmosphere or from water) and expelling waste carbon dioxide is called *respiration.* You can get an idea of how much oxygen an animal is using by the number of respirations it makes in one minute. (Each time a fish opens and closes its gill flaps it is taking one "breath.")

How Does Activity Affect a Fish's "Breathing"?

Do you think that a fish uses more oxygen when it is active than when it is resting? Does the temperature of the water have any effect on a fish's respiration? Here are some ways to find out. *(Continued on the next page)*

You will need four goldfish. Comet goldfish can withstand temperature changes better than other kinds, and it is easy to see their gill flaps opening. You can buy them at a tropical fish store for 20 to 50 cents each. You will also need three containers. Flat-sided tanks are better than round bowls, which make the fish appear distorted. You might use clear plastic sweater boxes from a variety store, but only for your investigations. (The plastic may have a bad effect on the fish over a long period of time.) And you will need a thermometer to check the temperature of the water in your tanks.

Place the fish in a tank with water at 70° F. (You can regulate the temperature by stirring in warmer or cooler water as needed—but do that *before* you put the fish in the tank.) Move one fish to another tank with water at 70°. Darken the room for a few minutes, then turn on the lights from a distance and approach the test tank slowly. The fish should be fairly quiet. Count the number of times its gill flaps open and close in one minute. Do this several times and find the average. Record this figure in Table 1.

When the fish is moving a bit faster, take several more counts. Then stir the water just enough to excite the fish, and count its respirations when it is swimming rapidly. Do the same thing with each fish, putting each one into the third tank (also at 70°) when you are through testing it.

1

Fish Respirations per Minute at 70° F

activity of fish	fish 1	fish 2	fish 3	fish 4
resting				
normal				
active				

2

Fish Respirations per Minute at Varying Temperatures (Normal Activity)

water tempera-ture	warming water		cooling water	
	fish 1	fish 2	fish 3	fish 4
80°F.			X	X
75°			X	X
70°				
65°	X	X		
60°	X	X		
55°	X	X		

Temperature and Respiration

Be sure to check the temperature of the water *each time* you count respirations. If the temperature has changed more than one or two degrees, record it with your respiration count. Fish are coldblooded animals, so their temperature changes with the temperature of their surroundings. Do you think that a change in water temperature will affect the respiration of a fish a great deal?

To find out, fill two tanks with water at 70°, and put two fish into each of them. Count their respirations separately, and record them in Table 2. Then stir a little warm water into one tank to heat up the water in the tank evenly, and bring it up to 75°. Add the warm water *very slowly* so that you won't shock the fish. Take at least 15 minutes to a half hour to raise the water temperature five degrees. Count the respirations of the fish in the "warm" tank again, and write the numbers down. Then raise the temperature of the water another five degrees, to 80°, and record the respirations. Watch to see if the fish begin swimming to the surface as the water gets warmer (can you guess why?). If this happens, don't add any more warm water.

Now stir cold water into the other tank *very slowly*. Take 15 minutes to a half hour to lower the temperature five degrees. Count and record the respirations of the two fish at 65°, and at each 5-degree step down to 55°.

What Did You Find Out?

From the findings in your two tables, how would you describe the effect of activity on a fish's respiration? How does heat or cold affect its respiration? Does the size of the fish seem to make any difference in the way activity or heat affects its respiration? Can you think of some possible explanations for your findings?—ANTHONY JOSEPH

INVESTIGATIONS

Do you think that vibrations outside the tank will speed up or slow down a fish's respiration? (Try placing the tank near a loudspeaker.) What if you dissolve some salt in the water (no more than a teaspoonful per gallon)? Does the strength of the light in the tank have any effect? How about the color of the light? You can probably think of many other ways to investigate things that change the speed of a fish's respiration.

Biologists are studying bald eagles to discover why these great birds have disappeared from many parts of North America. Their findings may help answer the question:

Can we save the Eagles?

by David Hancock

■ Bald eagles depend upon waterways to supply their basic food—fish. They need big trees to support their bulky stick nests, and usually need great forests for privacy. Once, bald eagles were found in North America wherever there were lakes, rivers, and ocean coasts.

Now the bald eagle has disappeared from much of its former range. There are only a few eagles left on the Atlantic Coast north of Florida. Many of them don't even raise young. The many bald eagles from the Great Lakes are completely gone. All that remains are a few huge, empty nests.

Only three areas in North America still have many eagles. Florida has about 200 nesting pairs. Although the eagles along the shores of the Great Lakes have disappeared, a fair number of eagles nest in the states south of these lakes, and in western Ontario, Canada. The remaining stronghold for the bald eagle is the rugged coast of British Columbia and Alaska.

Across most of the United States, the sight of a bald eagle—the national bird of this country—is now a rare event. Biologists have tried to find out why the number of eagles is dropping, and what can be done about it. In 1961, the National Audubon Society began a study of this bird. Biologists working for the United States Fish and Wildlife Service are also studying eagles. From their investigations, scientists have found four main reasons for the dropping number of eagles.

An Easy Target

Two kinds *(species)* of eagle live in North America—the bald eagle and the golden eagle. Both are protected by law throughout Canada and the United States. In fact, in the United States it is a Federal offense to shoot an eagle or to disturb eagle nests or eggs. Even with these laws, however, many eagles are still shot by people who don't know about the laws, or who just don't care. In a recent study, 119 bald eagles found dead in different parts of the country were examined to find the cause of death. Most had been shot. Eagles make easy targets because they are big and often are not wary. *(Continued on the next page)*

This eagle's nest in Florida was built in a dead tree. Bald eagles prefer to nest in living trees, but most big, live trees are cut down by man.

Sometimes the laws are broken deliberately, or a "loophole" is found. In southwestern states, some cattle and sheep ranchers still shoot and poison eagles. They believe that eagles hunt their livestock. The ranchers blame mostly the golden eagles, but both species are killed. Both are innocent. From their observations of eagles, biologists have discovered that these birds are mainly *scavengers,* eating dead animals. Only rarely does an eagle kill a living lamb or calf, and these are usually sick and dying individuals.

In Alaska, the state government once paid people to shoot eagles because the birds were thought to be harmful to salmon. The number of salmon in the streams had dropped. Fortunately a study was made and it was found that eagles do little harm to the salmon. The numbers of fish had dropped because man had fished the rivers too heavily. Eagles are now protected by law in Alaska (but some are still shot).

No Place Like Home

Both humans and bald eagles like to live near waterways, especially those that are rich in food fish. Unfortunately, when humans settle in a new area, they often cut down the trees, especially those close to the water. Soon the eagle nest trees are gone. The activity of cars, boats, and people becomes so great that the eagles are often disturbed. Eventually the adult eagles die out, leaving few or no young. In this way, eagles have disappeared from many areas of North America.

You might think that if an animal is "forced" out of one area, it could move to a more suitable place and live there. In nature, however, all of the available space is usually filled. The suitable areas are already occupied by eagles. When the homeland of some eagles is ruined by man, the birds may not even try to go elsewhere. They simply die.

Disturbing the Peace

There are many things about the lives of bald eagles that we know little—or nothing—about. For example, just how much "peace and quiet" and freedom from human disturbance do eagles need?

We need to know more about *what* disturbs eagles, especially those things that have an effect on the bird's nesting success. Will boats passing by a nest cause the birds to abandon it? Will a hiker's trail near a nest have any effect on the adults or young?

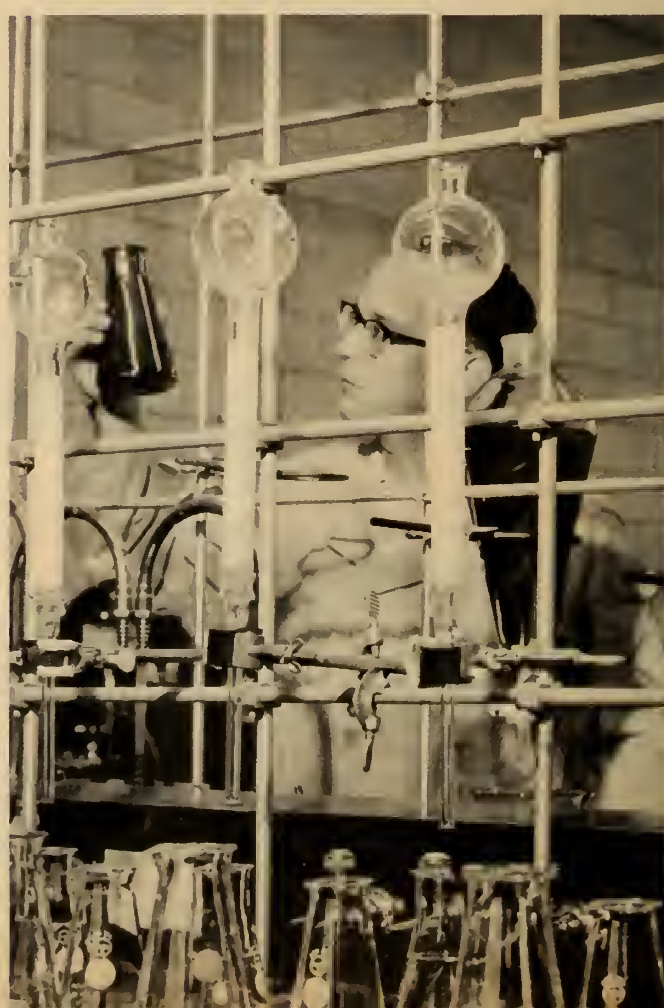
In my own studies of bald eagles, I discovered that my visits to eagle nests had done great harm. To the adult eagles, my visits to nests and close flights in a helicopter apparently meant that the nest was no longer safe. Because of this, the eagles had little success raising young during the next breeding season *(see "Nine Hours in an Eagle's Nest,"* N&S, *March 4, 1968).*

Death in Small Doses

There is one other threat to bald eagles (and other birds of prey, such as hawks) which may be even greater than the others. It is the use of long-lasting *biocides,* poisons used to kill insects and other small animals. The word "biocide" comes from Latin and Greek words meaning "life killer." Biocides are sometimes called "pesticides," or "insecticides," but they can kill many kinds of life (including humans), not just insects and "pests." Biocides are sprayed on farm crops of many kinds, and on forest trees.

Some biocides "break down" quickly and are no longer dangerous. Others last a long time. These chemicals may stay in soil for years, and are gradually washed into streams, rivers, and lakes. These long-lasting poisons worry many conservationists.

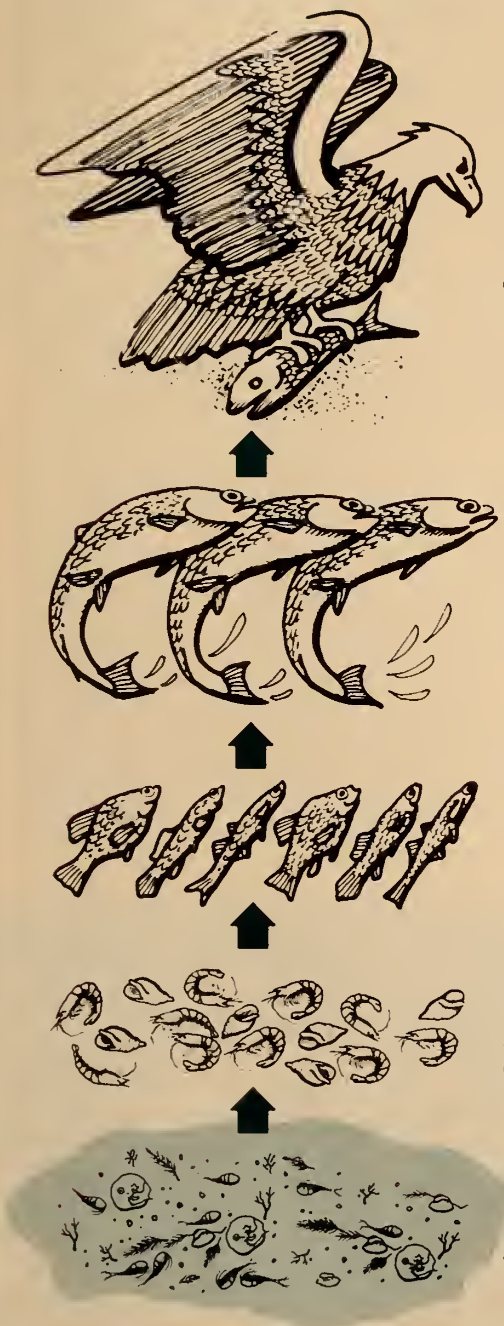
Biologists of the United States Fish and Wildlife Service



Chemists working at the Patuxent Wildlife Research Center in Maryland are able to measure the amount of biocides stored in the bodies of bald eagles and other animals.

have found large amounts of biocides in the bodies of dead eagles and in eagle eggs that did not hatch. The diagram on this page shows how it is possible for eagles to get big "doses" of biocides, even though they may live far from where the poisons were first used by farmers or foresters.

Wildlife biologists have not been able to study the effects of biocides on eagles as much as they would like. The



Animals at the top of the food pyramid get biocides concentrated from all the organisms below.

Hundreds of bigger fish feed on the smaller fish.

Thousands of small fish feed on the shrimp and snails.

Millions of shrimp, snails, and other small animals feed on the layer below.

Biocides first enter the cells of countless tiny plants and animals, both dead and alive.

As food energy moves up through a "pyramid of numbers" like this, long-lasting biocides also pass from one level to the next. The greatest concentration of biocides is in the bodies of the animals at the top of the pyramid.

Case of the Broken Eggs

British biologists studying eagles, falcons, and hawks have noticed a great increase in the number of broken eggs in the birds' nests, beginning in the mid-1940s. Checking further, Dr. D. A. Ratcliffe found that the weight of the eggshells from these kinds of birds had dropped. The eggshells weighed less (and were less strong) because they contained less calcium *(see "How Strong Is an Eggshell?,"* N&S, *Dec. 18, 1967).* The decrease in eggshell weight showed up at about the same time that DDT and other long-lasting biocides were first widely used in Britain, and has continued since. Biologists are now investigating the idea that biocides may cause some change in the birds' bodies that makes them produce weak eggshells.

scarcity of eagles makes it hard for scientists to get many birds and eggs for their investigations. So far, they have no definite proof that biocides cause the death of many eagles, or keep eagle eggs from hatching *(see "Case of the Broken Eggs," on this page).* From other studies, however, biologists know that long-lasting biocides such as DDT have harmful effects on other birds, fish, and many other animals.

Many people now recognize the dangers of long-lasting biocides. The use of such poisons as DDT has been stopped by laws in some areas. Since 1966, very little DDT has been used by the United States Forest Service. Many scientists are trying to find other, less dangerous ways of controlling harmful insects. They have had some success, but biocides will not be replaced soon.

Some steps have been taken to protect the eagles that remain (although it is impossible to protect them from biocides). In Florida, a man named George Heinzman led a group of conservationists who set up a million-acre sanctuary for bald eagles. About 75 pairs of eagles nest in the area. Mr. Heinzman and his helpers talked to the farmers and other people who owned the land. The landowners signed agreements that pledged their help in protecting the eagles, their nests, and the nest trees. Also, Stewart Udall, Secretary of the United States Department of the Interior, has ordered eagles and their nests specially protected on National Wildlife Refuges. No disturbance is allowed within a square-mile zone around each nest.

If the bald eagle is to survive, this sort of protection must be given to bald eagles everywhere. We need to learn more about the birds' needs, and these needs must be met, even if it means stopping people from cutting down trees on land they own. Bald eagles are still plentiful along the wild coast of Alaska and British Columbia, but in the original 48 states there is little time left to save the eagles ■

WHAT'S NEW?

by Roger George

The fiddler has struck again, this time killing an Alabama farmer. The fiddler is a small poisonous spider with a violin-shaped mark on its body (*see photo*). Also called the brown recluse, it is light to dark brown (sometimes yellow) and lives in dark corners of closets and other out-of-the-way places.

This photo shows the size of a male fiddler (top) and a female. The fiddle mark points backward toward the "waist."

The fiddler comes out at night and stalks its favorite food—insects. It bites people only when it feels threatened, as when someone brushes against it. The bite often develops into a huge sore that does not heal. It sometimes leaves a bullet-like hole that has to be covered by skin taken from another part of the body. Luckily the bite seldom causes death. The fiddler lives in central and southern states, but seems to be spreading to other areas.

The best protection against sharks is not a knife or a foul-smelling chemical but a plastic bag. The bag was developed by Dr. C. Scott Johnson for the United States Navy. A shipwrecked sailor or a flier downed in shark-filled water opens a small package on his life vest and unfolds the plastic bag. He fills it with sea water and gets into it. He then blows up air chambers in the bag, which help keep him afloat.

The bag has worked well in tests at sea. It keeps body odors from escaping and attracting sharks. It also holds in body heat, helping the person stay warm.

No hero's welcome will greet U.S. astronauts when they step from their spacecraft after their round trip to the moon about 1970. When the spacecraft is hauled aboard an aircraft carrier and its hatch is opened, the astronauts will walk into a plastic tunnel and follow it into a sealed van. This van will be flown to Houston, Texas, where the lunar explorers will go through another plastic tunnel into a sealed laboratory complete with bedrooms, kitchen, gym, and medical equipment. They'll be cooped up here for about three weeks with a dozen or so doctors and scientists. After this, they'll get the welcome they deserve.

What's the idea? To make sure no strange new germs from the moon have hitched a ride with the astronauts. This isn't likely to happen, because there's probably no life at all on the moon. But these safety steps must be taken. Moon germs could cause widespread disease. The human body wouldn't have built up an immunity to them as it has to many germs on the earth. Nor would medicines have been developed to fight these germs.

Fashion is an enemy of wildlife. It makes women want to wear furs of rare mammals such as the leopard, cheetah, and jaguar. These mammals are being killed faster than they can reproduce, says the World Wildlife Fund. Other animals are threatened for similar reasons. Polar bears are losing their lives because their hides make handsome rugs and decorations. The skins of sea turtles, alligators, and crocodiles are made into shoes, handbags, and belts.

If you want to help save these animals, the World Wildlife Fund has the following advice. Try not to use any product made from a rare or endangered wild animal. Urge your family and friends to do the same. If a local store sells such products, tell the owner how you feel.

Will we suffocate ourselves? This question was raised by a scientist recently. Our bodies get oxygen from the air we breathe. About one-fifth of the air is oxygen. The oxygen is kept at this level by a delicate balance between animals and plants. Animals breathe in oxygen and breathe out carbon dioxide. Plants, in the process called *photosynthesis,* take in carbon dioxide and give out oxygen.

Man may upset this balance if he keeps on destroying plants to make way for buildings and roads, warns Dr. Lamont C. Cole of Cornell University, in Ithaca, New York. "Grassland is being paved at the rate of about one million acres a year," says Dr. Cole. This lessens the amount of oxygen supplied to the air by plants. If plants produce less oxygen than animals use, the amount of oxygen in the air will drop, and life will be in danger. Dr. Cole says the oxygen content "may already be declining around our largest cities like New York and Philadelphia."

This photograph of atoms in the metal tungsten was made by a new microscope that can focus on a single atom (see arrow) and enable the scientist to tell what kind it is. The microscope's inventor is Dr. Erwin Mueller of Pennsylvania State University at University Park. With an earlier microscope he invented 12 years ago, Dr. Mueller became the first man to see an atom. His new instrument can separate a single atom from those around it. The scientist figures out what kind it is from how fast it travels along a tube.

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(continued from page 2T)

mals, but other factors also contribute to their decline. Alligators, for example, though protected by law, are hunted for their valuable hides which are used to make purses.

- *Do some animals thrive despite the changes made by humans?* Some species, such as the gray squirrel, can live well in suburban or city park environments. Others benefit from the changed habitat; deer are more plentiful in farm land than in virgin forests. The more specialized a species' needs, the greater the threat of extinction when its environment changes.

- *Why should humans bother to save animals from extinction?* The esthetic values are obvious with a species like the bald eagle, chosen as symbol of the United States. Also, humans still have much to learn about life, and they can learn from rare as well as abundant species. Studies of the complex social life of wolves have given scientists new insights into behavior of all mammals.

Extinction is probably inevitable for all present forms of life on earth, including *Homo sapiens.* This fact, however, doesn't give any one species the right to accelerate the extinction of other forms of life. Humans are the unique product of a long evolution; they tend to forget that condors and alligators are unique too, in different ways. If 48 humans were left on earth with a population of three billion whooping cranes, the humans would have no hope of assistance from the cranes. These birds are not capable of caring about the survival of another species. Humans *can* care, however, and the three billion humans on earth can take steps to protect 48 whooping cranes and a few thousand bald eagles.

- *Are there any alternatives to the use of DDT and other long-lasting biocides?* In a few years, hopefully, there will be, and scientists hope that the use of all chemical poisons can eventually be halted. The long-range effectiveness of these poisons is limited anyway, because insect populations evolve which have a resistance to the biocides.

Most of the methods of pest control now being studied involve knowledge of the pest's life cycle. One method is to spray a cropfield with a chemical substitute for an insect's juvenile growth hormone. This keeps the insects from developing into adults. The chief advantage of this method is that the chemicals apparently affect only insects and are not a threat to other forms of life. The chief drawback is that the hormones affect all insects, not just the few pest species. The goal of scientists studying pest control is to have selective control—methods that affect only the pest species.

References

- *Symbol of Our Nation* is a folder featuring a colored painting of the bald eagle and information about it. This folder is available for 50 cents from the Superintendent of Documents, U.S. Printing Office, Washington, D.C.
- *Audubon* magazine is published by the National Audubon Society, 1130 Fifth Avenue, New York, N.Y. 10028. A year's subscription (6 issues) costs $7. No longer focused mainly on birds, *Audubon* features articles about many conservation subjects and is beautifully illustrated.

Brain-Boosters

Mystery Photo. A high-speed camera "froze" the motion of the turntable as it was spinning around with the water-filled container. The water is made to curve up the walls of the container by *centrifugal force*—the force that tends to throw any revolving thing outward from its center of revolution.

There are many common examples of centrifugal force at work. Centrifugal force keeps a keychain taut when you twirl it. It is also the force that throws you toward the outside when you turn a corner in your car. (The car's path around the corner is an arc of a very large circle.)

A demonstration similar to the one shown can be made with a jar half-filled with water. Screw the cap on tightly, then spin the jar on its side on a flat, smooth surface *(see diagram).*

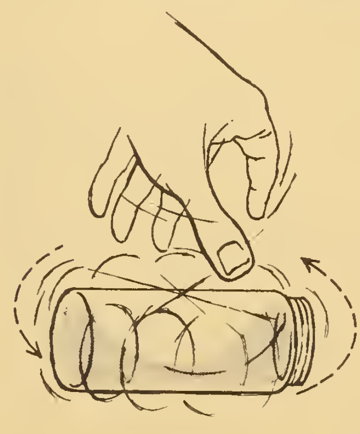
What would happen if? If your pupils have already discussed the Mystery Photo, they will have an easier time figuring out this problem. The farther a section of the box is from the center of revolution, the more centrifugal force is exerted on it, and the more the water will slant toward the outside. Diagram C most nearly represents what would happen if the turntable were spun with the box placed as shown. Since the first two sections of the box are at the same distance on opposite sides of the center, the curves formed by the water in them will be "mirror images" of each other.

Can you do it? Many "unlikely" materials can be made to burn if they are shredded fine enough. A pad of steel wool (without soap) can be lighted with an ordinary match. Blowing on it will make it burn more brightly.

The magnesium filament in a photographic flashbulb is surrounded by oxygen to make it burn quickly and brilliantly. If you break open an unused flashbulb and light the filament with a match, you will see that it burns more slowly and gives off much less light in the air. The filament in an ordinary light bulb is surrounded by a partial vacuum to make it burn more slowly than it would in air.

Fun with numbers and shapes. After your pupils have tried solving these number series, known as *mathematical progressions,* perhaps they can try to create some of their own for their classmates to solve. Any kind of mathematical operation can be used to make a progression; the only requirement is that the *same* rule be applied throughout.

In series A, each number is derived by doubling the one before; the missing number is 128. Series B consists of
(Continued on page 4T)



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the squares of the numbers 1 to 6; the last number is 49, the square of 7. The numbers in series C are all *prime numbers*—numbers that cannot be evenly divided by any number other than themselves (or 1). The next prime number is 23. In series D, 1 is added to the first number, 2 to the second number, then 3, 4, and so on, always adding 1 more to each number than was added to the one before. The final number is 29.

Keep in mind that a progression can sometimes be explained by more than one rule. Series B, for example, could be derived by adding 3 to the first number, then the next *odd* number (5, 7, 9, etc.) to each subsequent number in the series. The last number would still be 49. If a pupil discovers *any uniform rule* that can explain a progression, it's as "correct" as any other.

You might point out, also, that progressions are more than just a way for mathematicians to amuse themselves. They have some important scientific applications – one of which could be communication with "intelligent beings" on other planets. If we broadcast a series of numbers to another planet by means of short bursts of radio energy, intelligent life there might be able to complete the series by broadcasting the appropriate number of "beeps" back to us. *(See "What's in a Dot,"* N&S, *January 22, 1968.)*

For science experts only. If your pupils have ever done any gardening or digging for worms, they have probably noticed that the soil beneath the surface is relatively cool. Others may know that a sweater is advisable if you are visiting a limestone cave, even on a hot summer day.

But while the temperature just below ground is usually lower than it is at the surface, the temperature begins to increase beyond a certain depth. Near the center of the earth, the temperature is so high that the metals there are believed to be in liquid form. At the earth's innermost core, however, the pressure is so great that metals are forced to remain solid, despite the intense heat.

nature and science
TEACHER'S EDITION
VOL. 5 NO. 14 / APRIL 1, 1968 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Spaceship Earth

> *We travel together, passengers on a little spaceship, dependent on its vulnerable supplies of air and soil . . . preserved from annihilation only by the care, the work, and I will say, the love, we give our fragile craft.*
> —ADLAI STEVENSON

This special-topic issue will show your pupils how the supplies of air, water, and living space in some places on our spaceship are being polluted by the material wastes of human societies. The problem is that these material wastes—many of them dangerous to animal or plant life, or both—cannot be destroyed, but only discarded or re-used.


Drawing by Robert Osborn from *Not So Rich as You Think*

Under ordinary conditions, matter can be changed, but not annihilated or created. This is the Law of Conservation of Matter (or Mass)—a physical "law" that cannot be broken. Matter can be changed from solid to liquid, to gas, and back again, but you can't get rid of it.

(Under special conditions, certain kinds of matter such as uranium and plutonium can be changed from matter into nuclear energy, but only a portion of the matter is destroyed in this process; the rest is changed into waste materials, some dangerous to living things.)

Humans, especially those in the more heavily industrialized countries, have acted as though they can ignore this basic law of the universe. As George R. Stewart writes in *Not So Rich as You Think (see "For Your Reading," page 3T):*

"Collectively, they are like a family which has lived for many years in the same house without proper cleaning-up. Superficially these people took some pains. They swept the dust under the rugs, piled old newspapers in the corners of the living-room, and even carried some things to the attic and the basement. It was not too bad for a while. Eventually they were living in a slum, with mice, cockroaches, fleas, dust, and a foul odor. American civilization has arrived at that point."

In the United States, the Affluent Society can also be called the Effluent

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IN THIS ISSUE

IN THE NEXT ISSUE

Make a simple electric motor and find out how it runs . . . A scientist's adventures while spying on raccoons . . . The paper airplane contest winners . . . Flatworm behavior

Using This Issue . . .
(continued from page 1T)

Society, or the Throw-away Society. The policy of planned obsolescence, along with disregard for disposal of used goods, is an integral part of our industrial economy. A chemical company proclaims in an advertisement that it will produce hundreds of new products in a single year. You can be sure that no research has been done to discover how to get rid of the products after use.

The answer to some of our waste disposal problems is *recycling.* As the first article in the student's edition points out, recycling already occurs naturally and humans now recycle some matter, such as water. In the past, rust and the bacteria of decay eventually disposed of most of man's cast-off materials. Today the load of wastes is sometimes too great for natural recycling to cope with. Also, synthetic products, such as plastics, break down very slowly.

Recycling already occurs more than most citizens realize. Besides water, such materials as lead, copper, and some paper are recycled. The recovery of copper equals 80 per cent of newly-mined copper in the United States. Recently it was discovered that enough gold and silver can be recovered from dumps to make the effort profitable.

So far, recycling has been done because it is profitable. Soon, recycling will have to be done whether it is profitable or not; the government will probably subsidize recycling industries just as it now subsidizes other industries. Also, products may have to be designed for recycling. Automobiles, for example, could be built with recycling in mind. Presently the zinc and copper in cars makes it difficult to recover the steel that makes up the bulk of an auto. If autos were made without zinc and copper, the steel could be more easily recycled.

Topics for Class Discussion

Here are some suggestions for recycling and other ways of conserving natural resources, most of which are suggested by George R. Stewart in *Not So Rich as You Think.* Discuss them with your pupils. What effects would these changes have on their lives? On their communities?

- Human body wastes should be used as fertilizer, perhaps to grow algae or tiny water animals that could be eaten directly by humans or by domestic animals.

- The components of garbage will have to be separated, the food waste to be ground up and used as fertilizer, the

(Continued on page 3T)

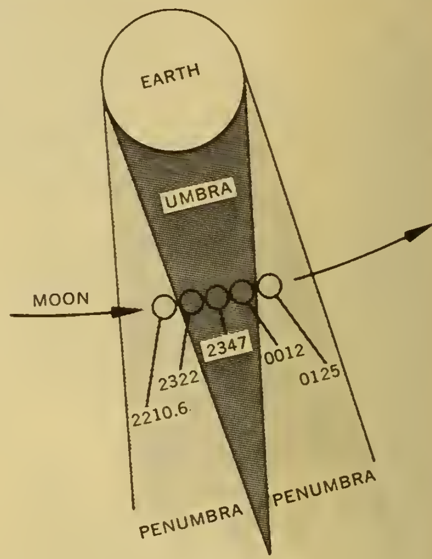
Drawing by Robert Osborn from *Not So Rich as You Think*

Watch a Total Lunar Eclipse on April 12

■ On April 12 there will be a total lunar eclipse. Whenever the moon passes into the shadow of the earth, a lunar eclipse occurs. The April 12 eclipse will be visible from coast to coast, beginning at 10½ minutes past 10 p.m. EST and ending at 25 minutes past one a.m.

As the diagram shows, the moon will edge its way into the primary shadow of the earth (the *umbra*) at 2210.6 hours (10:10.6 p.m.) EST. At 2322 hours it will be entirely within the umbra. At 2347 hours it will be at mid-eclipse. At 0012 the moon will begin to edge its way out of the umbra, and at 0125 it will again be entirely visible, having passed into the secondary shadow, the *penumbra.*

Because the earth's atmosphere acts as a lens and bends some of the sun's light into the shadow zone, the moon will not appear totally black.



An interesting way to observe the event is to look for varying degrees of brightness during the eclipse. The moon will spend less than an hour passing through each of two penumbra zones. See if you can notice any darkening at all during the penumbra phases of the eclipse ■

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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

nature and science

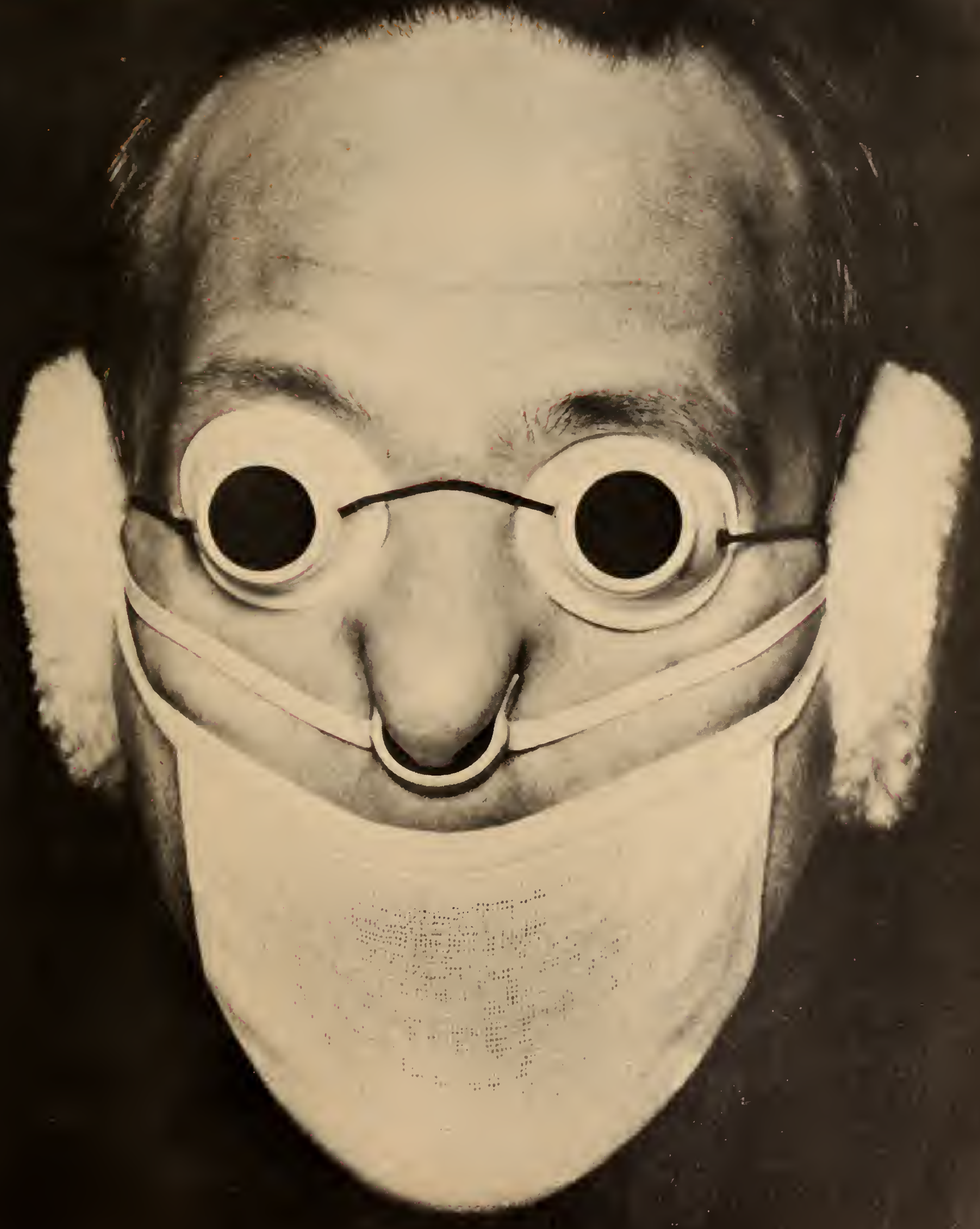
VOL. 5 NO. 14 / APRIL 1, 1968

SPECIAL-TOPIC ISSUE

SPACESHIP EARTH

Will you soon need protection like this to survive on Spaceship Earth?

see page 2



nature and science

VOL. 5 NO. 14 / APRIL 1, 1968

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Editor for this issue: Laurence P. Pringle

PICTURE CREDITS: Cover, courtesy of *Forbes Magazine;* pp. 3, 15-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, 5 (top), Franklyn K. Lauden; p. 5 (bottom), courtesy of Ford Motor Company; p. 6, photo courtesy of American Motors Corporation; p. 7, Wide World Photos; pp. 8-9, Robert G. Bryant; p. 10, Rondal Partridge; p. 11, Marvin Hardee (Black Star); p. 12, courtesy of Federal Water Pollution Control Administration; p. 13, photo by Don Rutledge (Black Star); p. 14, Tony Fusco; p. 16, photo by Joan Hamblin, from Education Development Center.

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

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Space

You are aboard a spacecraft that is hurtling through space. Will you and the rest of the human crew be able to survive with the supplies you have on board?

■ About four and a half billion years ago, the planet earth began its journey through space. The first life appeared on earth about three billion years ago, and man appeared just one million years ago. Then, as now, all the life on earth existed in the *biosphere*—the thin skin of soil, water and air that covers the earth's surface.

Unlike most spaceships, the earth received some "supplies" from outside—mainly energy from the sun. Without sunlight, all life on earth would cease. But even with a continuous supply of sun energy, human life aboard Spaceship Earth could come to an end.

Running Low on Food

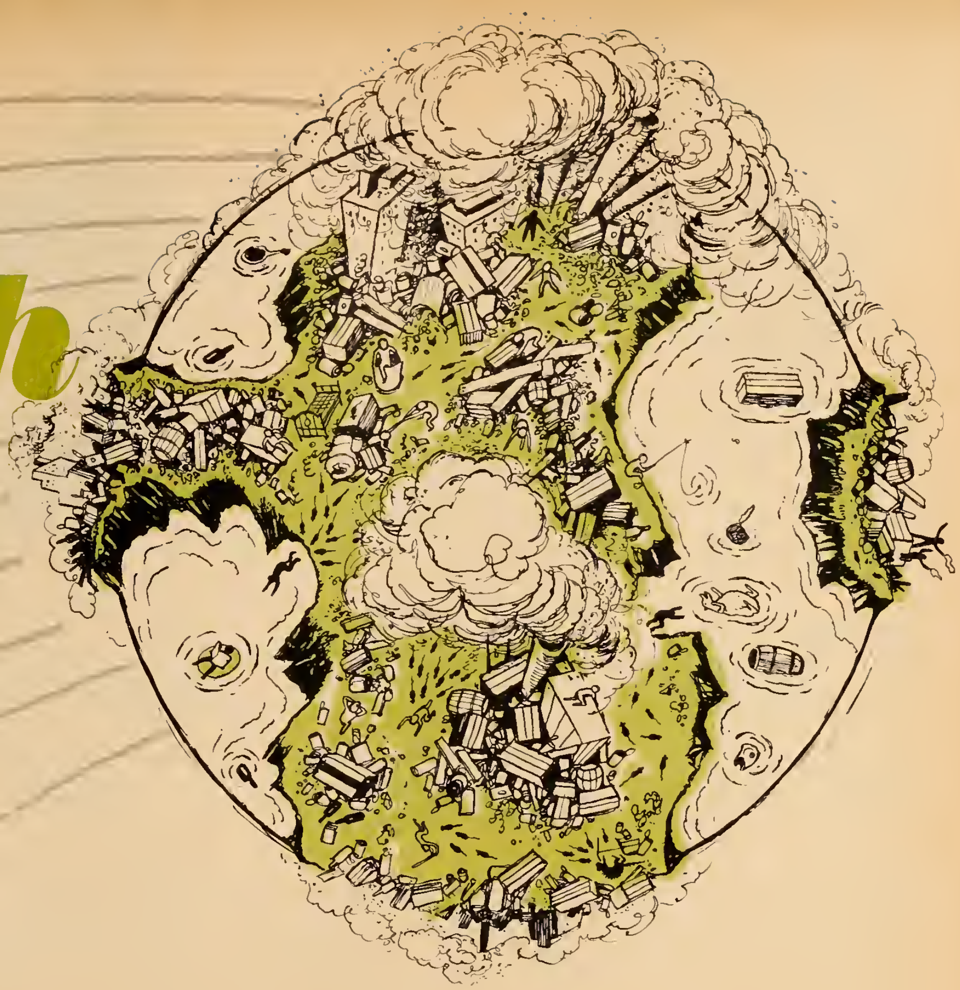
As scientists look into the future of Spaceship Earth they worry most about two problems: the growth of the human population, and the spread of *technology* (the materials and machines that man makes and uses). You have probably already heard about the "population explosion." There are now over three billion humans on earth in 30 years there may be more than six billion.

Biologists who have studied the populations of animal such as mice and insects have no doubt that the human population will eventually stop its rapid growth. But how Some food experts predict that death by starvation wil check the population growth in countries such as India beginning in the 1970s. Throughout the world, the numbe of people is increasing at a faster rate than the amount o food produced. Even in the food-rich United States, hug food surpluses are a thing of the past.

As the human population grows, man is affecting hi Spaceship in many ways. With his machines and chemicals man has great power to make changes on earth. Many o these changes, of course, have made it possible for human to live in comfort anywhere, to travel quickly from plac to place, to kill insects that eat food crops. Time after time however, people discover that the changes they make caus other, unexpected changes in the biosphere.

The automobile is one of man's most popular inventions, yet wastes from autos are now choking the air o

ship Earth



cities *(see page 4)*. Detergent "soaps" make washing easier; fertilizers help farmers to grow abundant crops. Yet the chemicals from detergents and fertilizers are helping to "kill" lakes and other waters *(see page 11)*.

No Deposit, No Return?

The United States is not as densely populated as many countries. But as the richest country on Spaceship Earth, it has special problems. Industries take natural resources (such as iron and wood), change them into products (such as toys, automobiles, magazines), and then sell the products to "consumers." But to "consume" means to do away with completely, so there are no "consumers." Instead, everyone is a *user*. We use a product, sometimes changing it in form, and then throw it away. In 1920 the average person in the United States threw away 2.75 pounds of "junk" a day. Now each person throws away 4.5 pounds a day. As the earth becomes more crowded, however, there is no longer an "away." One person's trash basket is another's living space.

Some things that are thrown away gradually disappear. An apple core becomes food for small animals. A piece of paper decays. Even a "tin" can (really made of steel with a coat of tin) rusts away and may become part of the soil. Many of today's products, however, are made of materials such as aluminum and plastic that may last for centuries. Instead of re-using glass bottles, industries encourage people to throw them away.

Industries in the United States use materials from all over the earth. Each year in the United States, people throw away three million tons of iron and more than 200,000 tons of aluminum, lead, zinc, and tin. Supplies of many of these materials will someday be used up. Then industries will be faced with the huge problem of recovering the metals from junkyards, dumps, roadsides, or wherever else the earth's metals have been thrown.

In 1966, the National Academy of Sciences studied the problems of waste "management" in this country. The report of the academy recommended that work must be started to *recycle* materials as much as possible. This is already done with water in some cities; the water you drink may have flowed through a sewer a few days ago. Cleaned of wastes and "germs," it is fit for human use again.

Scientists already know how to clean many kinds of wastes from water so it can be re-used. But how do you recover and use again the materials in automobiles, plastic bottles, or television sets?

Surrounded by wastes and without enough food to go around, the growing number of humans must soon learn to take better care of the supplies aboard Spaceship Earth. There is no choice. After all, it is the only earth we have.
—Laurence Pringle

The wastes that they pour into the air are making "horseless carriages" begin to seem more like "litter-buggies." Many people are now wondering...

Can we have cars and clean air too?

by R. J. Lefkowitz

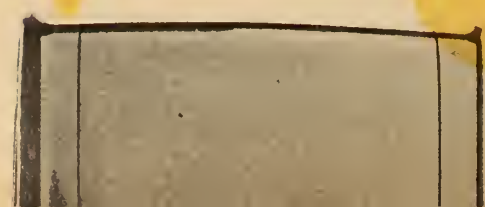
■ One day I watched a man walking along the sidewalk, eating a bar of candy. When he finished, he crumpled the wrapper and put it in his pocket. Before getting into his car, he took the paper from his pocket and threw it into a waste basket.

At first I thought, "That man is certainly trying not to litter the streets." But then, as he drove his car down the street, I wondered if he realized that he was now "littering" the air.

Exhaust Pipe "Litter"

His car, like millions of others, was releasing wastes, or *pollutants,* into the atmosphere. You can often see some of these wastes coming out the exhaust pipe of a car when the engine is started or speeded up. Most of the wastes, though, are invisible gases. One of these—*gasoline vapor*—is always escaping from the gas tank, even when the motor is not running.

Of course, automobiles aren't the only things that "litter" the air. Most heating and power plants send clouds of sulfur dioxide (from burning coal or oil) into the atmosphere. The sulfur dioxide combines with oxygen and water in the air and becomes sulfuric acid "mist." The mist "eats" away at buildings and irritates the sensitive lining of people's throats and lungs.



Chemical plants, oil refineries, incinerators, and many other things also pour pollutants into the air. Yet the automobile remains the single biggest air pollution "headache." One reason is that all of the automobiles in a city together produce more of some serious pollutants than other sources in the city produce. And it may be easier to control the amount of pollution from say, a single chemical plant, than from thousands of individual autos. Your town may not even have any big industrial plants to pollute the air around it, but it probably has many automobiles. And as the human population grows, and more and more people move to the cities, the number of automobiles in an area keeps going up.

Automobiles are in use just about all of the time. Not *every* automobile, of course—but at any time of day or any time of year there are many automobiles on the road. Most factories shut down at night, and heating plants are hardly active at all during the summer. But automobiles are always rolling.

Reducing Wastes from Cars

Perhaps some day public trains and buses designed so they don't produce much pollution will reduce the need for people to use their own automobiles. But people will still want to be able to get into their own car and drive wherever and whenever they please. So some way must be found for them to use their cars without polluting the air.

About one quarter of the waste that a car releases into the atmosphere is gasoline vapor that escapes from the engine chamber where it is supposed to be burned. Since

1963 all new cars must have a device that forces the escaping gasoline vapor back to the chamber to be burned.

Most of the rest of the wastes come out the auto's exhaust pipe. Many of them are *un*burned or *partly* burned materials that are dangerous to life. *Carbon monoxide,* for example, is a deadly gas that is formed when carbon in the gasoline doesn't get enough oxygen to burn completely in a car's engine.

When an animal inhales carbon monoxide, the gas uses oxygen from the animal's blood cells to complete its "burning" process and form carbon dioxide—a harmless gas. But this makes the animal breathe harder to get enough oxygen to keep it strong and healthy *(see "Gulp, Gulp, Gulp Goes the Goldfish,"* N&S, *March 18, 1968).*

Large amounts of carbon monoxide in the air are one of the reasons why doctors in the Los Angeles area of California have advised thousands of people with lung diseases to move to another area. Crops and other plants in many areas have also been damaged or killed by carbon monoxide from automobiles.

The pollutants that make an auto's "exhaust" look black —*unburned hydrocarbons*—can combine in air with another waste from the exhaust pipe, *nitric oxide* gas. When sunlight shines on these chemicals, they produce a kind of *smog* that affects some cities. When Dr. John T. Middleton was director of California's Air Pollution Center, he said that heavy smog had made California a place "where you can wake up in the morning and hear the birds cough."

Another gas, called *ozone,* is formed in the smog. Ozone in the Los Angeles area forced orchid growers to move to San Francisco to keep their plants from dying. But now their new area is being affected by ozone, and they may have to move again. Even in extremely small amounts, ozone can make your eyes sting.

If the gasoline were completely burned in an auto, there would be no carbon monoxide and unburned hydrocarbons in the car's exhaust. New cars now have to have an *afterburner* or other device to add more air to the unburned wastes from the engine and burn them further. But even these devices only take care of about half of a car's unburned wastes.

Back to Steam or Electricity?

Since it seems so difficult to stop all the air pollution from gasoline and oil-burning *(diesel)* engines, many people believe that some other kind of engine will have to be used to power automobiles. Some early cars ran very well on steam engines, which burn fuel much more thoroughly than gasoline or diesel engines do. In addition, a steam engine can burn fuel that contains less of the chemicals

that produce smog. Recently a few steam-powered cars have been made, but they are very expensive, partly because they are not made in large numbers.

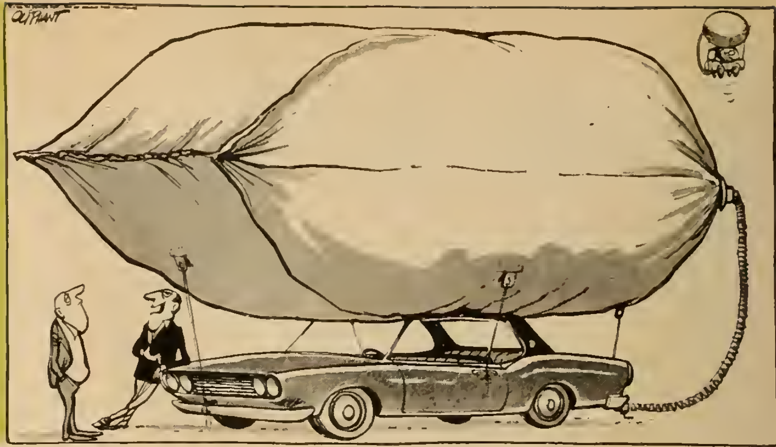
Today, however, more work seems to be going into efforts to develop electric-powered automobiles than steam-powered ones. Again, some of the early autos *(see photo)* had electric motors that were powered by *wet-cell batteries (see " 'Canned' Electricity,"* N&S, *February 19, 1968).* These batteries, like the one used to start the engine of a modern car, can be recharged whenever they "run out" of current. Battery-powered motors have been used for some time to drive small delivery trucks, golf carts, and tractors that carry materials around factories, for example.

The trouble with these cars is that the batteries are very heavy and take up too much space; they can't drive the cars very fast, or very far without being recharged. To solve these problems, a new kind of battery will have to be developed. It will have to be very light, very powerful, and able to supply current steadily for a long time. It will also have to be easy to recharge when its energy is used up.

Engineers and scientists have come up with several new kinds of batteries, but none of them can power an automobile over a long distance at high speed. One of these batteries, for example, is made with *lithium*—the lightest metal known. It is expected to take a tiny, three-passenger

(Continued on the next page)

This Baker electric car was called "a living room on wheels" when it was built in 1910. It and other "electrics" of the time soon gave way to the new "gas-buggies" that were noisier and dirtier, but could go farther and faster.



"...then, when the bag is full of hydrocarbons and noxious gases, you simply take it off and throw it away!"

Patrick Oliphant in The Denver Post

experimental car *(see photo)* 150 miles at low speed. But it probably couldn't take the car more than half that distance at the top speed of 50 miles per hour, or in stop-and-go driving.

Scientists are also investigating ways to *make* electricity in the car, instead of using electricity that is "stored" in batteries. They know, for example, that when oxygen and hydrogen combine to form water, large amounts of energy are released, and this energy can be changed into electrical energy. These two gases might be stored in separate tanks and combined in a *fuel cell* that powers a car and gives off only pure water as waste.

The Outlook for the Future

No one knows yet whether it will be possible to make a battery or a fuel cell powerful enough to drive a car as large as the ones we now have. Most of the electric cars that have been designed are very small compared with our gasoline-powered cars, and they can't go as far or as fast.

One company on the west coast of the United States began selling a two-passenger electric car last fall. The car uses a dozen ordinary car batteries, and it can't go faster than 25 miles per hour, or farther than 50 miles in good traffic conditions. Besides, the company had to stop making the car, because it did not meet the government's safety requirements.

So while it seems likely that electricity will be running at least some of the cars of the future, it will probably be several years before many electric cars begin appearing on the roads. One possibility is that electric cars will be used first in cities, where high speed and the ability to cover long distances are not so important, and where the dangers from pollution are greatest *(see "City of the Future?", page 7)*.

Some people—including some of those who make gasoline-engine cars or who produce gasoline—are against electric cars. They say that people won't want to drive cars that are small and can't go very fast or speed up very quickly. And they point out that not every community has a smog problem as bad as the one in Los Angeles, so pollution-free cars might not be necessary now in all areas.

Even now, though, many people in the United States buy small, low-powered, gasoline-engine cars made in other countries, or else drive powerful American cars without ever using all the power that the engine can produce. And there are many areas that could develop a smog problem like the one in Los Angeles as they get more and more of today's cars.

Air pollution is a difficult problem, and automobiles are only one cause of it. But so much of the pollution that affects our cities is caused by automobiles that something must be done soon to develop a car that won't pollute the air as much as our present cars do. Hopefully, people in government and industry, and individual citizens, will realize that the air we breathe is the same for all of us, and that we must all work together if we are going to "clean it up" ■

An electric car like this model may soon be tested by the American Motors Corporation. Two lithium batteries like the one shown will provide the main source of power for the car. The two batteries give as much electrical energy as 45 ordinary car batteries.

"The present-day city is strangling, poisoning, and suffocating itself."

■ Imagine a city without noise. Without smoke, without traffic jams, without slums. "Impossible," you say? Not according to Dr. Athelstan Spilhaus, President of the Franklin Institute in Philadelphia, Pennsylvania. He believes that we know enough right now to build such a city. In fact, he is already involved in designing one.

In this special city, all the major problems of our present cities would be overcome. There would be no waste and no dirty factories. The entire city would be clean, and there would be plenty of recreation areas for all. Everyone would have a job from which he could earn a comfortable living.

Of course, it might take a while to bring all this about. Nothing complex can be built perfectly the first time. But the city Dr. Spilhaus is thinking about will be easy to change and improve.

A City for Testing Ideas

The special city will be an experimental one. It will be as much like the ideal city as possible. Its main purpose, however, will be to let scientists and engineers see how their ideas work and how the city can be improved. Dr. Spilhaus says that the city will be "a true experiment to discover what will work and how and what it will cost and whether people will want to live and work there."

After the Experimental City is built and tested, changed, and improved, it may become a model for cities of the future. The idea is to find out how cities can be built to make them enjoyable for people to live and work in. This is especially important today, for each year another three million people are born in the United States. This is the same as adding a city of 250,000 people every month!

In the past we have been taking care of the extra people just by "tacking on" new sections to old cities, making buildings higher, and "patching up" rundown areas. But the power, sewer, water, and road systems of the cities were not planned to take care of so many people. According to Dr. Spilhaus, "The present-day city is strangling, poisoning, and suffocating itself."

Goals of the New City

The Experimental City that Dr. Spilhaus is thinking about will differ greatly from present cities in several ways. The most important difference is that it will be planned—the layout of the homes, businesses, and everything else will all be decided *before* any work is done on the city.

Once the Experimental City is built, no new sections will be tacked onto it. There will be no need for additions, because the number of people in the city will stay about the same; only a certain number of people will be allowed to live there.

The Experimental City will be complete. Whatever is necessary to take care of the everyday needs of the people will be included within the city. Hospitals, parks, theaters, places of work, and schools will be built so that everyone can reach them easily.

The Experimental City should be a most enjoyable place in which to live. In fact, the whole idea sounds so good that it seems like a dream. Maybe it is. But on the other hand, what if the Experimental City succeeds? Then, in another 20 years, you may actually find yourself living in one just like it! *(See next page.)* ■

EXPERIMENTAL CITY

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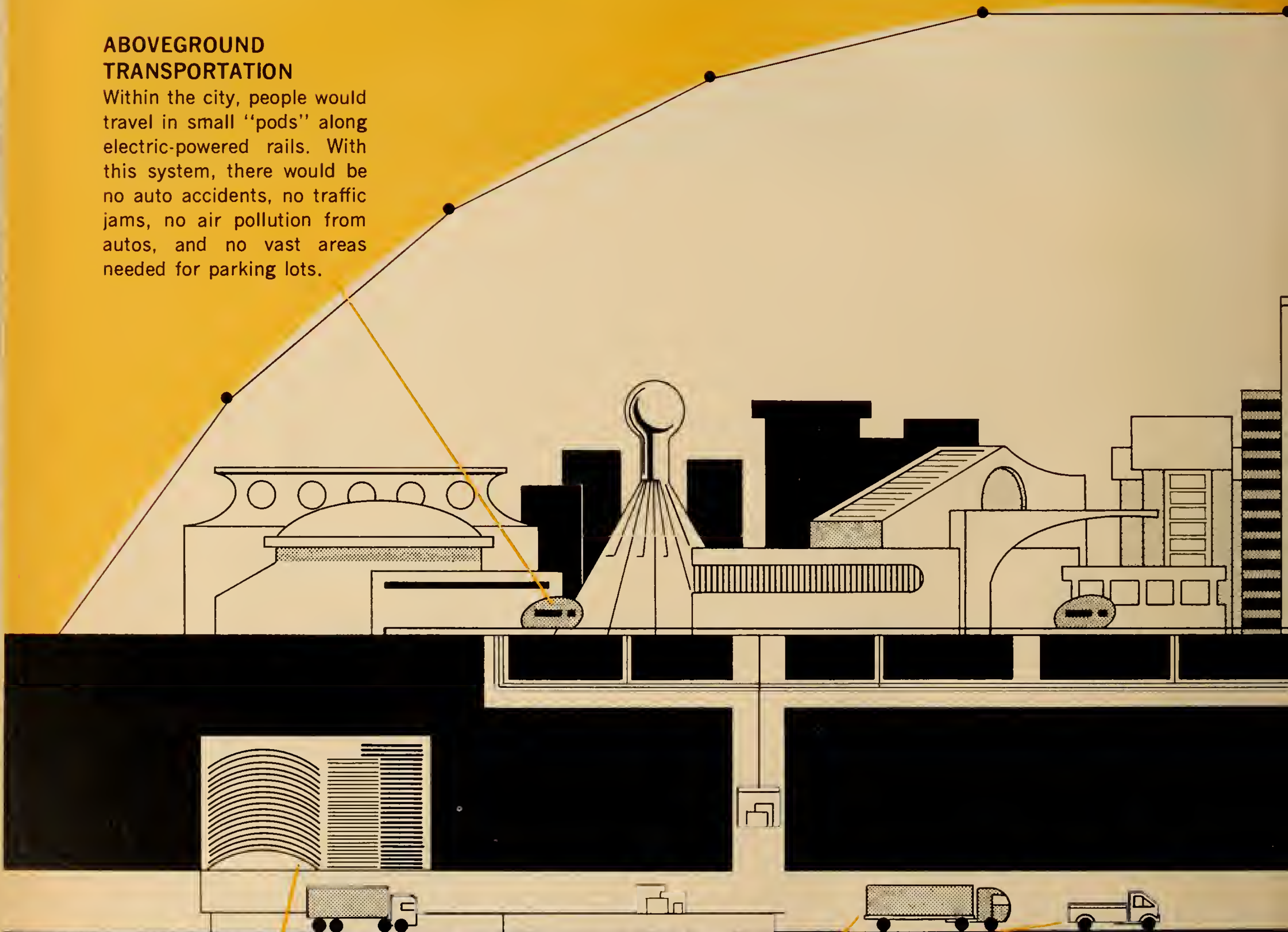
ABOVEGROUND TRANSPORTATION

Within the city, people would travel in small "pods" along electric-powered rails. With this system, there would be no auto accidents, no traffic jams, no air pollution from autos, and no vast areas needed for parking lots.



BUILDING PANELS STORED UNDERGROUND Large building panels could be stored underground and then taken to the surface near where a new building is to go up. These panels would allow faster building of many different kinds of structures. They could also be re-used easily after the buildings are taken apart.

UNDERGROUND TRANSPORTATION All fume-producing cars and trucks would have to travel in tunnels. The polluted air could then be collected from the tunnels and cleared.

ENERGY AND COMP
the center of the city
plant and a giant heati
city. There would even
connections to all hom
and maybe even voting
a button in your living

rs and scientists at the University of Minnesota, olis, have begun work on the design of an Experi-y to test ideas for use in building cities of the *page 7)*. A total of $300,000 is being used to y, and Dr. Walter Vivrette, director of the project, building can begin by 1974. The first Experi-y will be located in Minnesota, 100 miles or more arest existing city. It is being planned for 250,000 one of the facts that scientists and engineers want to learn is whether this is the best size or not.

A committee of 20 members from government, education, and business is advising Dr. Vivrette on the project. None of the details about the city has yet been worked out, so this WALL CHART shows only a general idea about what some of the features of the Experimental City might be. It is based on ideas for the city's possible design reported by Dr. Athelstan Spilhaus, one of the co-chairmen of the advisory committee.—DAVE MECH

TRANSPARENT DOME
A giant dome covering all or part of the city could save money in heating and snow removal costs. It would let light in but would keep out rain and snow. At present, domes two miles across can be built.

SURROUNDING THE CITY
Outside the city would be a wide belt of forests, lakes, parks, and farms, providing for some of the food and recreation needs of the city's people. The airport would be located in this belt of undeveloped land, and would be connected to the city by tunnels.

CENTER Located at be an atomic power to supply the whole omputer center with n shopping, banking, be done by pressing

UNDERGROUND CONNECTIONS All wires from the power plants and computers, all heating pipes, water pipes, air ducts, and sewage pipes could pass through tunnels. These could go underground throughout the city to wherever needed. To repair or change any connection, workmen could just enter the tunnels instead of tearing up the surface as is done today.

PURIFYING PLANTS Special cleaning plants would purify the air and water. Thus both could be *recycled*—used over again after each cleaning. Since factories that pollute air or water would not be allowed in the city, these resources would be much cleaner to begin with. The purifying plants would keep them this way.

People *versus* Parks

■ Crowded . . . noisy . . . dirty. That's a fair description of most big cities and many smaller ones in the United States. No wonder so many people leave such places to vacation in one or more of the national parks. Yet, if you visit certain national parks you may find scenes like the ones described by writer Jack Hope in *Natural History* magazine (*February 1968*). Here is a summer scene in California's Yosemite National Park:

"Row upon row of tents butt up against one another . . . 40,000 visitors swarm over the landscape . . . Lines of automobile traffic clog the access roads . . . In the evening, a haze hangs over Yosemite; not the fragrant mist of a wilderness valley, but a heavy layer of campfire smoke and exhaust fumes . . . Many of the daytime visitors depart, and the sound of human voices lessens somewhat; but the clatter of pots and pans, the snarl of a motorcycle, the noise of transistor radios rises to take its place."

"Tent cities" have come to the national parks. "Why not?" you may ask, "National parks are for people, aren't they?"

The answer is "yes" *and* "no." When the National Park Service was set up by Congress in 1916, it was given the job of protecting the wild lands of national parks, keeping them "unimpaired" (undamaged) for the "enjoyment of future generations." Some of those future generations are here now. They are "enjoying" the national parks so much that they threaten to destroy the wildness that the Park Service is supposed to save for still later generations.

In 1916, only 356,000 people visited the national parks that existed then. The use of parks increased slowly for many years. As the population grew and as more people had cars, time, and money for travel, the rush to the national parks was on. There were 79 million visits in 1960; last year the total was about 145 million.

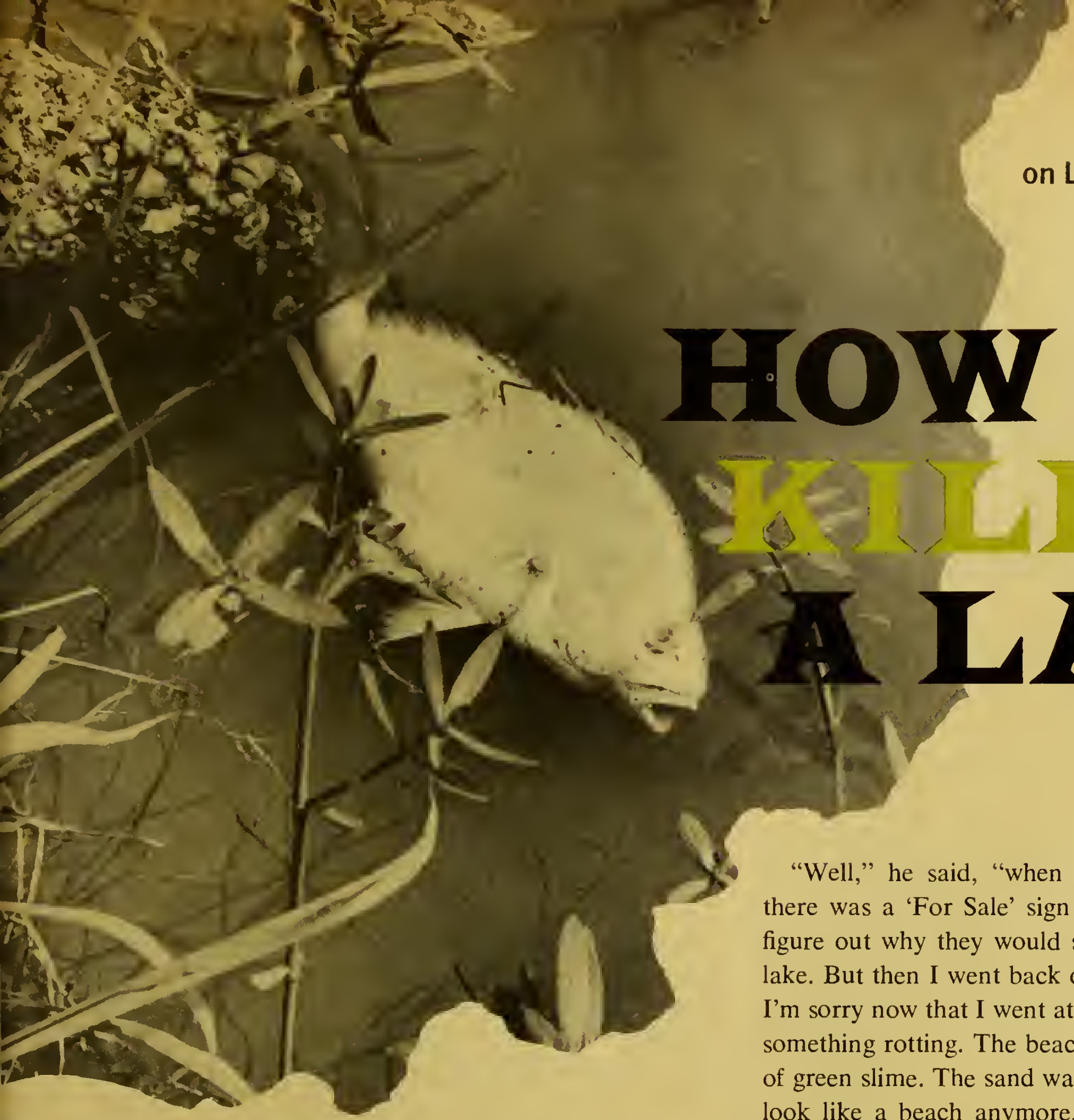
Wilderness through a Windshield?

People come to national parks for many reasons, but most of the reasons have little to do with a park's beauty, wildness, or wild animals. Most people are "windshield visitors." They never get far from their cars, even when they camp overnight. They see only easy-to-reach areas and tame "wildlife." The Park Service has displays and programs that tell about the area's land, plants, and animals. These programs are the only contact that most visitors have with a park's wild land and its life.

Many park service employees are thankful that the crowds stay close to roads. This simplifies their job of protecting wild areas. But the pressure is growing to build more roads, open more camp grounds, set up more souvenir stands. When this is done, the new tourist area is soon crowded, and the Park Service is urged to "develop" still other wild lands.

Some people believe that the National Park Service should stop trying to meet the needs of "windshield visitors." Many scientists, for example, think that the national parks should be kept as undisturbed as possible. With so much of North America already changed by man, scientists say, the national parks are especially valuable as outdoor "laboratories" for study of the natural world. They say that the aim of the National Park Service should be to keep the parks as different from cities as possible, rather than to give visitors a city in the outdoors.

Many people believe that the steadily increasing numbers of visitors can only lead to the destruction of the national parks. The National Park Service must soon decide if and how it is going to save its wild land for the generations yet to come ■



My friend looked forward to his vacation on Lake Erie. He came back looking angry and grim, however, for he had a lesson in...

HOW TO KILL A LAKE

by Russell McKee

■ A few years ago, a friend of mine decided to visit his cousin who lived in a little town in Ohio, on the shore of Lake Erie. Once, many years before, he had gone there on a vacation. He recalled playing on the sand beach behind his cousin's house, and remembered swimming in the clear lake waters and sailing past the white cottages that lined the shore. The two boys had found something new to do at the lake every day.

So my friend was very happy as he packed for another visit. "See you in two weeks," he said as he boarded the train that afternoon. "I haven't seen my cousin in a long time, but I know we're going to have a lot of fun. I'll try to send you a postcard–if I can find a minute from sailing and swimming."

Three days later he was back. The smile was gone, and he looked angry.

"What's wrong?" I asked. "Why did you come back so soon?"

"It's the lake," he said. "Lake Erie. It's awful. Something has happened to Lake Erie."

"What do you mean? What happened?"

"Well," he said, "when I got to my cousin's house, there was a 'For Sale' sign in the front yard. I couldn't figure out why they would sell such a nice house on the lake. But then I went back of the house to see the beach. I'm sorry now that I went at all. The smell was awful, like something rotting. The beach was all covered with lumps of green slime. The sand was dark and oily. It didn't even look like a beach anymore. There were signs along the water that said 'No Swimming.' Even the water looked dark and dirty. Just about then, my cousin saw me and came out of the house. He said the green stuff was water

(Continued on the next page)

Wastes pouring into the Great Lakes are speeding up the death of these huge bodies of water. The worst pollution is in Lakes Erie and Michigan; little is being done to stop it.

This is a view of Maple Beach, near where the Detroit River empties into Lake Erie. Once used for swimming, the beach is now covered with wastes and decaying algae.

How To Kill a Lake (continued)

plants called *algae* that washed ashore and rotted there. He said it was getting worse every year because the lake was so polluted."

My friend decided to find out exactly why Lake Erie has become such a mess, and what can be done about it. A month later he told me what he had learned about Lake Erie. He had written to the Federal Water Pollution Control Administration in Washington, D.C. He wrote to the public health departments and conservation departments of the states around the Great Lakes (*see map*). And the answers he received add up to quite a story.

Murder of a Lake

Man and his activities are rapidly killing Lake Erie. Lake Michigan is in danger, too. At first you may not think of a lake as being alive, but lakes really do "live" and "breathe."

Oxygen from the air is dissolved in the water. Underwater plants also produce this gas. Oxygen is used not only by fish and plants, but also by small water animals, called *zooplankton,* and by crayfish and insects. All of these plants and animals, large and small, make up the life of a lake. A lake is, indeed, a very lively place.

But lakes don't live forever—they are born, they become old, they die. A lake usually dies by being filled in until there is no longer any room for water. Rivers carry silt and mud into a lake. Water plants die and decay on the lake's bottom, gradually piling up and making the water more shallow. Over many thousands of years, the lake fills up. It becomes a marsh or swamp, and eventually it becomes dry land. The lake has died. One authority estimates that the United States now has only about half as many lakes as it had 12,000 years ago.

The filling in of a lake is important to the life in it. This is the way in which a lake gets its food, renews its bottom soils, changes its water. This natural "feeding" is taking place in all of the Great Lakes, as it is on every lake and pond. But it is happening very fast in Lake Erie and in other parts of the Great Lakes.

Do Not Feed the Lake

"It's hard to believe," my friend said, "but Lake Erie is dying because it has *too much* food. The plants and animals can't use all of the food that's washing into the lake. The lake is simply dying from too much nourishment."

Many kinds of "foods" are washing into the lake. Human wastes are one of the biggest problems. They take great amounts of oxygen from the water as they decay, reducing the oxygen available for fish and other life. Another problem is the detergent "soap" that people use for washing clothes and dishes. It contains large amounts of a chemical called *phosphate.* Farmers also use phosphate. It is a rich plant food, and can make plants grow rapidly. *Nitrate* is another rich plant food found in wastes from homes, farms, and factories.

Here is the estimated cost of cleaning water of wastes from industries and cities during the next five years. The bill will be paid through taxes and through higher prices for goods. In future years, as the number of people increases and more wastes are produced, the cost of cleaning the nation's waters will rise even higher.

Leonard Herman, from National Wildlife

"We always try to show them as they appear in their natural surroundings!"

These chemicals wash off the land or are dumped into rivers. Once in the lake, they settle to the bottom. They cause a great growth of algae. When the algae die, they decay, using great amounts of oxygen. In some parts of Lake Erie today the amount of oxygen in the water is very small.

Lake Erie is, on the average, only 58 feet deep. It is the shallowest of the five Great Lakes. Erie does not have enough water to "digest" all the wastes pouring in.

There are still plenty of fish in Lake Erie. In fact, Lake Erie seems to have as much fish life as the other four Great Lakes combined. But there's another side to this story. Some kinds of fish, such as whitefish and pike, are very valuable and bring high prices. The catches of these fish are getting smaller. In 1956, over 18,000,000 pounds of blue pike were caught in Lake Erie; in 1965 less than 500 pounds were caught.

Today, most of the catch is made up of fish such as perch, smelt, sheepshead, and bass. They are less valuable as food and bring lower prices. Also, the total catch of fish is expected to go down steadily if the pollution of Lake Erie continues. And it is continuing—18,000 tons of sewage, fertilizers, and chemicals flow into Lake Erie *each day!*

Clean Water Is Costly

Engineers know how to remove most kinds of wastes from water. But few cities and industries are able or willing to spend enough money to avoid polluting lakes and rivers. The "murder" of Lake Erie—and of other lakes and waterways—can only be stopped by passing laws that force a "cleanup" and by providing money for the job.

One such law was passed in 1965. The Federal Clean Waters Act requires all states to begin cleaning wastes from any water that passes from state to state. Of course this includes the Great Lakes, but one expert says, "It might take 20 years for Lake Erie to clean itself, even if we stopped all pollution right now."

As my friend told me of the polluted lake, I could see he was hopeful that some day he might swim again in a clean Lake Erie. Other people, however, are not so hopeful. They see the thousands of tons of waste pouring into the Great Lakes, and they wonder if we ever will overcome the problem. But I was happy to see that my friend was not only hopeful. He was also angry. Other people are getting angry, too. If enough people become concerned about water pollution, it can be stopped ■

In flowing streams, detergents can cause a suds problem because there may not be enough oxygen in the water to enable bacteria to "break down" the chemicals. In lakes and ponds, detergents add too much phosphate to the water, causing overgrowths of algae.

The germs we found in our river

by Tony Fusco

Tony Fusco, author of this article, Debbie King, and Caral Fuhrman collected samples of water from several places along the edge of the Chagrin River, in Ohio.

■ In October 1967 I joined a group of other high school students who were interested in studying the problem of pollution. We were worried about pollution across the nation as well as in our own community. We wanted to study water pollution and bring our findings to the attention of the community. In a few years, this problem will directly affect all of us as adult citizens.

Fortunately, in our area there is a program sponsored by the federal government to give students a chance to explore the field of science that interests them most. Many students wanted to study pollution, so we divided into two groups to study different pollution problems. One group tried to find out how different amounts of wastes in water affect fish.

Our group *(see photo)* decided to investigate the water of the Chagrin River, which drains part of the northeast section of Ohio and empties into Lake Erie *(see "How To Kill a Lake," page 11)*. Much of the water supply for the surrounding communities is taken from the Chagrin. Perhaps there is a river like this in your area.

The Search for Bacteria

There are many kinds of pollution in the Chagrin, including factory wastes, acids, and detergents. Our group was mainly interested in measuring the numbers of *bacteria* that get into the water from human wastes. We were especially looking for a kind of bacteria called *Escherichia coli,* or just *E. coli.* It and another *coliform* bacteria make the water unsanitary—unfit for drinking or washing. (These bacteria can be killed, however, by treating the water with chemicals.)

We gathered water from many points along the river in order to get a wide range of samples. Then we tested each sample to see how many bacteria it contained. First we measured exactly 100 milliliters (about a fifth of a pint) of each water sample through a small plastic container that has a filter for trapping bacteria. Then we added a special food that bacteria feed upon. If conditions are right, in about a day each bacterium develops into a colony of bacteria on this food. We could see the bacteria colonies through a microscope, and figure out roughly the number of bacteria in the sample.

According to the United States Public Health Service, water is unfit for drinking if it contains more than 5,000 coliform bacteria per 100 milliliters. Also, the water is unfit for swimming if it contains over 1,000 coliform bacteria per 100 milliliters. In most of our water samples, we found about 1,500 coliform bacteria in 100 milliliters of water. As far as our studies could tell, this water was safe to drink (after treatment with chemicals) but was unfit for swimming. However, we were only able to tell that the bacteria were in the coliform group. We weren't able to tell if the colonies were caused by *E. coli.* If only four bacteria colonies from a 100 milliliter water sample are proved to be caused by *E. coli,* the water is not safe to use.

We presented our findings in our school's science fair. We stressed the importance of stopping pollution now, before it gets worse. By bringing our findings to the attention of the community, we tried to arouse people to help stop the pollution of the river. Even though we can't vote, we have tried to help fight water pollution by giving people a picture of the problems that exist in their own river ■

Tony Fusco, 17 years old, is a junior at North High School, in Eastlake, Ohio.

HOW MUCH DUST IS IN THE AIR?

■ With each breath you take, a variety of gases is sucked into your lungs. Most of the dust and other tiny particles in the air, however, never reach your lungs. They are trapped by hairs inside your nose and by wet surfaces there and inside your mouth.

This SCIENCE WORKSHOP tells how you can use another sort of trap to measure the amount of dust, soot, and other particles that are in the air. You can find some dust almost everywhere, even in the country. Each month about 10 tons of dust settles on a square mile of land in the country. The biggest dustfalls are in and near cities.

Collecting and Weighing

To measure the amount of dust that falls in your neighborhood, you will need at least three wide-mouthed glass jars, 1-gallon size. Restaurants usually get relishes or mayonnaise in such jars; you can probably get empty ones there or from a school cafeteria. You will also need about two gallons of distilled water, which you can buy at a drugstore. (Ordinary tap water may contain tiny particles that would affect your measurements of dustfall.)

You will also need a 2- or 3-quart pan or other container that can be heated without breaking. Last but not least, you will need to use a balance that weighs things to the nearest *centigram* or *milligram*. Most school science departments have one.

Make sure that the jars are clean, then rinse them out with some of the distilled water. Next pour a quart of the water into each jar. Mark the water level with fingernail polish, a file mark, or anything else that rain won't wash away. Cover the top with a wire screen to keep insects out. Set each of the jars in a different location outdoors. They should be about five feet above the ground, and not under trees or eaves of buildings. Label each jar with your name, the location, and the date you set it out.

Leave the jars in their places for 30 days. Visit them every few days, adding distilled water to the original water level. (If the jar dries out, the wind may blow away the dust.) Rain may fall into the jar, but this causes no trouble unless the jar overflows; then you have to start over.

After 30 days, bring the jars indoors. To find out how much dust is in each jar, first weigh the pan on the balance, then pour the water into the pan. Use more distilled water to rinse out the jar, making sure you have moved all the dust particles from the jar into the pan. Then, with the help of an adult, heat the water until it all evaporates. Don't overheat the pan or you will burn the dust.

Let the pan cool and then weigh it on the balance. This gives you the weight of the dust and the pan. To find the weight of the dust alone, subtract the figure you wrote down earlier, when you weighed the pan. If the balance you use just weighs to centigrams, multiply the weight of the dust by 10 to change it to milligrams.

How Much Is That in Tons?

Dustfall is usually measured in tons per square mile per month. Your figures only tell how many milligrams fell through the mouth of the jar in a month. Here is how to change your measurements to the figures used by air pollution scientists.

First measure the inside diameter of the jar's mouth in centimeters. Use this figure to find out the *area,* in square centimeters, of the jar's mouth. Suppose, for example, that the diameter is 10 centimeters. First take half of this number to get the radius of the jar mouth. Then multiply this number (5) by itself to get the square of the radius (25). Finally, multiply this number by 3.14 to get the area of the jar mouth in square centimeters.

You now know how many milligrams of dust fell through a jar mouth with an area of, say, 75 square centimeters. To find the amount of dust that fell on *one* square centimeter, divide the number of milligrams of dust by 75.

Fortunately, air pollution scientists have an easy way to change their measurements in jars like yours to dustfall measured in tons per square mile. Just multiply the number of milligrams per square centimeter times 28.6. The number you get is the tons of dust that fell on a square mile of your neighborhood in 30 days.

Do you get the same sort of figure for each of the jars you set out? (If the numbers vary a lot, take an average of them to get a more accurate idea of the dustfall in your area.) Can you think of reasons why one jar would catch more dust than another? Repeat your investigations in another month, or next year, to see if the amount of dust in the air varies ■

prepared by **DAVID WEBSTER**

BRAIN BOOSTERS

Mystery Photo
What is it?

What will happen if . . .

. . . you blow through a straw across the top of another straw that is in a glass of water? Will any bubbles come out in the water?

Submitted by Charles Ewing, Cape Elizabeth, Maine

Can you do it?

Can you touch something with your right hand that you can't touch with your left hand?

Fun with numbers and shapes

Arrange 10 dots in 5 rows, with 4 dots in each row.

For science experts only

Here are three reasons why some early scientists believed that the earth was not rotating:

1. If the earth were spinning, there would always be a strong wind blowing from the direction toward which the earth turned.
2. If the earth were spinning, everything would be thrown off into space because of centrifugal force.
3. If the earth were spinning, a stone thrown straight up into the air would land at a different spot from where it was thrown.

Since the earth really *is* spinning, can you explain why these three things do *not* occur?

Just for fun

Find out how long a plant can live sealed up inside a jar containing moist soil.

ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

Mystery Photo: The plastic container is on a turntable that is spinning around. The surface of the water is curved because of *centrifugal force*. The photo was taken in a tiny fraction of a second to "stop" the motion of the turntable. What shape would the water take if the turntable were spun much faster?

What would happen if? Diagram C shows how the water in the box sections would look if the turntable were spun.

Can you do it? Steel burns easily if it is in small enough pieces. Ask your parents to help you use a match to burn a steel wool pad (one without soap).

Fun with numbers and shapes: A. Each number is double the one before it, so the next number in the series is 128. **B.** To square a number, you multiply it by itself. The numbers in series B are the squares of the numbers from 1 to 6. The next number should be 49, which is the square of 7. **C.** The numbers in this series are all *prime* numbers. A prime number is a number that cannot be evenly divided by any number except itself and one. The next prime number is 23. **D.** The next number is 29. Can you figure out what rule was used to make this series?

For science experts only: The ground just beneath the surface is usually cooler than the air above. Once past a certain depth, however, the temperature begins to increase.

Using This Issue . . .
(continued from page 2T)

cans, aluminum foil, and other such materials collected for recycling or reuse.

- The aluminum can should be outlawed; the "self-opening" can should be outlawed or remodeled so that the "tab" stays attached to the can.
- Bottles should be standardized as to sizes and shapes, so that they can be reused. "No deposit, no return" must end.

Activities

You might have your pupils investigate these questions, evaluating their own community in terms of Spaceship Earth:

- *What happens to garbage and trash after it leaves your house?* Is any of it recycled? If it is dumped somewhere, is it destroying any land or water of value? Is your community running out of places to put such wastes?
- *How much garbage and trash does your family throw away in a week?* Find out by weighing refuse cans before they are emptied, then subtract the weight of the empty can. Assuming that you picked a typical week, figure out how many pounds—or tons—of trash your family discards in a year. If your family "throws away" a car by trading it in, be sure to include its weight.
- *What becomes of junk cars in your community?*
- *Are the human wastes of your community given primary treatment or secondary treatment?* (Primary removes about 35 per cent of wastes, secondary about 90 per cent.) What happens to the treated water and the wastes that are removed? Is your community one of 2,000 in the United States that dump sewage into streams without any treatment at all?
- *What kinds of wastes are produced by industries in your community?* What happens to the wastes?

PEOPLE, NOISE, BIOCIDES
For more information about resource problems aboard Spaceship Earth, see these articles in past issues of *Nature and Science:* "The People Problem," Feb. 21, 1966; "Noise, Noise, Noise," Oct. 17, 1966; "Eat and Go Hungry," Jan. 9, 1967; "Can We Save the Eagles?", March 18, 1968.

How To Kill a Lake

Shallow Lake Erie is a dramatic example of how too much "food" can speed the death of a body of water. Scientists still hope that Erie's life can be extended; its shallowness has one advantage—the lake changes its water completely in about three years. It would take many more years than that, of course, for wastes accumulated on the bottom to decay. Scientists fear that Lake Michigan may soon be in worse shape than Erie. A deep lake, Michigan changes its water slowly, and many of its tributary streams bear a heavy load of wastes.

The success of the Federal Clean Water Act (and of other state and local water pollution laws) depends on enforcement and funds. The federal act is supposed to provide aid amounting to 30 to 35 per cent of the cost of waste treatment projects. Obviously, no state or community is going to miss a chance to pay part of a project's cost with federal funds. Thus, the pace of water pollution cleanup depends directly on the amount of federal money available. In fiscal 1968, Congress authorized $450 million for construction of waste treatment projects, then reduced it to $203 million. Water pollution experts agree that *billions,* not millions, of dollars are needed soon to affect pollution significantly.

Dust in the Air

The atmosphere, even in wilderness areas, contains varying amounts of dust particles, including pollen. The larger particles settle out, and this is a useful index of the dust load in the air. The dustfall your pupils find in an urban or suburban area may be two or three times that found in most rural locations.

Dustfall is, of course, only one ingredient of the polluted air. The article "Can We Have Cars and Clean Air Too?" mentions some of the other wastes in the air. Some of these can be measured by advanced students who have access to apparatus used in chemistry. Directions for 18 experiments, designed for high school students, can be found in the 48-page booklet, "Scientific Experiments in Environmental Pollution." The booklet was prepared by the Education Activities Committee of the Manufacturing Chemists Association and is available for $1 from Holt, Rinehart & Winston, Inc., 383 Madison Avenue, New York, N.Y. 10017.

CONSERVATION FILMS
A helpful guide to audio-visual aids for teachers is "A Critical Index of Films and Film-strips in Conservation," prepared by the Conservation Foundation. Copies are available for $1 each from Audio-Visual Center, The Conservation Foundation, 30 East 40th St., New York, N.Y. 10016.

For Your Reading

- **Not So Rich As You Think,** by George R. Stewart, Houghton Mifflin Co., Boston, 1968, $5.
- **The Frail Ocean,** by Wesley Marx, Coward-McCann, Inc., New York, 1965, $5.95.
- **The Hungry Planet,** by Georg Borgstrom, The Macmillan Co., New York, 1965, $7.95.
- **Famine 1975,** by William and Paul Paddock, Little, Brown and Co., Boston, 1967, $6.50.
- **Man . . . An Endangered Species?,** Conservation Yearbook No. 4, United States Department of the Interior, available for $1.50 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Brain-Boosters

Mystery photo: The mystery photo shows a head of cabbage in cross-section. You might ask your pupils to draw pictures of what they think

(Continued on page 4T)

Using This Issue . . .
(continued from page 3T)

the insides of other vegetables and fruits look like. The drawings could be compared with the cut-open fruits to see how accurate they are.

What will happen if? If you demonstrate this to your class, or let the children try it themselves, they will see that when you blow across a straw standing in a glass of water, water is forced up the straw and comes out in a fine spray. This happens because the air flowing over the straw exerts less downward pressure than the air pressing downward on the rest of the water in the glass. The effect is explained by the Bernoulli principle (*see "Just for fun,"* N&S, *March 4, 1968, p. 4T*).

A perfume atomizer works in exactly the same way. You might bring in an atomizer and see whether your pupils can figure out how squeezing the bulb makes the perfume come out in a fine mist.

Can you do it? You can touch your left elbow with your right hand but not with your left hand. See what other parts of the body your pupils can find that can be touched with one hand only.

Fun with numbers and shapes: The diagrams show two ways to arrange 10 dots in five rows of four dots each.

For science experts only: The three arguments raised by the ancients all seemed to be valid "proofs" that the earth does not spin. What the ancients did not know, however, is that the earth's atmosphere, and everything within it, spins right along with the earth. That is why we do not have a constant wind from one direction, and why a stone thrown straight up lands at the same place from which it was thrown. These ancients also failed to realize that the centrifugal effect generated by the earth's rotation is more than counterbalanced by the earth's gravitational pull.

After your pupils have had a chance to refute these early arguments, see whether any of them can explain why the earth's spinning doesn't make them dizzy.

Just for fun: Most plants will live for many months in moist soil, even inside a closed container. If you demonstrate this in your classroom, have your pupils record their predictions for the life of the plant on a chart that can be referred to later. After some time has gone by, you might discuss with your pupils how to determine when the plant is dead.

If you seal the plant in a plastic bag instead of enclosing it in a jar, remember that the thin plastic will allow some air to pass through.

One reason that a plant can live so long without a supply of fresh air is that during photosynthesis a plant returns to the air oxygen that it can later use again.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 15 / APRIL 15, 1968 / SECTION 1 OF TWO SECTIONS

◄ N & S REVIEWS ►

Recent Life Science Books for Your Pupils

by Richard M. Klein and Barbara Neill

Adventures with Flowers, by Elizabeth T. Billington (Frederick Warne & Co., 60 pp., $2.95). Mrs. Billington has written a low-key, beautifully illustrated, and very clever book on plants which can be highly recommended for students in the fifth grade. Starting with well-written sections on the parts of the flower, she moves neatly into some of the historical lore about flowers and then to a number of topics including economic botany, flower shows (a weak point in the book), flower arranging, plant collecting, and several topics in between. One possible criticism is the consistently feminine point of view, a problem which will probably be solved by boys skipping a few pages. Aside from this minor flaw—if it is a flaw—*Adventures with Flowers* is highly recommended for an introduction to plants via flowers. —R.M.K.

The Strangler Fig and Other Strange Plants, by Olive L. Earle (William Morrow and Co., 64 pp., $2.95). This is a difficult book to recommend or even to review. It is a collection of botanical miscellany designed to attract in about the same way that the late Robert ("Believe It or Not") Ripley attracted his audiences: by presenting something just a bit beyond the experience of the audience. The book is, to the author's credit, well-written and very well illustrated. It might be useful for a student who has a bit of plant science background and is becoming bored with the usual thing, but even here, the interest is likely to be minimal. Let's call this book, "One hour of browsing in the school library."
—R.M.K.

The Wonders of Nature, by Geoffrey Coe, Grace F. Fergeson, and Amy Elizabeth Jensen (Grosset & Dunlap, 160 pp., $3.95). Once the reader gets beyond the title of this book, he will find a beautifully illustrated, well-written volume which successfully surveys the plant kingdom. There are tidbit stories about some of the plants, which lead naturally into information about the ecology, life history, and structure of plants other than the algae. There is enough physiology to pique the interest of students, but not so much that they get bogged down in details. Plants of the desert, forest, waterways, and fields are discussed as ecological units—a very effective way of handling the abundance of organisms. The book is unhesitatingly recommended for all school libraries serving children from about the fifth to the ninth grades. I just wish the publisher had chosen a more adequate title.
—R.M.K.

Plants in Time, by Margaret Cosgrove (Dodd, Mead and Co., 64 pp., $3.25). The fossil record of plant evolution is, unfortunately, a difficult one to discuss well for younger readers. In part this is due to the necessity of requiring the reader to hold both geological and botanical information in his mind at the same time. Of the relatively few books on paleobotany at the elementary or intermediate school level, this is probably the only recent book which does an adequate job of presenting the subject. It is doubtful whether many of the audience will become fossil botanists under

(Continued on page 3T)

Dr. Richard M. Klein is Professor of Botany at the University of Vermont, in Burlington. Barbara Neill is Senior Instructor in the Education Department of The American Museum of Natural History, New York City.

IN THIS ISSUE

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

● **Tornadoes—What Makes Them Go?**
Scientists don't know yet, but here are some of the ways they are trying to find out.

● **Brain-Boosters**

Make and Investigate an Electric Motor
With some nails, wire, and tape, your pupils can make a motor that runs on flashlight cells, then discover what keeps it spinning.

"Better Airplanes" from Readers
Winners of the paper airplane design contest, and some of their planes for your pupils to try.

● **Spying on Raccoons**
Biologists have learned about the life and death of raccoons by using radios to trace their travels.

● **Worms That Grow New Parts**
Your pupils can study regeneration and behavior in flatworms.

IN THE NEXT ISSUE

Ecology of the Everglades . . . The physics of baseball . . . SCIENCE WORKSHOPS: Evaporation and cooling, Investigating snail behavior . . . How and why do fish "school"? . . . Index to Volume 5.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Tornadoes

Your pupils may be surprised to find out that meteorologists have yet to discover the forces that generate and drive a tornado. They should understand, though, that the erratic occurrence, short duration, and destructive violence of tornadoes makes it almost impossible for a scientist to study them by direct observation and experimentation. This is why Dr. Vonnegut, for example, seeks information from people who have observed these storms and looks for similarities in their descriptions that may provide clues to the solution of the mystery.

Another approach often used by scientists is to build a model of the thing they are trying to understand. It may be a mathematical model — formulas that seem to describe how the real thing works—or a physical model like Dr. Chang's "laboratory tornado" *(see page 4)*. In Dr. Chang's model, the rising smoke imitates the rising warm air in a storm cloud; the slowly turning cage starts the air rotating somewhat in the way that colder air in the atmosphere swirls in to replace the rising air in a storm area. The rotating column of smoke that results is like a real tornado in two ways: It whirls faster at the top than at the bottom, and the air pressure is greater around the bottom than around the top.

An Australian scientist, Dr. J. S. Turner, describes a model that you can make in your classroom:

Get a large bottle of soda water and take off the label to give a clear view of the liquid. Open the bottle and pour off the top two or three inches. Now center the bottle on a 78-rpm turntable, turn on the power, and wait until the liquid is rotating at the same speed as the bottle.

Most of the carbon dioxide stays in solution until you drop a pinch of sugar in to provide nuclei for the gas to form bubbles around. As these bubbles rise, they produce an upcurrent in the rotating liquid much like the rapidly rising convection currents in a storm cloud. The result: A tight vortex, similar to a tornado funnel, will form.

Spying on Raccoons

During the past decade, radio-tracking has become a valuable tool in studies of wild animals. Tiny radio transmitters have made it possible to trace the travels of pigeons, deer, rabbits, grouse, and polar bears, to name a few. One problem in evaluating results is determining if the radio itself has influenced the animal's behavior. In other words, is the information gathered typical of the animal—or of a *radio-carrying* animal. With smaller animals, such as pigeons, the radio is more likely to affect behavior than with bigger animals, such as raccoons.

The diagram on page 14 of the student's edition shows how two radio receivers (or two compass readings taken with one receiver) are used to locate the radio-carrying animal. This process is called *triangulation*. The accuracy of the method varies with distance; the farther from the transmitter the greater the error. Once a biologist gets within a few hundred yards of the transmitter, however, he can use just one receiver to locate the animal, using the strength of the signal as a guide.

Topic for Class Discussion

• *What adaptations of raccoons enable them to survive, especially in areas where winter brings snow and cold?* This article stresses adaptations of physiology (fat storage) and behavior (sleeping much of the winter). Point out that raccoons do not *hibernate;* hibernation is an almost deathlike state in which an animal has a low body temperature and slow heart beat. Other adaptations your pupils might mention include the raccoon's heavy fur coat and its *omnivorous* diet (it eats anything).

For more information on raccoons, see "My Friends, the Raccoons," *N&S*, Sept. 20, 1965. The best popular factual book on the subject is *The World of the Raccoon*, by Leonard L. Rue III, (Lippincott, 1964, $4.95). In discussing animal adaptations, remind your pupils of such animals as kangaroo rats, camels, opossums, bats, and eagles, all featured in the current volume of *N&S*.

Worms That Grow Parts

Many plants and some animals (such as lobsters and starfish) can regenerate parts. Before regeneration in starfish was generally known, oyster fishermen who found starfish would tear them apart and toss the parts back into the water (because starfish prey on oysters). Instead of destroying starfish, they were multiplying them, because each arm grew into a whole starfish.

Flatworms are capable of learning, though they do not learn easily and they forget quickly. For example, flatworms normally stretch in the light. By teaching them to associate an electric shock with light, however, they can learn to contract in the light.

Experiments have shown that this learning can be transferred in at least two ways. For one, trained planarians were cut in half and the regenerated halves learned faster than other planarians being trained for the first time. In another series of experiments, trained planarians were chopped into small pieces and fed to untrained flatworms. A control group was fed bits

(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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.

SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

nature and science

VOL. 5 NO. 15 / APRIL 15, 1968

SPYING ON RACCOONS

see page 12

A giant funnel of violently whirling wind sweeps down from a thundercloud, drawing into it nearly everything it passes over...see page 2 TORNADOES—WHAT MAKES THEM GO?

nature and science

VOL. 5 NO. 15 / APRIL 15, 1968

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PICTURE CREDITS: Cover, Wide World Photos; pp. 3, 5, 8-10, 12, 14-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, photo from United Press International; p. 4, courtesy of The Catholic University of America; p. 5, photo by David Webster; pp. 6-7, Robert G. Bryant; pp. 8-10, photos by Franklyn K. Lauden; p. 11, left, courtesy of U.S. Department of the Interior, right, United Technology Center, a division of United Aircraft Corp.; p. 12, photo by Dave Mech; p. 13, left, Dave Mech, right, Leonard Rue III.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** R. J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen
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TORNADOES what makes them GO?

by
Roy A. Gallant

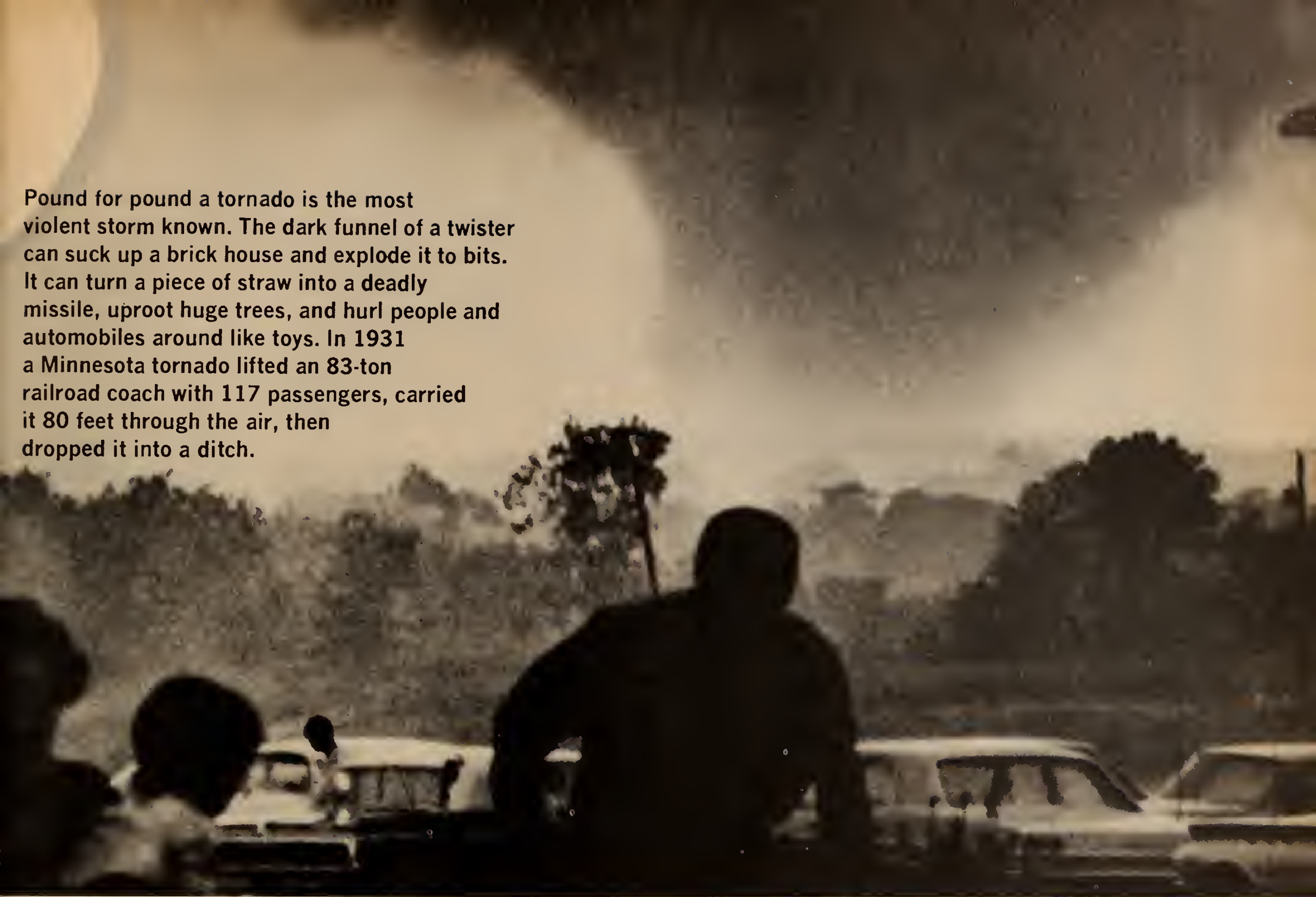
■ At this time of year, on hot afternoons when thunderstorms are in the making, people in the central part of the United States keep an anxious eye out for tornadoes. They have learned to associate these violent "twisters" with thunderstorm weather. And in this area—called the "tornado belt"—May brings more twisters than any other month (*see "Where and When Tornadoes Strike"*).

Surprisingly enough, the scientists who study weather know very little about the forces that start tornadoes and keep them going. Tornadoes are hard to study for several reasons. They do not stay still, they seldom last for as long as an hour, and no one wants to be near one.

When Air Masses Clash

According to one theory, a tornado may be born something like this: When fast-moving cold, dry air flows eastward and crosses the Rockies, it rides on top of moist, warm tropical air moving up from the Gulf of Mexico. Usually, a moving mass of cold air wedges its way under a mass of warmer air, because the colder air is heavier. But when the air masses do not behave in the usual way, a storm is in the making.

Where the two air masses meet, rain clouds begin to form. The storm may develop into a mild thunderstorm, or it may build into a very large one that towers 10 to 12 miles high. These particularly large thunderstorms seem to be the tornado producers. The lighter warm and moist air near the ground rises, rushing upward in a spiral pattern—sometimes at a speed of 200 miles an hour or more. Suddenly, the spiral may tighten and take on the shape of a funnel of wind sweeping in a clockwise or counterclockwise



Pound for pound a tornado is the most violent storm known. The dark funnel of a twister can suck up a brick house and explode it to bits. It can turn a piece of straw into a deadly missile, uproot huge trees, and hurl people and automobiles around like toys. In 1931 a Minnesota tornado lifted an 83-ton railroad coach with 117 passengers, carried it 80 feet through the air, then dropped it into a ditch.

direction at speeds of 300 miles an hour or more. A tornado is raging.

The funnel wanders around over land or water, sometimes moving very slowly, sometimes at speeds of 50 or more miles an hour. Like a giant vacuum sweeper it uproots trees and fences and draws into it nearly everything it strikes. The pressure of the air inside the funnel is so weak that the pressure of the air outside it pushes objects up into the funnel. The business end of a tornado may be from 100 feet to several thousand feet across. When it suddenly passes over a building, the building usually explodes, its walls and roof pushed outward by the pressure of the air inside the building.

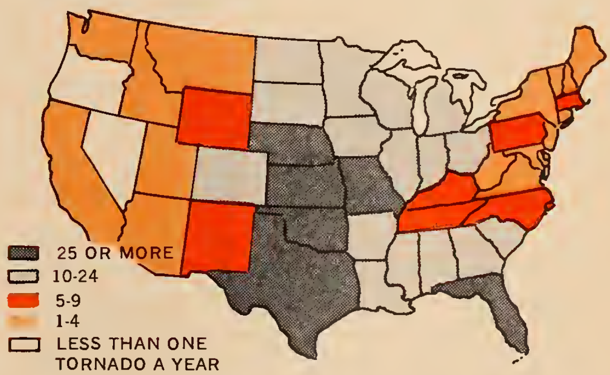
One of the most vivid descriptions of a tornado appeared in the magazine *Monthly Weather Review*, May 1930. It was written by Will Keller, a Greensburg, Kansas, farmer:

"At last the great shaggy end of the funnel hung directly overhead. Everything was still as death. There was a strong gassy odor, and it seemed as though I could not breathe. There was a screaming, hissing sound coming directly from the end of the funnel. I looked up, and to my astonishment saw right into the heart of the tornado. There was a circular

(Continued on the next page)

WHERE AND WHEN TORNADOES STRIKE

Over the past 10 years or so about 600 tornadoes a year have swept over various parts of the United States. The map shows the average number striking each state in a single year (Alaska and Hawaii average less than one).



About half of these twisters took place in April, May, and June. Tornadoes may strike at any hour of the day or night, but most form during the warmest hours of the day. More than half of the storms take place from 3 p.m. to 7 p.m. About 80 per cent strike between noon and midnight.

A rising column of smoke is turned into a "model" tornado in this rotating cage built by Dr. C. C. Chang at The Catholic University of America, in Washington, D.C. As the cage turns slowly, the air inside starts rotating faster and faster, producing a tornado-like column of smoke that whirls around at speeds up to 40 miles an hour. Dr. Chang uses these "models" to study the causes of tornadoes and seek ways to protect buildings from their destructive force.

Tornadoes (continued)

opening in the center of the funnel about 50 to 100 feet in diameter, and extending straight upward for a distance of at least half a mile.... The walls... were rotating clouds and the hole was brilliantly lighted with constant flashes of lightning which zigzagged from side to side. Around the rim of the giant vortex, small tornadoes were constantly forming and breaking away. These looked like tails as they writhed their way around the funnel. It was these that made the hissing sound."

What Makes Them Go?

One problem is to account for the high wind speeds in a tornado's funnel walls. Where does the energy come from? Some weather scientists believe that the difference in temperature between the colliding air masses is not enough to supply so much energy. The energy may be produced by electricity.

Electrical currents that are produced within the thunderclouds would tend to flow down the funnel of a tornado. The low pressure of the air in the funnel makes it easier for electricity in the clouds to flow to the ground in sparks of lightning. Such a flow of electrical current could raise the temperature of the air in the funnel by 100 to 200 degrees Fahrenheit, supplying enough heat energy to produce the very high wind speeds in a tornado.

One scientist who is investigating the electrical nature of tornadoes is Dr. Bernard Vonnegut, a physical scientist at the Atmospheric Sciences Research Center, State University of New York, in Albany. Over the years he has found a great deal of evidence linking tornadoes with electricity. People as far back as 60 B.C. have reported seeing unusual lightning displays along with tornadoes.

You know that the needle of a magnetic compass points north and south along the earth's magnetic field. A scientific observatory in Oklahoma, according to Dr. Vonnegut, reported a twister that passed within six miles of the building. Instruments at the observatory recorded "changes in the electric current flowing through the earth and a change in the strength of the earth's magnetic field. Such changes in strength," says Dr. Vonnegut, "indicate the sudden flow of a large electric current."

The big questions Dr. Vonnegut is asking now are these: Do all tornadoes have electrical activity? What is the nature of the electricity that we observe in some tornadoes? Does electricity *cause* a tornado? Or does something else cause it and then the tornado produces electricity?

"Much more information is needed," says Dr. Vonnegut, "and so to my request: If you see a tornado, first take refuge. Then, if it can be done safely, take pictures of the twister—either still pictures or movies in either color or black-and-white. Take notes and sketch what you saw. Remember that everything may be highly important. Perhaps with your help we may have the anwer to this fascinating science mystery." ■

TORNADO SAFETY RULES

The United States Weather Bureau gives this advice about what to do if a tornado strikes:

If you are in open country work out the general direction the tornado is moving, even though the funnel is zig-zagging. Once you know, move away from the storm at a right angle to its path. Don't run away from it along its path. If there isn't time to escape, lie flat in the nearest ditch or other low place and anchor yourself.

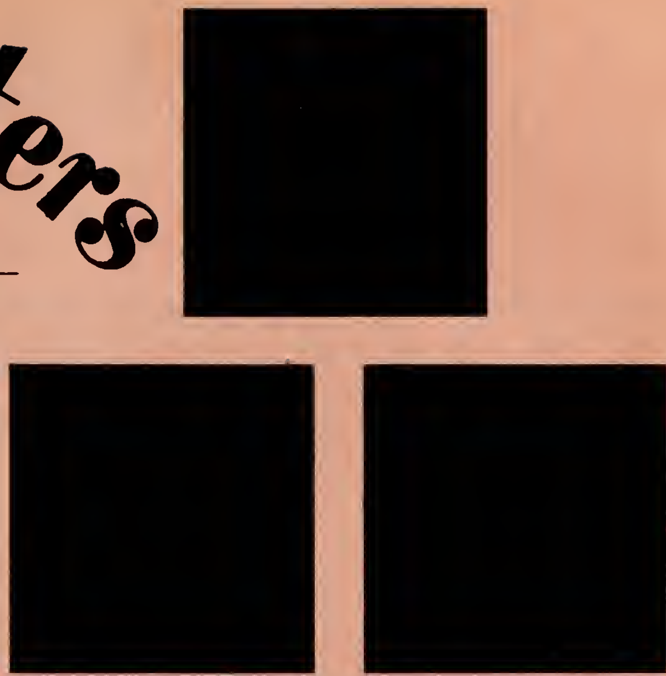
If you are in a city go to the nearest storm cellar or some other underground place. Next best is a *large* steel-framed or concrete building. Stay away from windows!

If you are at home, the corner of the basement nearest the storm is usually the safest place. If your house doesn't have a basement, take cover under heavy furniture in the center part of the house. Keep some windows open, but stay away from them!

Avoid taking cover in large public rooms such as school auditoriums and gymnasiums. Usually, the roof is not strong enough to withstand a direct hit by a destructive tornado.

brain-boosters

prepared by DAVID WEBSTER



FUN WITH NUMBERS AND SHAPES

Cut up and reassemble these three squares to make one large square.

Submitted by Scott Meyer, Tübingen, Germany

MYSTERY PHOTO

Which way was the tractor going?

FOR SCIENCE EXPERTS ONLY

If you have a balloon filled with helium in a car, the balloon will float backward when the brakes are put on. Can you explain why the balloon does this, while everything else goes forward when the car is slowed down?

WHAT WILL HAPPEN IF...

...you punch holes in a milk carton at the four places shown, and then fill it with water? From which hole will the water squirt farthest?

CAN YOU DO IT?

Can you make a drop of water smaller than a pencil dot? Put some drops on a piece of wax paper or aluminum foil. Then try to make little drops by pulling apart a big drop with two paper clips.

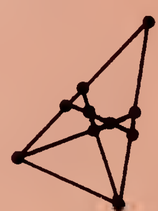
ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo is a picture of a cabbage that has been cut in half.

What will happen if: When air is blown across the top of the short straw, no bubbles come out in the water. Instead, water is forced *up* the straw and comes out in a fine spray.

Can you do it? You can touch your left elbow with your right hand but not with your left hand.

Fun with numbers and shapes: Here is one way to arrange 10 dots in 5 rows, with 4 dots in each row. Can you find another way to do this? (Try arranging the dots in the shape of a star.)



For science experts only: The spinning earth does not create a wind because the atmosphere spins along with the earth. If a stone is thrown up in the air, it, too, moves along with the earth. Things don't fly off into space because the centrifugal force created by the earth's rotation is not as strong as the earth's gravity.

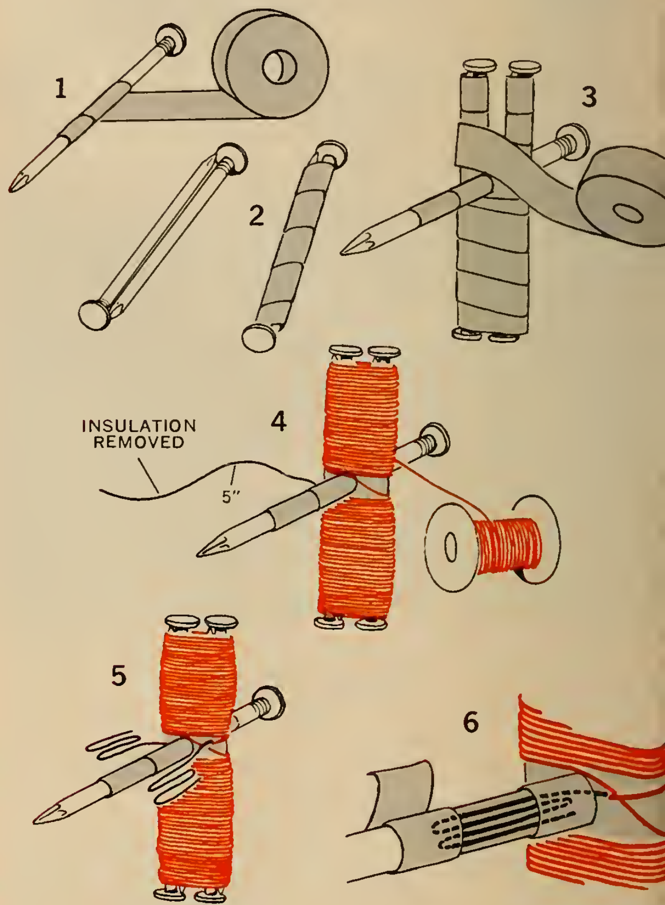
Make and Investigate an

by Robert Gardner

With some nails, wire, and tape you can make

■ Taking an electric motor apart to find out how it works would be like taking an alarm clock apart. Your chances of finding out would not be very good, and your chances of getting it back together so it works would be even worse. It's easier, and more fun, to make a simple motor that will actually do some work, and investigate how it runs. Here is what you will need:

- 1 roll of Number 24 enameled (or cotton-covered) wire (from an electronics or hobby store)
- 1 roll of insulating tape (cloth tape is best)
- Small wooden board (4 inches square will do)
- 3 nails 3½ inches long
- 4 nails 2½ inches long
- 4 finishing nails 2½ inches long
- 2 tacks or thumbtacks
- 2 small pieces of clay
- 4 or 5 dry cells connected in series (see *"Bulbs and Batteries,"* N&S, *March 4, 1968*)



Making the Armature

The moving part of your motor is an electromagnet called the *armature*. To make it, begin by winding two layers of tape around the middle 1½ inches of one of the large nails (*see Diagram 1*). Next, tape two 2½-inch nails together (*Diagram 2*), then tape the other two together the same way. Center the large taped nail between the two pairs of nails so that they are about 1 inch from the head of the large nail, and tape the two pairs of nails together (*Diagram 3*). Wind two full layers of wire around the two pairs of nails in this way: About 5 inches from the end of the wire, start winding it around the nails next to the shaft (large nail). Wind always in the same direction, out to one end, then back to the center, around the shaft, out to the other end, and back to the center. Then cut the wire, leaving about 5 inches at each end of the armature coil (*see Diagram 4*).

Use sandpaper to remove the enamel insulation (a dull knife will do if the insulation is cotton) from both 5-inch ends of the armature coil. Fold the bare ends of the wire as shown in Diagram 5. Then use narrow strips of tape to fasten the folded wires to opposite sides of the shaft (*Diagram 6*). (Be sure that plenty of bare wire is exposed on each side of the shaft.) This part of the armature is called the *commutator*.

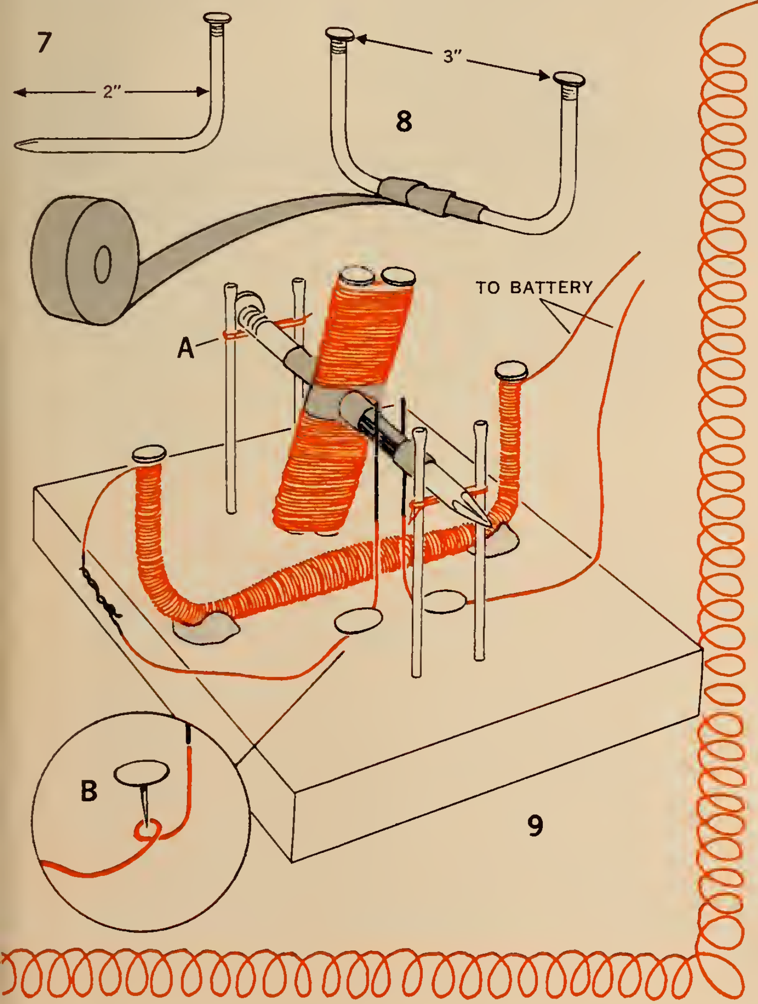
Making the Stator

The part of the motor that doesn't move is a U-shaped electromagnet called the *stator*. To make it, first bend the other two large nails about two inches from their pointed ends, as shown in Diagram 7. (To bend a thick nail, drive it through a board to the point where you want to bend it, then use the hammer to bend the nail over. Hammer the point of the nail to drive it back out of the board.)

With the heads of the two nails about 3 inches apart (*see Diagram 8*), wrap the ends of the nails together with several layers of tape. Wrap about 400 turns of wire around the nails as shown in Diagram 9. Be sure to wind always in the same direction, and leave 4 or 5 inches of wire at each

ELECTRIC MOTOR

small electric motor and find out what makes it run.



end. Diagram 9 shows how to hold the stator in place on the board with two pieces of clay.

To support the armature shaft, drive four 2½-inch finishing nails into the board as shown in Diagram 9. Place them so that the armature coil will be halfway between the two poles of the U-shaped stator. Wrap wire around the nails to support the shaft at the same height as the stator's two poles (*Diagram 9A*).

Next, make the *brushes*. Bare the ends of two 6-inch pieces of wire and bend the wires as shown in Diagram 9B. Then tack them to the board as shown in Diagram 9, so that the brushes push against opposite sides of the commutator.

Bare the ends of the stator coil wires and twist one of them tightly together with the end of one of the brushes (*Diagram 9*). Place the armature on the supports, as shown, and bend the brushes if needed to push them against the commutator. Connect the wires from one brush and one end of the electromagnet to the battery and give the armature a flip. Adjust the push of the brushes against the commutator until the motor runs best.

How Does It Work?

With a pocket compass, you can find out what makes the armature (an electromagnet) turn around between the poles of the stator (another electromagnet). Remove the armature from the motor and hold the two brushes together so that a current is flowing through the stator coil. By holding the compass near each of the poles of the stator, you can tell which is the north pole and which is the south pole. Next, connect a dry cell to the two sides of the commutator so that a current flows through the armature coil. Use your compass to find its north and south poles. Now switch the wires from the dry cell so that they touch the opposite sides of the commutator, sending current through the armature coil in the opposite direction. What happens to the poles of the armature coil?

Replace the armature on its supports, with the commutator between the brushes. Turn the armature slowly with your finger, and you can see that the brushes touch opposite sides of the commutator each time the armature turns half way around. Can you figure out now what makes the motor run? (Remember, *like* poles of two magnets *repel*, or push away from each other; *unlike* poles *attract*, or pull toward each other.) ■

INVESTIGATIONS

- Can you think of one or more ways to make the armature spin in the opposite direction? Will reversing the battery connections do it? Why?
- See if you can make the motor do some useful work, such as moving air, turning a wheel, or pulling a weight. You might use such things as cardboard, paper, a rubber band, a spool with a nail through it, and so on.
- If you could turn the armature fast enough by hand, do you think your motor would generate an electric current? Can you explain why? (See *"Electricity from Magnets,"* N&S, *March 18, 1968.*)

Holding a "fly-in" at the American Museum of Natural History, *N&S* editors Larry Pringle *(left)*, Bob Lefkowitz, and Steve Morris test fly—

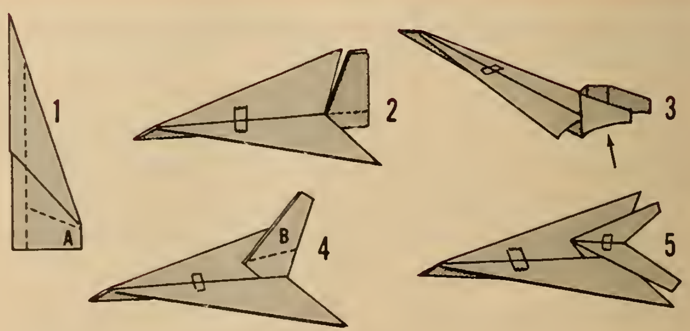
"Better Airplanes" from our readers

■ The editors of Nature and Science recently spent a day flying paper airplanes—the hundreds of planes sent in by readers at our invitation (see "Build a Better Airplane," N&S, January 8, 1968). When the air and the floor in the Education Hall at The American Museum of Natural History in New York City were finally cleared of planes, the best entries—the ones that flew best and those with the most original designs—had been selected.

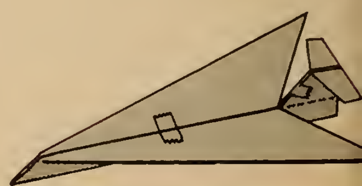
Instructions for making some of the best-flying planes are given in these pages, together with the names of the "engineers" who designed them. Each of the persons named in this article will receive an "Honorary Airplane Design Engineer" certificate.

You might make some of these planes yourself and test their flying ability. See if you can figure out why some fly better than others. Try putting paper-clip weights on the planes or making them out of heavier or lighter paper to see how they fly best. (You can also find out how to make other kinds of paper airplanes in a paperback book published recently: "The Great International Paper Airplane Book," by Jerry Mander, George Dippel, and Howard Gossage, Simon and Schuster, New York, 1967, $2.95.) ■

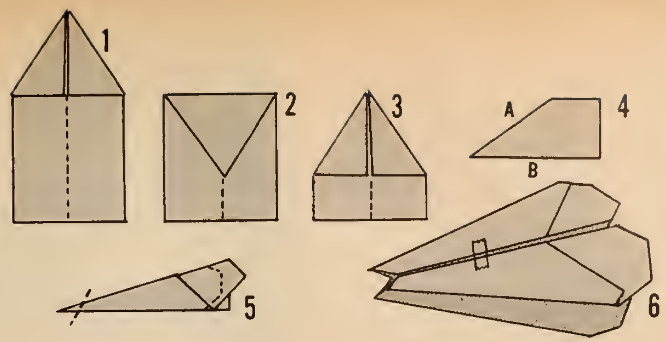
You can make a plane with a pair of rear wings like the ones on some modern jet liners. First fold a complete hook-nosed plane *(see "Build a Better Airplane,"* N&S, *January 8, 1968)*. Then fold the wings back in again and cut them along line A in Diagram 1. Next, fold the wings down and tape them together to get Diagram 2. Push the tail of the plane forward *(Diagram 3)* so it folds inside out and stands up in the body of the plane as in Diagram 4. Then fold the upper wings down along line B in Diagram 4 and tape them together to finish the plane *(Diagram 5)*.—**Design submitted by Brad Thomason, Downieville, Calif.**



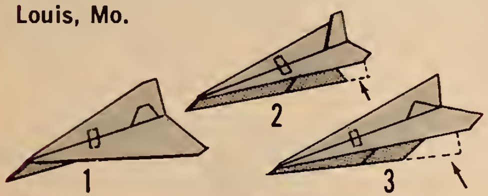
You can make a different tail for this plane by folding the rear wings down after step 2, as shown in this diagram.



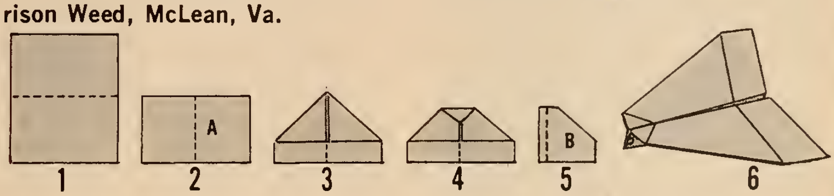
Fold a piece of paper in half the long way, then open it again. Fold the top corners in to the center so it looks like Diagram 1. Then fold the whole triangle-shaped part down to get Diagram 2. Fold the new top corners in to the center *(Diagram 3)*. Then fold the plane in half *(Diagram 4)*, and fold the wings down so that edge A lines up with edge B. Cut along the dotted lines in Diagram 5. Then fold the wings up and tape them together at a slight upward angle *(Diagram 6)*.—**Design submitted by Steve O'Donnell, Boise, Idaho.**



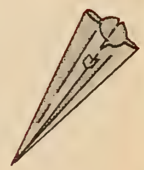
Here are some ways to add a tail fin to a delta-wing or a hook-nosed plane shown in *N&S*, January 8, 1968. Tape a small piece of paper inside the body of the plane so that it sticks up *(Diagram 1)*. Or, cut the back part of the body of the plane free from the rest of the body so you can push it up through the body of the plane with your finger *(Diagram 2)*. Or you can push the back end of the body up through the body without cutting it *(Diagram 3)*. **—Designs submitted by (1) Jeff Marsh, Pueblo, Col.; (2) Matthew Jacobs, Minneapolis, Minn.; (3) Jackie Coleman, St. Louis, Mo.**



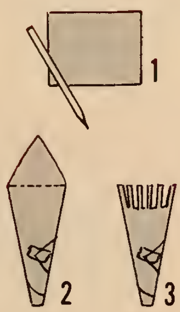
Fold a piece of paper in half the short way *(Diagram 1)*, and leave it folded. Then fold it in half along line A in Diagram 2, and open it again. Fold the top corners in to the center as in Diagram 3, and then fold the point part-way down to get Diagram 4. Fold the plane in half (with the folds inside), and fold the wings down along line B in Diagram 5. Put some tape on the front and back of the plane to keep it together *(Diagram 6)*.—**Design submitted by Harrison Weed, McLean, Va.**



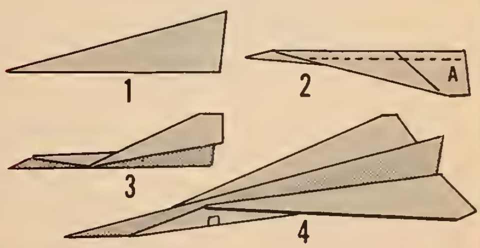
To make this arrow-shaped plane, just tape two delta-wing planes together, wing-to-wing. (Make the planes so that the folds come out on the tops of the wings, which will be hidden when you tape the planes together.)—**Design submitted by Jonathan Bailey, Berwyn, Pa.; Paul Mendelson, New York, N.Y.; and Eddie Vela III, Garland, Texas.**



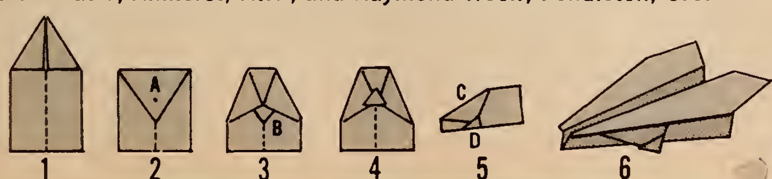
Use a pencil to help you roll a piece of paper into a cone *(Diagram 1)*. Widen out the top of the cone with your fingers, and tape it together. Cut off the top of the cone so that it's straight across *(see Diagram 2)*. Then make a lot of cuts in the top to make "propellers" *(Diagram 3)*. Bend the "propellers" slightly outward. Give the "plane" a little spin as you throw it high into the air, and watch it twirl as it comes down. **—Design submitted by a reader from St. Louis, Mo., who gave no name.**



Begin making a hook-nosed plane *(see N&S, January 8, 1968)*, but fold the plane in half so that the previous folds are on the inside *(see Diagram 1)*. Then fold the wings back normally as in Diagram 2. Next, fold each wing up along line A in Diagram 2 to get Diagram 3. Turn the plane upside down and "open up" the wings so the plane looks like Diagram 4. Use some tape to hold the plane together. **—Design submitted by Wayne Parsons and Paul Jubinsky, Hyde Park, N.Y.**



Fold a piece of paper in half the long way, and open it again. Then fold the top corners in to the center so it looks like Diagram 1. Fold the whole triangle-shaped part down to get Diagram 2. Then fold the new top corners in to point A in Diagram 2, so it looks like Diagram 3. Fold the little tab (B) up to get Diagram 4. Then fold the plane in half so that all the folds are on the outside *(Diagram 5)*. Next, fold the wings down on each side so that edge C in Diagram 5 lines up with edge D. Diagram 6 shows the finished plane. This plane needs no tape because the folds are "locked" in place by the tab, and the body of the plane should be "open" when the plane is thrown.—**Design submitted by Jeff Marsh, Pueblo, Col.; Eric Steinhaus, Los Alamos, N.M.; Brian Tatro, Amherst, N.H.; and Raymond Woolf, Pendleton, Ore.**



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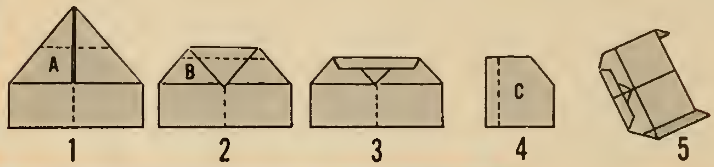
From the peak of the pile, "Chief Airplane Design Engineer" R. J. Lefkowitz surveys the planes to be tested in the "fly-in." Each plane was numbered to identify its maker.

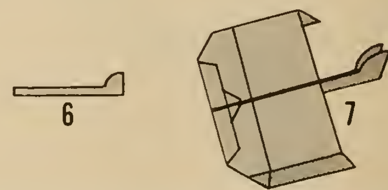
The planes in this photo were chosen mainly because of their interesting designs. Not all of them flew too well. Here are the designers of the planes:

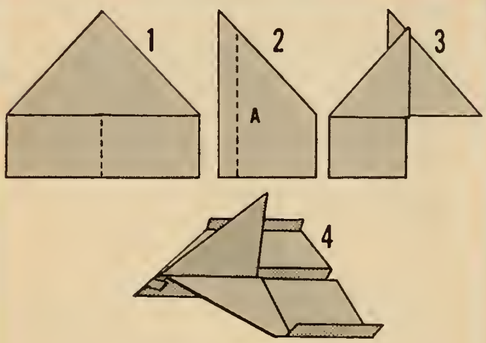
1. **Kenneth William Schmuhl, Fox Lake, Wis.**
2. **Gerry Robertson, Bandon, Ore.**
3. **Lincoln Stoller, Rye, N.Y.**
4. **Stephen Morgan, Gibbsboro, N.J.**
5. **Steven Litt, Larchmont, N.Y.**
6. **Fred Simon, Gibbsboro, N.J.**
7. **Freddy Kutilek, St. Louis, Mo.**
8. **R. Brouk, St. Louis, Mo.**
9. **Marvin B. Wolf, M.D., Chicago, Ill.**
10. **Cindy Hoffarth, St. Louis, Mo.**
11. **Andrew Thompson, Anacortes, Wash.**
12. **Fred Simon, Gibbsboro, N.J.**
13. **Kay Kucera, Shaker Heights, Ohio**
14. **Danny Shannon, Bozeman, Mont.**

Fold a piece of paper in half the short way, and open it again. Fold the top corners in to the center *(Diagram 1)*. Then fold along line A in Diagram 1 to get Diagram 2. Fold along line B in Diagram 2 to get Diagram 3. Next, fold the plane in half, and fold the wings back along line C in Diagram 4. Fold the wing edges down and tape the body together to complete the plane *(Diagram 5)*. This plane will often do several loops. **—Design submitted by Phil Rives, Mt. Prospect, Ill.**

To add a tail to this plane, or to any plane like it, fold a long, narrow piece of paper in half, and cut it to the shape shown in Diagram 6. Slip the tail inside the body of the plane as far as it can go *(Diagram 7)*. How does the tail change the way the plane flies?—**Design submitted by David Spencer, Youngstown, Ohio.**







Here's how to make a "shark" plane: Begin to fold a blunt-nosed plane *(see N&S, January 8, 1968)*, but stop when the plane looks like Diagram 1 above. Then fold the plane in half to get Diagram 2. Fold the wings back along line A in Diagram 2, but leave the loose point on the right side of the plane sticking straight up *(see Diagram 3)*. Fold up the edges of the wings and tape the body together to finish the plane *(Diagram 4)*.—**Design submitted by Robert K. Hubble, Liberty, Pa.**

"Honorary Airplane Design Engineer" certificates will also be sent to the following readers, whose planes could not be shown:

Les Beddoes, Dallas, Texas
Tom Bingham, Dallas, Texas
Jon M. Califf, Orange, Calif.
Thomas C. Connolly, Library, Pa.
Carol Eikelberry, Newark, Ohio
Robert Fredrick, Cortez, Col.
Fred Gartner, Chicago, Ill.
William Tolin Gay, Kirkland, Wash.
Paul Gillis, Lexington, Ky.
Ed Greenleaf, Auburn, Ala.
Wayne Gruber, Sugar Grove, Pa.
Christopher Hall, Cambridge, Mass.
Eddie Hatchett, Dallas, Texas
Judy Honorowski, Easton, Conn.
Mark Jones, Louisville, Ky.
Elvis Kimura, Hilo, Hawaii
Bruce Leiman, Denver, Col.
Walter Mane, Flushing, N.Y.
Brian Mayou, Sodus, N.Y.
Darlene McKee, Lockport, N.Y.
Paul Meyers, Wethersfield, Conn.
Greg Peterson, Rhinelander, Wis.
Guy Schultz, Sugar Grove, Pa.
Douglas Shiro, Hilo, Hawaii
Paul Smeltzer, Munster, Ind.
Richard Terhanko, Youngstown, O.
Glenn Vint, Dublin, Calif.
Bob Violi, Massena, N.Y.
David Ward, San Diego, Calif.
Steven L. Watkins, St. Louis, Mo.

WHAT'S NEW?

By Roger George

Stalactites have appeared in a strange place — under the Lincoln Memorial in Washington, D.C. These "stone icicles" are usually found hanging from cave ceilings, but the Lincoln Memorial stalactites hang from the ceiling of a room under the monument.

They form in the same way as other stalactites: Water seeping through cracks in the marble picks up and carries with it a mineral called *calcite* (calcium carbonate). As the water drips from the ceiling of the room underneath, some of the water evaporates, leaving hard calcite that grows into stalactites. In a similar way, water dripping onto the floor forms upward-growing *stalagmites (see photo).* The stalactites have grown to more than five feet long since the monument was finished in 1923. This very fast growth is probably caused by moving air that evaporates the water quickly.

This photo shows a water drop about to fall from a stalactite (top) under the Lincoln Memorial. The drop will add a tiny bit of calcite to the stalagmite growing up from the floor.

Tooth decay might disappear if scientists can do for humans what they've done for hamsters. Tooth decay has been traced to bacteria that live in the mouth *(see "Look, Mom—No Cavities!",* N&S, *January 8, 1968).* These bacteria mix with saliva and the sugar in food and form a thin, sticky film on the teeth, called *plaque.* Brushing teeth after meals removes most of the plaque. But in the plaque that is left, the bacteria change the sugar into an acid that can eat through teeth, causing cavities.

Scientists at the National Institute of Dental Research, in Bethesda, Maryland, have learned that bacteria living in the mouths of hamsters make a substance called *dextran* from sugar. Dextran acts as a glue that holds the plaque together on hamsters' teeth. Now scientists at Merck, Sharp and Dohme Research Laboratories, in Rahway, New Jersey, have found a substance that destroys dextran. Given to hamsters in their drinking water, it removes plaque from their teeth and reduces decay almost to zero. Scientists will see if human cavities can be prevented in the same way.

You have to be tough to be a long-distance runner. How tough? A scientist in England, Dr. L. G. C. E. Pugh, examined 63 runners who ran in a 26-mile race. During the race, the runners lost an average of 6½ pounds each. The winner lost about 9 pounds, including almost 7 pints of body fluids that left his body as perspiration. Loss of so much fluid would cause an ordinary person to collapse, according to Dr. Pugh.

The body temperature of most of the runners was far above the normal 98.6 degrees Fahrenheit. The winner had the highest temperature of all—105.8 degrees. If your body were this warm, a doctor would say you had a high fever, and were probably very sick.

A swordfish attacked a submarine in the waters off the Georgia coast. The sub was the *Alvin,* a research vessel belonging to the Woods Hole Oceanographic Institution at Woods Hole, Massachusetts. The *Alvin* was cruising along the ocean floor at a depth of 1,800 feet when the crew saw a seven-foot swordfish in the sub's lights. Suddenly the swordfish attacked. It rammed into the submarine so hard that its sword stuck between metal plates of the hull.

The fish thrashed strongly, but couldn't pull its sword loose. Then a light began flashing inside, warning that the sub was leaking. The skipper took it to the surface. The crew worked for two hours to pry the sword from the hull; their reward was swordfish dinner. Swordfish have attacked boats before; no one knows why.

Giant "pogo sticks" like these are suggested for making moon travel easy for astronauts.

A giant "pogo stick" could carry astronauts over the moon's surface in 400-foot leaps, a scientist says. Such leaps can be made because the "pull" of gravity is only one-sixth as strong on the moon as it is on the earth. Dr. Howard S. Seifert of the United Aircraft Corporation says the stick would work like this:

Two spherical cabins—one for astronauts, the other for the engine and equipment—slide up and down a hollow pole 40 feet long (*see photo*). A solid piston that fits inside the pole slides with the cabins. During a leap, the cabins and piston are near the top of the pole. When the pole lands, cabins and piston slide down the pole, and the piston squeezes a gas inside the pole. The squeezed gas acts like a spring. It expands and pushes the piston and cabins upward until they lock in place near the top of the pole. Their motion carries the pole into the air for another leap.

Spying on Raccoons

By fitting these mammals with tiny radio transmitters, biologists have been able to trace their travels and learn more about how they live and die.

■ It was dusk when the raccoon poked its nose out from under an old stump. In the next two hours the raccoon ambled across a tangled cedar swamp. Through the long night it traveled to cornfields, recrossed the swamp, swam across a creek, and explored a lake shore. As dawn approached, the animal headed to another swamp, where it slept away the day.

Throughout the night, the raccoon had kept its eyes, ears, and nose alert to avoid any danger. As far as the raccoon could tell, its travels were known only to itself.

Little did the raccoon know, however, that its movements were being "watched" constantly. This animal was No. 616—just one of the many raccoons that I was spying on for the University of Minnesota, with the help of radios, computers, and several assistants. We were trying to learn all we could about the life of raccoons, especially about their travels.

Two miles away from raccoon No. 616, a pair of radio antennas were turning. They were picking up signals sent from a small radio transmitter that the raccoon was wearing around its neck. From the antennas, the signals were sent through several electronic devices, and later the information from the signals went into a computer. Signals from the computer then guided a pen in drawing a map of the raccoon's travels.

One Way To Catch a Raccoon

The first step in our study was to capture raccoons so we could put radio-collars on them. There are many ways to catch raccoons, and we tried them all. A method that we often used was for one person to pull the animal out of a hollow tree and put it in a sack that someone else was holding. As simple as that may sound, it never did work quite so smoothly.

One time, for instance, a raccoon almost landed on my head. It was winter, and the animal had been sleeping deep inside the hollow of a broken-off tree stump about eight feet high. My assistant, Norm Peterson, stood on a ladder trying to get the animal to come up to where he could catch it with a noose of rope. Meanwhile, I waited on the ground, holding the bag.

Suddenly, Norm yelled, "Here he comes!"

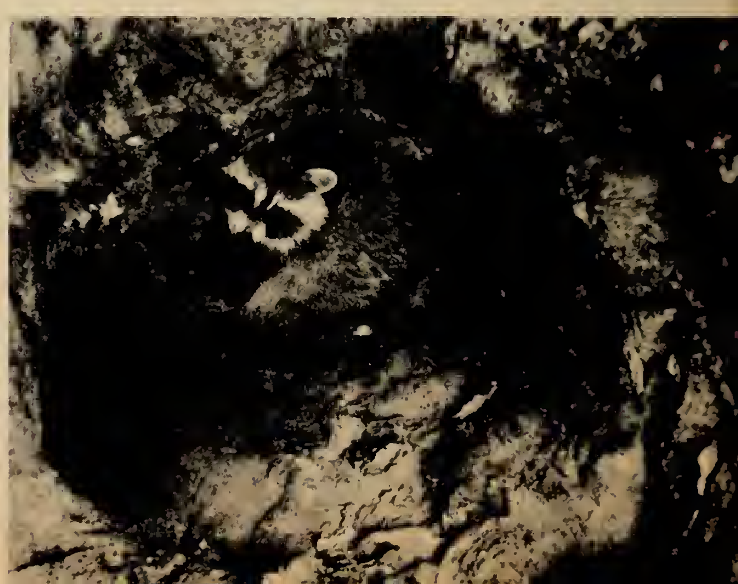
I looked up just in time to see the raccoon come flying over Norm's head, straight down toward me. The raccoon had suddenly scrambled up the inside of the tree, and in one motion Norm had grabbed the animal by the scruff of the neck, yanked it out, and flung it over his head.

There wasn't time to get the bag under the falling animal, so I just ducked. The raccoon barely missed my head and plunged into the snow. Before the animal could gather its wits, I grabbed it by the tail. Norm then came down, and we worked the animal into the sack.

Once a raccoon was captured, the rest was easy. We forced it into a special box, poured in some ether, and waited for the animal to go to sleep. Then we pulled the raccoon from the box and put a special radio-collar around its neck. We also weighed and measured the animal, took notes on its age, sex, and general condition, and then put a numbered tag on its ear. If the raccoon started to wake up during all this, we just gave it a few more drops of ether to breathe.

What the Radios Revealed

Soon after the raccoon awakened, we let it go at the place where we had first caught it. From then on, for the



by Dave Mech

next few months, its travels would cease to be a secret.

One of the most surprising facts we learned about raccoons concerns their daytime resting habits. People used to think that each raccoon had a special den, usually a hollow tree, in which it rested each day. But that turned out to be a false idea. Instead each animal uses many resting sites, and may not return to any particular one for several days, if ever.

Although resting sites may be in hollow trees, in our study area most of them were on the ground, usually under blown-down trees or at the base of shrubs. Most of the time they were in swamps.

One time I found three young raccoons curled up together next to a clump of willows. One of the animals already wore a radio and I had used a small radio receiver to find its resting place. I knew that the other two raccoons did not have radios, so I wanted to catch them. But I had nothing to capture them with.

Before I could figure out a plan, the raccoons ran off. I dashed after the closest one, without any idea of what I'd do if I caught it.

When I finally cornered the raccoon, I held it down with my heavy leather boot. Then I took off my jacket, tied the end of one sleeve, and forced the raccoon inside the sleeve. That was the end of that jacket—the raccoon tried to chew and claw its way out as I carried it a quarter of a mile back to the lab.

Some raccoons were caught when found inside hollow trees *(left)*. Captured raccoons were "knocked out" with ether, then fitted with a collar *(above)* containing a small radio transmitter. When the animals were let go, the radio signals enabled biologists to trace their travels.

The animal weighed 15 pounds, which is about as heavy as a young raccoon gets by the time of its first autumn. Almost half a raccoon's weight at this time of year is fat. Because raccoons in the north spend most of the winter asleep, they need all this fat for energy to keep them alive. During August and September an adult raccoon feeding on corn and acorns may double its weight in about a month, but over the winter the raccoon may lose all this fat again.

To measure just how much fat a raccoon loses in a certain period, I weighed a young female in the middle of winter, radio-tagged her, and turned her loose. She wandered around until she found a sunny spot in the snow at the base of an alder clump. There she tucked her nose beneath her tail and continued her winter's slumber. Day after day, falling snow built up around her. Soon she was covered by about six inches of snow, except for a small hole kept open by her warm breath.

About a month later, I hauled her out of the hole and weighed her again. The raccoon's weight had dropped from 9.5 pounds to 8.0 pounds, an average loss of about ¾ ounce per day.

If a raccoon does not find enough food during the fall, or if the winter is especially long and cold, its fat may not last long enough. Then the raccoon starves. In our studies we learned that in some winters starvation is the greatest natural cause of raccoon deaths.

How Raccoons Live and Die

Ordinarily it is hard to tell the causes of death in raccoons. Few bodies of dead animals are found. But radio

(Continued on the next page)

collars helped us with this problem. Whenever the radio-tracking system "told" us that an animal was not moving when we thought it should be—such as during a warm spell in winter—we tried to find the animal. By using a portable radio receiver, we could tell exactly where the raccoon was (*see diagram*). If we found the animal dead, we could then examine the body to try to find the cause of death.

Biologists use portable receivers to get two different compass directions of the signals from a raccoon's transmitter. When the compass direction lines are drawn on a map, the raccoon is located where the two lines cross.

Besides learning about how raccoons die, we also found out a great deal about how they stay alive. Raccoons always seem to be on the move. Even a raccoon less than a year old may travel over three miles in a night; older animals often move farther.

Raccoons will eat almost any kind of fruit or animal matter, including corn, acorns, crayfish, grasshoppers, frogs, fish, and berries. When they learn of an area with an abundance of food, they may visit it almost every night. One animal that we tracked for 135 nights went to a certain cornfield on 87 per cent of those nights.

Even when a raccoon does find a supply of food, however, it will spend part of the night wandering into other areas. Probably this enables the animal to discover new sources of food. One raccoon we studied spent a few days in one area, then in one night suddenly moved to a new feeding area almost four miles from the first one.

This is just one of the many surprises that we have had in spying on raccoons. Not long ago we had a surprise of a different kind. A raccoon slipped out of its radio-collar. A storekeeper found the collar out in a field and took it. Soon after that we were trying to track the raccoon. Imagine our surprise when we found the signal coming from inside a little country store! ■

SCIENCE WORKSHOP

worms that grow new parts

No matter how you slice it a planarian is likely to develop into something more than the sum of its parts

by Edward Lindemann

Adapted with permission of The Macmillan Company from Water Animals for Your Microscope, *by Edward Lindemann.*

■ Cut a "cross-eyed" flatworm called a *planarian* in half one way, and it may grow into two worms. Cut it some other way and you may wind up with a worm with two heads or one with no head and two tails. These fascinating animals are easy to keep and you can investigate their behavior as well as their amazing ability to grow new parts.

One way to get some planarians is to tie a piece of meat or fish on a string and drop it into a cool or cold pond, stream, or spring. In 15 minutes to an hour or so the meat may be covered with planarians—and probably other kinds (*species*) of flatworms as well. If you don't live near a pond or stream, you can buy planarians from a biological-supply company (*see box*).

The planarians you get from a pond will probably be flat, gray worms half an inch long or shorter. You can recognize them by their triangle-shaped heads and their eyes, which appear to be "crossed" as if they were drawn by a cartoonist (*see drawing*). The dark part of the eye actually keeps light out, so the left eye, for example, can only receive light from the left side of the animal. (Do you think a planarian is really cross-eyed? When you cross your eyes, which side does the light come from that reaches, say, your left eye?)

How a Planarian Moves, Eats, and Reproduces

Unlike worms with a pipelike shape, the planarian has a definite upper and lower surface. It travels on its under side, pushed forward by thousands of hairlike *cilia* so that it glides over a slimy substance that comes from its body. If you prod a planarian, its muscles work rapidly, sending a wave of motion along its body that carries it along faster than usual.

The planarian's mouth is an opening near the middle of its body on the under side. When the worm mounts a piece of food, its throat—a tube called the *pharynx*—is pushed out of its mouth to suck in food.

Each planarian is *bisexual;* it has female body parts that produce eggs and male parts that produce sperms. But no planarian fertilizes the eggs in its own body. Instead, two of the worms come together and each inserts a tube into the other's body, leaving sperms that fertilize the eggs as they are laid.

Look for the eggs in streams. They will be about this big: ◯. In midsummer they will be in thin cases with see-through walls, attached to plants, stones, or branches in the water. Toward fall the cases have thicker walls that you can't see through. After two or three weeks the eggs hatch out very small planarians that are like the adults but without reproductive organs.

Some species of planarians reproduce a different way. As the worm's body grows longer, it also becomes thinner at a point behind the pharynx (*see diagram*). While the worm is gliding forward, the rear part, with only a thin strip holding it to the front part, will suddenly grip the surface it is on. A sort of tug of war between the front and the back parts goes on for as long as several hours. Then, suddenly, the front part breaks loose and goes off by itself.

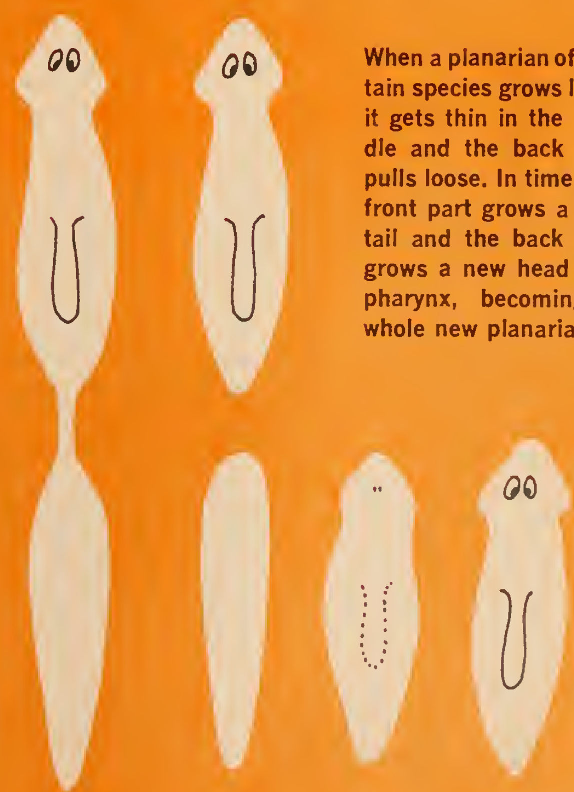
In time the front part will grow a new tail. The rear part, headless, eyeless, and without a pharynx, will gradually *regenerate,* or develop all these parts, and a new planarian will be formed.

Scientists have found that some kinds of planarians can regenerate complete new worms from certain parts that have been cut off. Splitting a planarian's head and part of its body may result in a worm with two heads. (Single worms with as many as 10 heads have been produced this way.) A small piece cut out of a planarian directly behind its head might develop into a short worm with a head at each end.

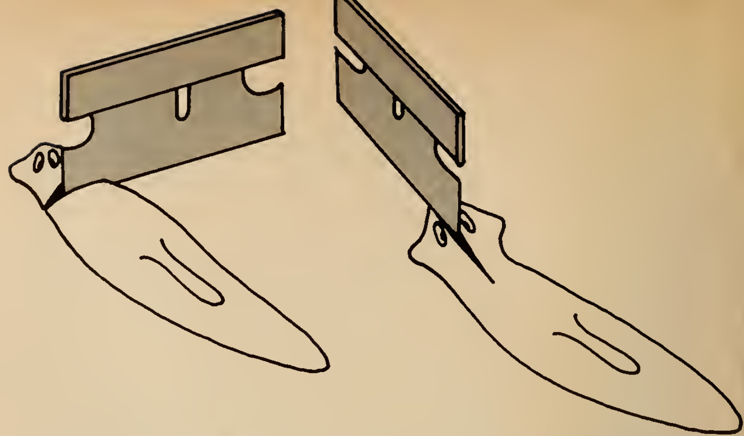
(Continued on the next page)

Where To Buy Planarians

You can buy black planarians from biological-supply houses for about $3 to $4 a dozen. Write to Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, N.Y. 14603 or to Ward's of California, P.O. Box 1749, Monterey, Calif. 93940; or to Turtox, Inc., 8200 South Hoyne Avenue, Chicago, Illinois 60620.



When a planarian of certain species grows long, it gets thin in the middle and the back part pulls loose. In time, the front part grows a new tail and the back part grows a new head and pharynx, becoming a whole new planarian.



In cutting a planarian to see how it generates new parts, hold the single-edged razor blade straight up and make the cut in a single stroke.

Investigating Regeneration in Planarians

You can find out something about how planarians develop new parts through some simple experiments. Planarians can be raised in pond or aquarium water, or in tap water that has been left standing in an open container for 2 or 3 days. Put the planarians in a small jar or a shallow dish with the water, and feed them two or three times a week. To feed them. pour off most of the water and put thin strips of beef liver into the dish. After two or three hours, squirt water through an eye dropper to push the worms off the meat, then discard it. Rinse the dish several times, then add fresh water and leave the worms in a dark or shaded place until the next feeding.

The best time to try regeneration experiments is two or three days after the worms have been fed. Place a planarian on a piece of wet cardboard under a magnifying lens or the low-power lens of a microscope. Hold it in place with another piece of wet cardboard. Use a new, unused, single-edge razor blade to cut straight across its body just behind the head (*see diagram*). Hold the blade straight up and down and make the cut in a single stroke.

Place the two parts of the worm in a dish with water and observe them often through the next four days. Does the head generate a new body? Does the body generate a new head? Do you think the same thing will always happen?

You might cut another worm apart in the same way, but farther back from the head. (Be sure to label each dish in which you put a severed worm, so you will remember how it was cut.) Do its parts regenerate the same way as those of the first worm you cut? What will happen if you cut a worm into three pieces?

Try this with another planarian: Make a cut between the eyes, from just behind them through the worm's "snout" (*see diagram*). Carefully renew the cut once a day—oftener if necessary—to keep the two parts of the head from growing together again. Does each half of the head develop into a complete head? What happens if you divide each of them the same as before?

Try cutting a planarian in half from head to tail. How long does it take each half to become a complete worm?

From your investigations, do you think the nerves in the head of a planarian have anything to do with the way its parts regenerate? How can you tell? ■

Investigating Planarians' Behavior

With some simple equipment, you can investigate how planarians behave under certain conditions.

- Put an active planarian in a soup plate of water. Draw water into an eye dropper, place the tip in the water close to the end of the worm, and squirt some water at its tail from the side. Does the worm move toward the current, away from it, or not at all? Squirt water currents at its head from the side. Does it move the same way as before? Try holding the dropper behind the worm and squirting currents along its body toward the head. Do you think the knobs on each side of its head are sensitive to water currents? Can you suggest how this might help the animal survive?

- Put an active planarian in a flat, white container, such as a soup plate. Darken the room. Shine a flashlight at one side of the worm. Which way does it go? Switch off the flashlight and move it to a new position before switching it on. Using this light, can you make the planarian travel in a circle?

- Attach one wire to each pole of a six-volt battery, which you can make with wire and four flashlight cells connected in series (*see "Bulbs and Batteries," N&S, March 4, 1968*). Place the bare end of one wire in the water just ahead of a planarian gliding along the bottom of a dish. Gently place the other wire in the water behind the animal. Is the animal affected by the small electric current flowing through the water? Take the wires out until the planarian is acting normally again. Put the wires back in the water. Does the planarian react the same way after you have exposed it to an electric current several times? Do you think it might be reacting to the water movement caused by putting the wires into the water? How can you find out?

Using This Issue . . .
(continued from page 2T)

of untrained planarians. The result: The planarians that were fed with trained worms learned better than the control group.

The results suggest that memory is stored in some chemical that can be passed from one organism to another. This theory caused a rash of sensational stories in newspapers and magazines, including suggestions that humans would soon be able to improve their memories and intelligence by taking certain chemicals in the form of pills. Transfer of learning in planarians, however, is still being investigated. Some scientists have tried and failed to duplicate the results of the first memory-transfer experiments. Others have reported success, both with planarians and with other animals. Much remains to be learned about the subject.

For Your Reading

• *Water Animals for Your Microscope* (Crowell-Collier Press, 1967, $4.50), from which this article was adapted, is a valuable book for classroom use.

Brain-Boosters

Mystery photo. The tires on a tractor are always installed so that the point of each "V" in the tread hits the ground before the wider part. If the tread went the other way, mud would become packed against the inside of the "V," and this would tend to make the tires skid. The track in the photo was made by a tractor traveling from left to right.

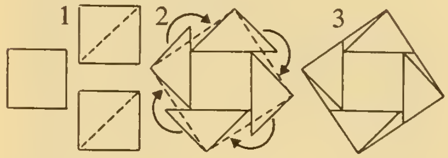
What will happen if? Punch four holes in a quart milk container with a paper clip and ask your pupils what they think will happen when the container is filled with water. (The holes should not be directly above one another, so the stream from one hole will not interfere with the stream from a lower hole.)

If the container is filled and held over the sink, water will squirt farthest from hole 4. But if the container is placed on the floor, the floor will stop the stream of water from hole 4 before it has gone as far as the stream from hole 3, which will then go the farthest.

Can you do it? Sprinkle a few drops of water on wax paper or aluminum foil, and have your pupils try to divide large drops into smaller ones or combine small drops into larger drops, using a sharp pencil point or the end of an unbent paper clip. Both operations are hard to do, because *surface tension* makes a drop of water behave as if covered with an elastic skin.

Have your pupils try the same operations with drops of slightly soapy water, then see if they can figure out how soap helps in cleaning. (It weakens the surface tension of water, letting the water mix more readily with dirt and grease, which can then be wiped or rinsed away more easily.)

Fun with numbers and shapes. The squares can be any size, but should be cut exactly square. Here is one way to cut the squares (along dotted lines) and form one large square:



For science experts only. As a car slows down, everything inside that is not fastened to the car keeps moving forward at the same speed as before. The air moving forward in the car piles up in front of the lighter, helium-filled balloon, pushing it to the rear.

N&S REVIEWS...
(continued from page 1T)

any circumstances, but if any of the readers of such books can be so stimulated, this one will do it. One small criticism: the author's drawings, while adequate, don't begin to match the intellectual achievement of her text.

—R.M.K.

Built to Survive, Windows on the World, and **Secrets of the Heart and Blood,** all by Anne Terry White and Gerald S. Lietz (Garrard Publishing Co., 80 pp., $2.07 net). Here are three books in a series called "Wonder of Wonders: Man." The approach to the subject of the human body is far different from the usual textbook discourse. Despite a sometimes irritating, breathless, "Oh, the wonder of it all!" attitude, the authors are gifted teachers, using familiar examples, similes, and anecdotes to explain the often complex construction and workings of the body. The language is simple and the diagramatic drawings are most helpful. The reading is grade five, the interest level, from grades four to seven.

Built to Survive explores human anatomy in relation to environment. The first part of the book emphasizes the skeletal structure and its adaptations. The latter part of the book deals with the accomplishments of early man due to his superior brain: his making of tools, domesticating animals, etc. When writing of the human body the authors are usually accurate, but their knowledge of natural history is somewhat shaky. There are several questionable statements and at least one that's false: "today all the great apes, all except the gibbon, live on the ground."

Windows on the World concerns not only the eyes and the sense of seeing, but the other senses, including the senses of heat and cold, the sense of weight, of pressure, and of pain. There are diagrams of the eye, the ear, and the taste buds. Stories of Louis Braille and Helen Keller show how man has coped with limitations of the senses. And we see how inventions such as microscopes, telescopes, radio, and television have become extensions of the senses.

Clear descriptions of how the heart works will be found in *Secrets of the Heart and Blood*. The composition of the blood is explained, as well as its functions. Stories of Harvey, Malpighi, and others show how relatively recent our knowledge is. The last two chapters deal with modern vaccines and "miracle" drugs.

—B.N.

Question and Answer Book about the Human Body, by Ann McGovern (Random House, 68 pp., $1.95). "Can you feel your voice? Why do you sneeze? How do you taste?" These and about a hundred other questions are answered in a satisfactory manner for most eight- and nine-year-olds. Colored pictures and diagrams on every page are a big help. Some questions are answered in detail and in a way to interest older children, but many answers are so simplified that they amount to stating the obvious. But what can you do with a question like, "How does your brain help you play tag?"?

—B.N.

(Continued on page 4T)

N&S REVIEWS...
(continued from page 3T)

Anatomy and Physiology for Children, by Jean M. Ashton (Dover Publications, 61 pp., $1.50). This is a soft-covered manual with a large format. The first half contains precise directions for dissecting a chicken, with clear drawings at every step. In the dissection, emphasis is on the digestive and respiratory systems and those other organs, muscles, and bones which are shared by both sexes and can easily be related to the human anatomy. The last half of the book explains these relations, and there are drawings of human organs which help to show them. The book was written with ten- or twelve-year-olds in mind. However, it is suggested that younger children, with the help of an adult, could also use it. The book has a well-planned, practical approach which reflects the experience of an excellent science teacher. It includes a glossary, bibliography, and index.

—B.N.

The Wonders of the Human Body, by Martin L. Keen (Grosset and Dunlap, 128 pp., $3.95). A feature of this book is a front section of six colored anatomical plates, four of them on transparent overlays. The rest of the book is well illustrated throughout, mostly with black and white drawings. The text is full of information about the muscular, nervous, reproductive, and other body systems. There are chapters on the mind, the teeth, and the care of the body. The last third of the book is a short history of medicine. The reading level is for the upper elementary grades. The book is not always easy reading, but it should be most useful as a reference book. Indexed.

—B.N.

Bacteria and Viruses: Friends or Foes?, by William and Nellie Slaton (Prentice Hall, 64 pp., $3.50). The authors have bravely tackled a most complex subject for the eight- to twelve-year-olds. Not only is the concept of life of such infinite smallness difficult, but there is a whole new vocabulary to go with it. However, the authors are aware of the problems and they proceed slowly, explaining what bacteria and viruses are, how they live, and how they affect us. Children can learn a few facts firsthand by following instructions for growing bacterial colonies. Difficult words are always explained, and there are a glossary, index, and helpful black and white drawings.

—B.N.

nature and science

TEACHER'S EDITION

VOL. 5 NO. 16 / MAY 6, 1968 / SECTION 1 OF TWO SECTIONS

(FOR YOUR CLASSROOM BULLETIN BOARD)

Things You Can Do This Summer

The explorations, investigations, and projects you read about in *Nature and Science* this year but didn't have time to do can add a lot of fun and excitement to your summer vacation. Here's a list of suggestions and the date of the issue in which each one appeared:

Make a fun-house mirror and see yourself as others see you. *Sept. 18.*

Test leaves from trees and try to predict what color the leaves will turn in the fall. *Oct. 2.*

Find your balancing point. *Nov. 13.*

Test your bicycle gears to see how they help you start, speed up, or go up hills. *Oct. 16.*

Make a balance scale and discover how to adjust it for weighing different things. *Nov. 13.*

Investigate how light can affect the growth of a seed. *Oct. 16.*

Test your sense of touch. *Dec. 4.*

Explore inside an egg and test the strength of its shell. *Dec. 18.*

Figure out your own horsepower. *Jan. 8.*

Make paper airplanes that fly better than the usual kind, and try to design even better ones. *Jan. 8 and April 15.*

Investigate how a plant's roots reach for water. *Jan. 8.*

Explore the messages you send and receive, and find out how successful they are. *Jan. 22.*

Search for galls on leaves and stems and try to find out what causes them. *Feb. 5.*

Use toy trucks to see what happens when two cars collide. *Feb. 5.*

Find as many ways as you can to make an electric cell. *Feb. 19.*

See what happens when you connect batteries and bulbs in different kinds of circuits. *March 4.*

Make a magnet with electricity, make electricity with a magnet, and send a radio signal. *March 18.*

Build an electric motor that can do work and find out what makes it turn. *April 15.*

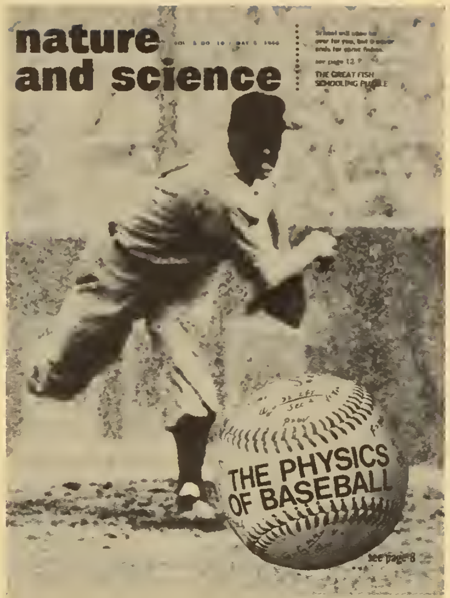
Raise gerbils and investigate how they live and behave. *Feb. 19.*

Investigate how weather conditions change the flow of sap in plants. *Jan. 8.*

Find out what kinds of behavior make a goldfish "breathe" faster. *March 18.*

Watch flatworms grow new or extra heads and tails. *April 15.*

Measure how much dust and soot falls from the air in your neighborhood. *April 1.*



IN THIS ISSUE

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

This is the last issue of *Nature and Science* for the current school year. You can reserve your subscriptions for next fall right now, and receive free a copy of *It Works Like This*, a collection of "How It Works" articles from previous volumes of *N&S*. (See page 4T.)

We hope we will be able to serve you and your pupils again next fall.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Snail Trail

Snails are in the *Gastropod* class of the phylum *Mollusca*. There are about 100,000 species of gastropods, and 19,000 of them are land snails. Your pupils may find other gastropods in gardens, especially land slugs, which resemble snails but have no shells. You can investigate the senses of slugs in the same way as the article suggests investigating those of snails.

Have your pupils watch closely to find out how a snail glides along. A gland at the front of its "foot" secretes a layer of mucus, and waves of muscle contractions in the foot move the snail along this mucus path.

Like all living things, snails can be judged both "good" and "bad" by humans. They are considered a delicacy but may also damage vegetables in a garden. Some species of land snails are intermediate hosts to parasites of other animals *(see "The Mysterious Moose Malady,"* N&S, *March 18, 1968).*

Everglades

The article about "Life in the River of Grass" illustrates the concept that *organisms are adapted to their environment.* Through natural selection, animals and plants have evolved certain characteristics that enable them to survive in their environment.

In this case, the life of the Everglades has adapted to a broad, slow-flowing river that suffers from annual droughts. This article suggests some ways in which different animals survive the dry season. The lives of these organisms depend on the flood that follows the drought. This is when most species produce a new generation. Man's tampering with the flow of water in the Everglades threatens to disturb this annual replenishment of animal populations and plant growth.

With your pupils you might compare the adaptations of some Everglades animals and plants with life in the desert, another habitat where water is especially critical (*see the special-topic issue, "Life in the Deserts,"* N&S, *Oct. 30, 1967).*

The concept of adaptation to environment is stressed again and again in *N&S* articles. An appreciation of this concept will help your pupils understand why some species (including themselves) thrive while others disappear and why environmental changes wrought by humans often have a disastrous effect on other life.

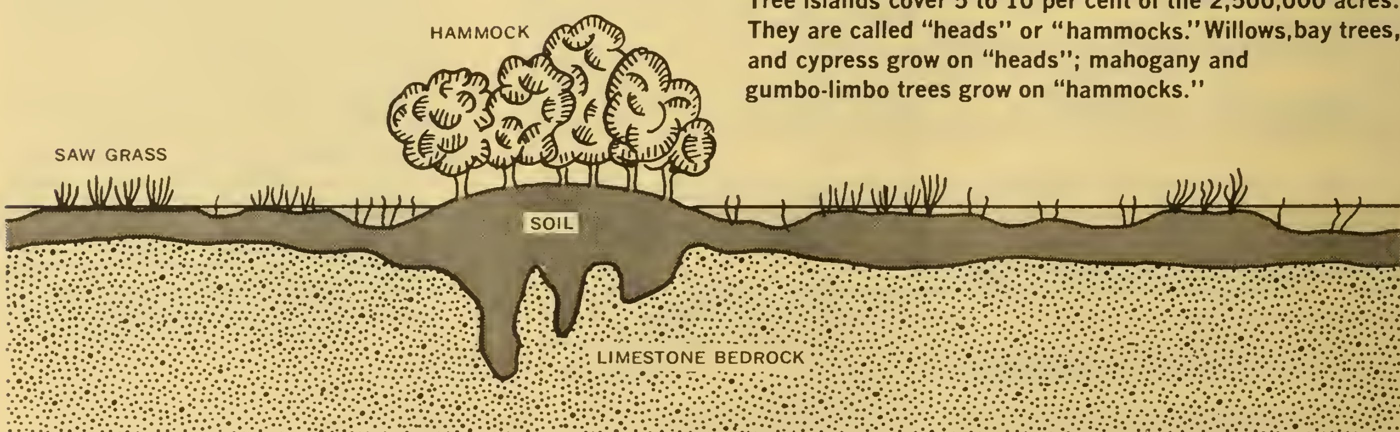
Keeping Cool

The cooling effect of air—even warm summer air—moving across one's skin is so familiar that your pupils are likely to predict a drop in the temperature shown by an alcohol thermometer when air is fanned across it (or the thermometer is swung through the air on a string). The discovery that the temperature does not change should stimulate your pupils' interest in investigating cooling by evaporation as suggested in this article.

Suggestions for Classroom Use

With an inexpensive alcohol thermometer, moisture-absorbent cloth, and a little water, rubbing alcohol, and cooking oil, your pupils can make the investigations at home or in the classroom. Before discussing their findings in class, you might have them also work out their ideas about "Things To Think about and Look for" *(page 10),* and try to design ways to investigate the factors that affect the rate of evaporation of a liquid *(see Project,*
(Continued on page 3T)

Most of the Everglades is either open water or saw grass. Tree islands cover 5 to 10 per cent of the 2,500,000 acres. They are called "heads" or "hammocks." Willows, bay trees, and cypress grow on "heads"; mahogany and gumbo-limbo trees grow on "hammocks."



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, December through April; monthly September, November, May, and July (July special issue). 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, N.Y. 10024.
SUBSCRIPTION PRICES: In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

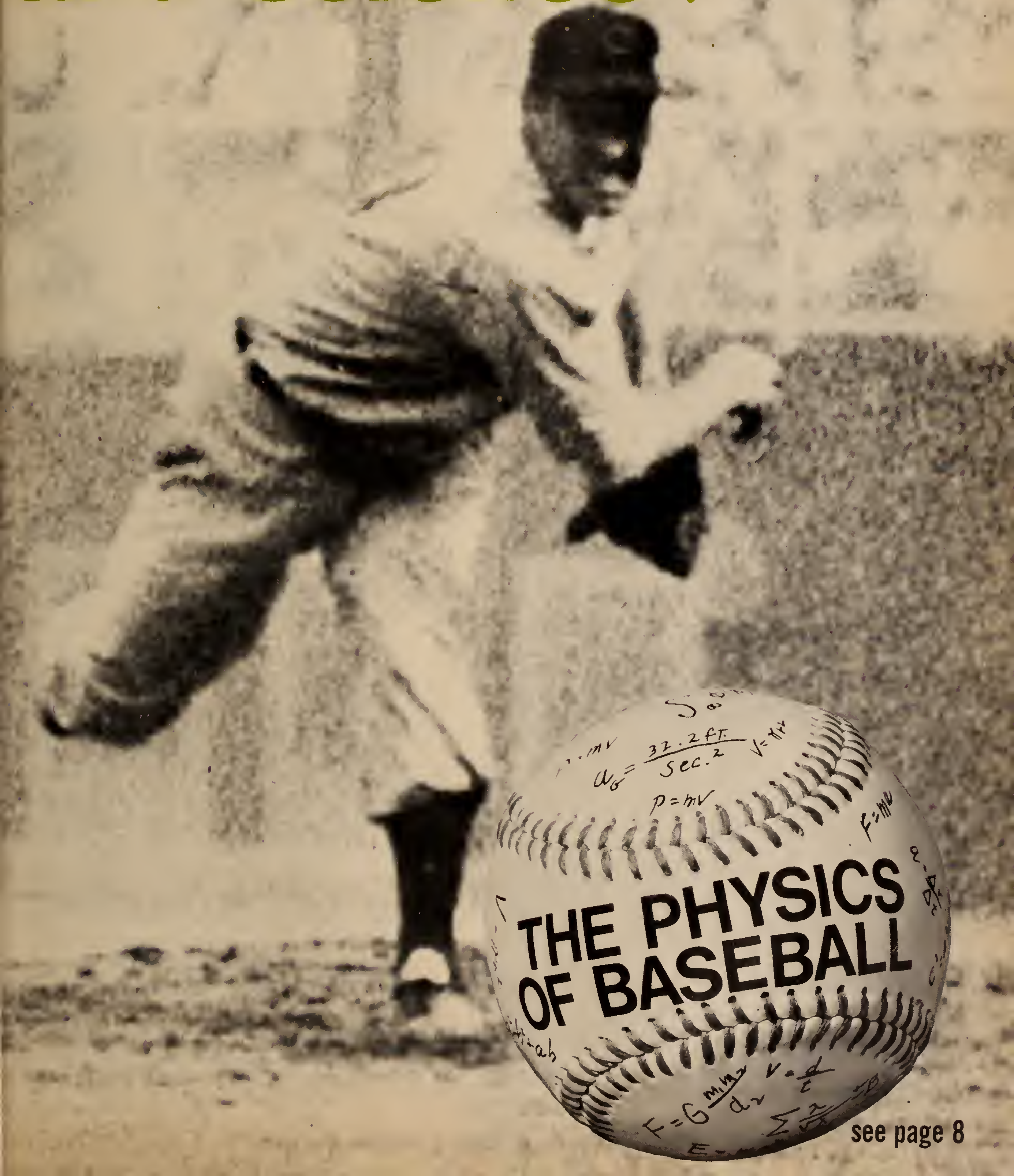
nature and science

VOL. 5 NO. 16 / MAY 6, 1968

School will soon be over for you, but it never ends for some fishes.

see page 12

THE GREAT FISH SCHOOLING PUZZLE



THE PHYSICS OF BASEBALL

see page 8

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PICTURE CREDITS: Cover, United Press International; pp. 2-4, 6, 8-14, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, photo by Joan Hamblin; pp. 5, 7, photos by Alan H. Anderson; p. 11, photo by Robert Gardner; p. 12, photo by Russ Kinne, from Photo Researchers, Inc.; p. 14, photo from Evelyn Shaw; p. 16, photo from Pictorial Parade, Inc.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; EXECUTIVE EDITOR Laurence P. Pringle; ASSOCIATE EDITORS R. J. Lefkowitz, Steven W. Morris; EDITORIAL ASSISTANT Alison Newhouse; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Donald B. Clausen
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PROMOTION DIRECTOR Elizabeth Connor;
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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, December through April; monthly September, November, May and July (July special issue). 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, N.Y 10024

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WHERE DOES

How do land snails find their food and hiding places? To find out, try these investigations.

■ A few years ago, an English biologist wondered about the land snails that lived in nearby gardens and fields. Do snails return to one particular place after each night's search for plant food? Or do they move from one hiding place to another?

To find out, the biologist marked the shells of several snails so he could recognize them, then took notes on their hiding places. During the next two weeks he found that the snails *did* return to the same place each morning.

You might try the same investigation with land snails in your area. They are a different kind *(species)* from those in England. Also, you can investigate another question: *How* do the snails find their food and hideouts?

The Snail's Return

Land snails are active at night, but you can find them during the day in cool, damp hiding places among piles of rocks, or under bits of wood and bark. Find at least

THE SNAIL TRAIL END?

by J. W. Gosden

10 snails. Then mark their shells with small dots of fingernail polish or paint that will not come off if the shell gets wet. To tell the snails apart, use a different number or pattern of dots on each one. Keep notes on the markings you use, and on the hiding place of each snail.

Check the hiding places each day to see if the snails are still there. Do most or all of them return to the same place? How can you be sure that a snail actually left its hideout?

If a snail fails to return, this may not mean that it is hiding someplace else. It may have been eaten by a bird or mammal. Because such things happen to snails, it is important for you to mark as many snails as possible in order to learn about their ability to find their way "home."

What Does a Snail See?

If, after two weeks, some of the snails continue to return to the same place, ask yourself: How do they find their way? By sight, smell, some other sense?

Give a snail a sight test. A snail's simple eyes are on the ends of its *tentacles (see diagram).* When a snail senses that something is going to touch its eye tentacles, the tentacles shrink back into its head.

Wait until a snail's tentacles are stretched out fully. Then slowly bring a finger closer and closer to its eyes. At what distance does either tentacle begin to shrink back into the snail's head? Do you think that a snail's sight enables it to find its way?

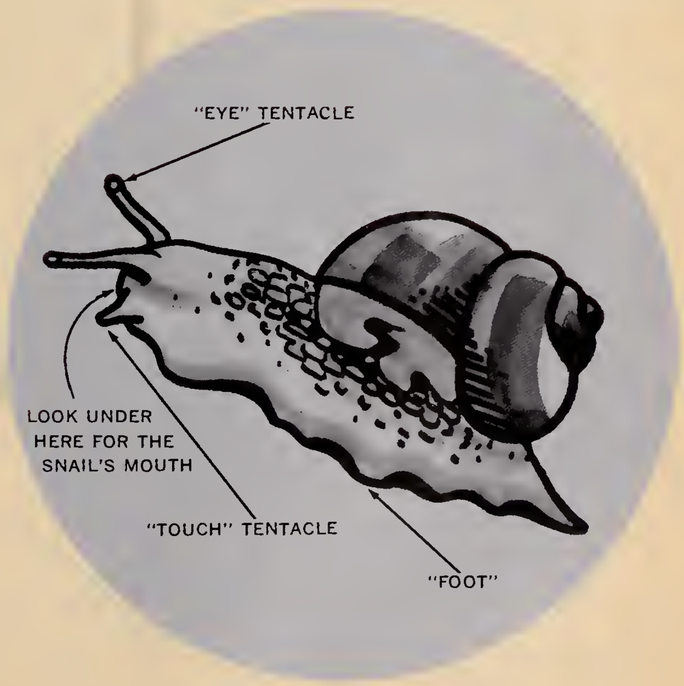
What Does a Snail Smell?

You can also investigate a snail's sense of smell. Put some snails inside a box or jar. Be sure to allow air to enter, and keep the container moist by putting in a damp sponge or paper towel. Do not give the snails any food for a day or two. Hunger seems to make the sense of smell keener, both in snails and in humans.

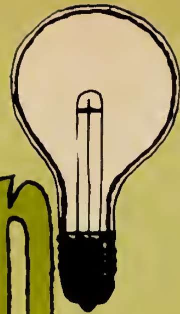
When you think the snails are hungry, take one from the container and offer it some food, such as fruit or lettuce. Let the snail eat for a few minutes. Then move the food about a foot away. What does the snail do? Is it able to find the food at this distance?

Try the same investigation with other snails. Also take the food they have begun to eat and hide it from sight. Can the snails find it? Do you think that a snail's sense of smell helps it to find its way?

By now you have probably noticed that a snail leaves a trail of shiny mucus at it moves along. Do you suppose that a snail could follow the scent of its mucus in order to return to its hideout? See if you can think of a way to test this idea ■

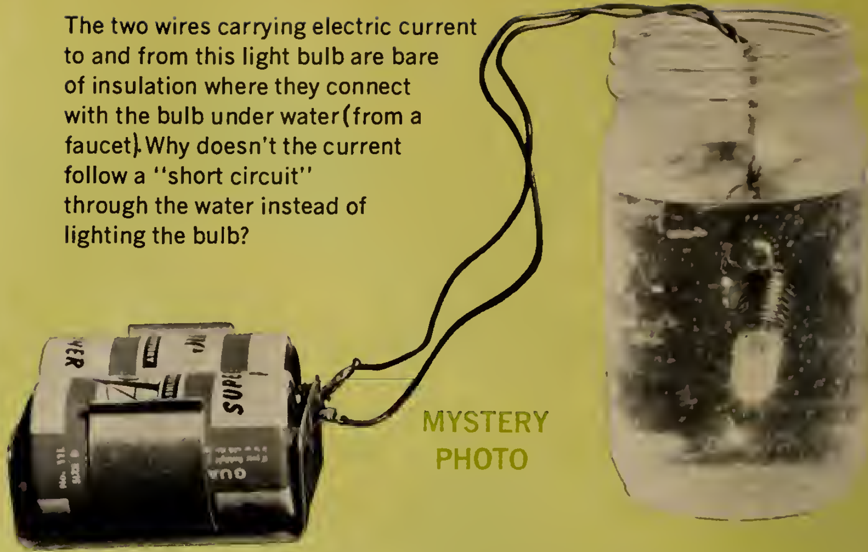


Brain Boosters



prepared by **DAVID WEBSTER**

The two wires carrying electric current to and from this light bulb are bare of insulation where they connect with the bulb under water (from a faucet). Why doesn't the current follow a "short circuit" through the water instead of lighting the bulb?



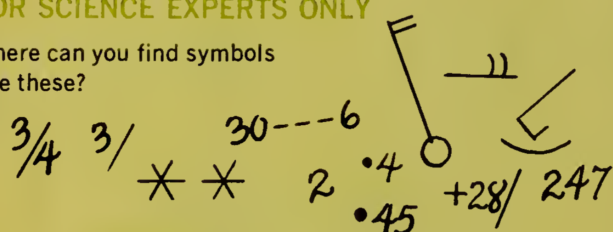
MYSTERY PHOTO

FUN WITH NUMBERS AND SHAPES

Two sports cars have a 240-mile race. Car A travels 40 miles per hour for the first 120 miles and 80 miles per hour for the final 120 miles. Car B goes 60 miles per hour over the entire distance. Which car wins? Why doesn't the race end in a tie?

FOR SCIENCE EXPERTS ONLY

Where can you find symbols like these?

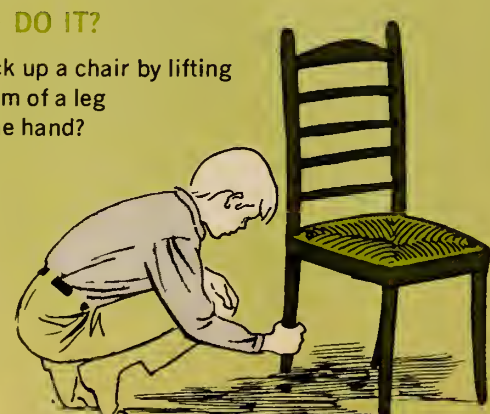


JUST FOR FUN

Are you "right-thumbed" or "left-thumbed"? Clasp your hands together. Is your left thumb over your right thumb, or is your right thumb over your left thumb? Now clasp your hands so that the position of your thumbs is reversed. Does this feel comfortable? A person usually clasps his hands in the same way every time. Does everyone in your family clasp his hands the way you do?

CAN YOU DO IT?

Can you pick up a chair by lifting at the bottom of a leg with just one hand?



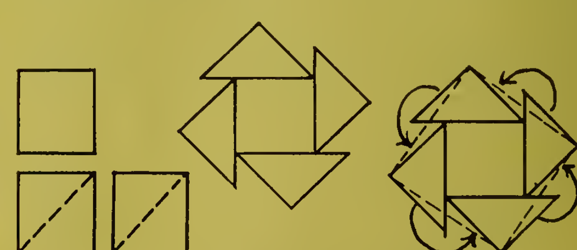
ANSWERS TO BRAIN BOOSTERS IN THE LAST ISSUE

Mystery Photo: The tractor was traveling from left to right. A tractor tire is put on so that the point of each "V" on the tread touches the ground before its wider part. If the treads went the other way, mud would get packed against the inside of the "V." This would tend to make the tires skid more easily.

What will happen if? If the milk carton with the four holes is held up, water will squirt farthest out of hole 4. But if it is placed on the ground, the water coming from hole 3 will shoot the greatest distance before hitting the ground. What happens to the water streams if you block up one hole with your finger?

Can you do it? Most drops of water are larger than a pencil dot. It is difficult to pull water drops apart because *surface tension* tends to make the water stick together.

Fun with numbers and shapes: Here is how to cut up three squares and reassemble the pieces into one large square. Can you figure out a way to cut up three triangles to make one large triangle?



For science experts only: As a car slows down, the air and everything else inside it that is not fastened to the car keeps moving forward. The air piles up in front of the lighter, helium-filled balloon, pushing it backward.

Answers to these Brain-Boosters are printed on page 7.

Floods and droughts are normal happenings for plants and animals in the Florida Everglades. With humans controlling the water supply, however, disaster may threaten...

LIFE IN THE RIVER OF GRASS

by Alan H. Anderson

■ The most outstanding feature of the Florida Everglades is water—or lack of it. When there is water, there is so much that the Everglades flow like a flat, grassy, slow-moving river. The Seminole Indians call it *Pa-hay-okee*—River of Grass. When there is *drought,* or a long dry spell, the River of Grass becomes a desert.

The Everglades "river" is about 50 miles wide, only a few inches deep, and may be the slowest-flowing river in the world. The water moves only a few yards a day in some places. Roughly half of the bottom is covered with sharp-edged saw grass that is taller than a man. The River of Grass is dotted with small clumps of mahogany, cypress, or gumbo-limbo trees.

Under the thin layer of mud and grass is a flat table of limestone that was the bottom of the ocean 5,000 years ago. The northern end of this table is raised about 17 feet above sea level. The southern end, 100 miles away, is at sea level *(see map on the next page).* It is because the tilt is so slight that the river flows so slowly.

From Drought to Flood

For the animals of the Everglades, life can be one disaster after another, including grass fires and hurricanes. The animals must be able to survive floods in the summer and drought in the winter and spring. In the last few decades, man has made the droughts worse by bulldozing and dredging a vast system of canals and dams in the northern

(Continued on the next page)

These raccoons are searching for food in the saw grass of the Everglades. Although the raccoons are in shallow water, you can still see mud cracks left from the drought.

River of Grass (continued)

part of the Everglades. He has so cut and blocked the River of Grass that it only flows normally below the Tamiami Trail *(see map).*

For water to get into Everglades National Park now, it must pass through man-made gates. In a very dry year there is the chance that humans may take all the water. The animals and plants of the Everglades may not even get the small amount of water that they usually receive in the dry season. This upsets a natural balance that has existed for at least 5,000 years.

During the spring of 1967, the heat was so great that the water level dropped by as much as half an inch a day in some places. The shallower pools evaporated, and most of the flat land was baked into six-inch cakes of flaking dust. As many as four out of five small fish—the main food of the larger animals--were trapped in puddles and died.

Then in late May, when conservationists and park rangers were beginning to worry that this drought might become a disaster, the rains came. They came in true Everglades fashion, with eight inches in two days. This is nearly as much rain as Tucson, Arizona, has in a full year.

Most of southern Florida was flooded overnight. Soil that had been parched for many months was suddenly submerged. Within a few weeks of the first downpour, swarms of mosquito fish, sailfish mollies, and other small fish appeared everywhere. The Everglades had rebounded toward wet good health almost overnight.

Survival Depends on Pools

How is this possible? Many other areas would require years to recover from such a drought. In the Everglades, however, life has a "secret weapon." Because water can dissolve limestone, there are many holes in the otherwise flat rock. The holes may be no more than a few feet deep, but they hold water when the rest of the area is dry.

Without these holes, there would be no wet places during the dry season. Then the animals of the Everglades would be quite different and probably not as plentiful. These pools, especially the deeper ones, contain millions of frogs' eggs, tiny fishes, and insect larvae. The ponds are like giant seeds that bloom with life when the rains come.

Let's take a look at the Everglades as they endure the hot, dry winter months of the yearly cycle. As the water begins to drop during the fall, the tree clumps and higher grassy areas dry out first. Many tiny plants and animals are trapped in pools that dry out. Usually, these organisms are food for small fish, which are food for larger fish, which are food for the mammals, reptiles, and birds. This is a *food chain.* When the tiny plants and animals die, animals all along the food chain are affected.

The drought usually begins to spread to the shallow open areas by winter or early spring. Many of the small mosquito fish, killifish, mollies, sunfish, largemouth bass, and gars (the main diet of alligators) are left high and dry. Others make their way to the ponds or one of the main sloughs (pronounced "slows"), which are like the channels of a river. Frogs, newts, and crayfish that cannot reach a pool seek safety in deep mud burrows. Here they wait, barely alive, for the water to come again.

The larger animals roam far and wide searching for a water hole that has not gone dry. Alligators may move several miles; birds, 40 or 50 miles. The larger members of the food chain begin to cluster around the water holes: Alligators and otters, bobcats and raccoons, white-tailed deer and marsh rabbits, ibises, herons, egrets, anhingas, ducks, snakes, and black bear gather and become "neighbors." They prey on the fish in the pools—and sometimes on each other. The larger fish travel where they can, sometimes meeting salty water that seeps into the Everglades from the ocean. When this happens, fish that are used to life in fresh water may die off in great numbers.

As the water level drops in the River of Grass, the amount of oxygen in the water also decreases. Carbon dioxide gas in the water increases. The water animals may not be able to get enough oxygen. Remember though, droughts have affected the Everglades for thousands of years. During that time, different kinds *(species)* of animals and plants have gradually developed ways of surviving the droughts. Many species of fish, for example, have developed the ability to gulp oxygen above the surface of the water. Some of them, such as killifish, catfish, and gar, can live for long periods in mud without any water at all. In one experiment in Miami, a biologist put a 10-inch gar in a tank without food or running water. As the weeks and months passed, the tank became filthy with wastes and algae. The fish began gulping air. It continued to live in this way for an almost unbelievable 354 days—nearly a year!

Dividing up the Water

Biologist William Robertson, one of the rangers working in Everglades National Park, says that he has rarely seen any of the large mammals, birds, or reptiles die as a result of drought. But he and other conservationists are worried about the effects of what man has done to the park. Since the natural flow from the north has been controlled for human use, even the water holes may not be enough to help the life of the Everglades through drought. As Mr. Robertson says, "To stop the normal flow puts things in an entirely new light. We used to get water free. Now we are going to have to bargain for it."

About 44 per cent of what used to be wild grassland has either been drained or will be drained for farms and houses. Another 49 per cent has been set aside as a water storage area for Florida cities and crops. Only 7 per cent has been reserved for wildlife. Even this area—which includes Everglades National Park—depends on political agreements for its water.

This is not the most reliable way to get water. In 1965, during one of the most severe droughts in the history of the park, only 140 acre-feet of water were allowed past the Tamiami Trail in April. (An acre-foot is an acre of water a foot deep.) At the same time, officials dumped more than 280,000 acre-feet into canals leading to the sea because Lake Okeechobee had to be lowered to get ready for the coming rains so it would not flood the farmlands around it. This wasted fresh water would have been almost enough for the park for a whole year.

In the seven years that the dam along the Tamiami Trail has been completed, there have been three unusually long droughts in the park, and there will probably be more. Unless man decides to do something about this system, he may cause more damage to the Everglades than all the natural droughts of the last 50 centuries ■

Symbol of the Everglades, the alligator *(left)* can survive in pools of water during the dry season. Birds such as the red-shouldered hawk *(right)* and the anhinga *(lower left)* may have to fly long distances to find food during the drought. The anhinga, or snake-bird, can swim underwater and is shown drying its wings.

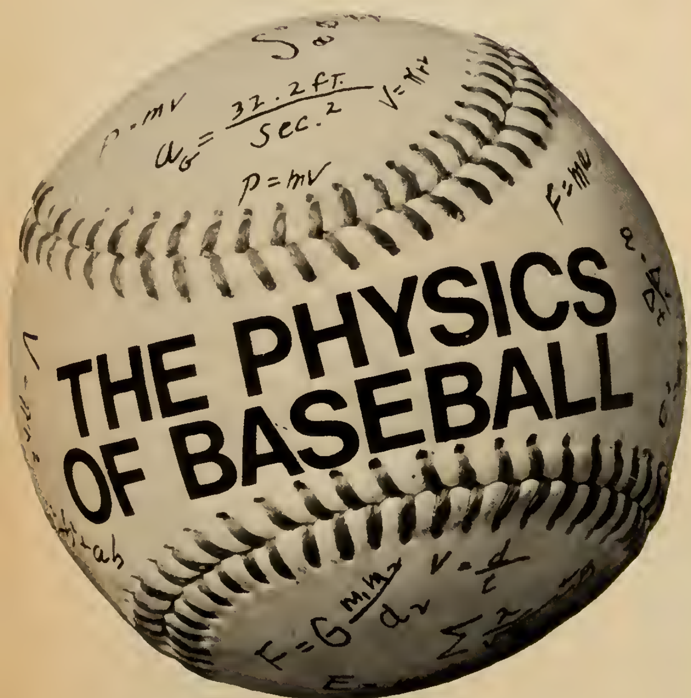
ANSWERS TO BRAIN-BOOSTERS IN THIS ISSUE

Mystery Photo: The filament in the bulb is a better conductor of electricity (see *"Bulbs and Batteries," N&S, March 4, 1968*) than faucet water is, so most of the current flows through the bulb. Unless *all* the impurities have been removed from water, however, it does conduct electricity, so *never touch an electric switch or appliance when any part of your body is wet!*

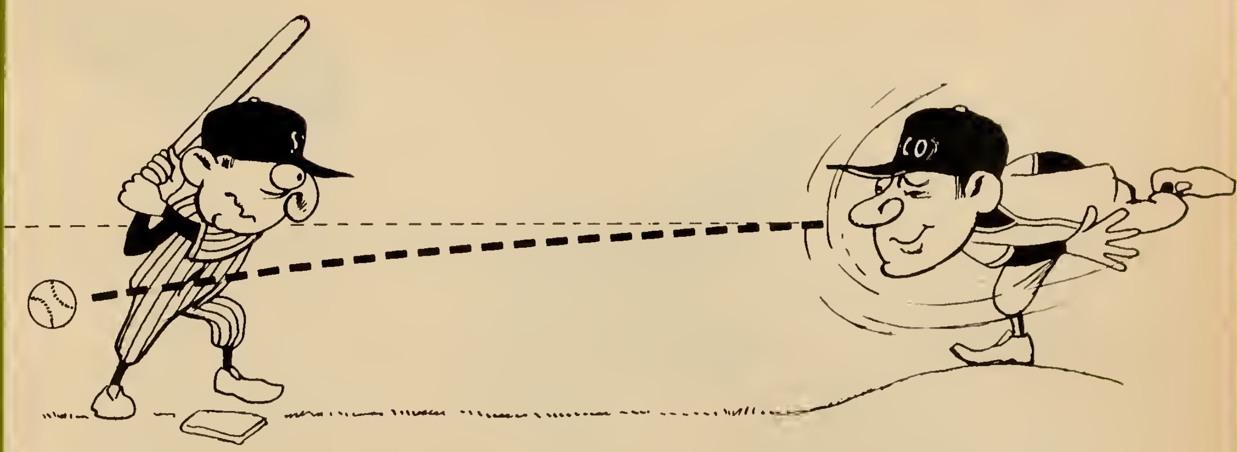
Can you do it? If you are strong, you can pick up a chair by lifting at the bottom of one leg with just one hand. Grip one of the back legs and lift the other three legs a little off the floor. Then quickly lift the chair, keeping the leg you are holding lower than the other legs.

Fun with numbers and shapes: Car A took 3 hours to go 120 miles at 40 miles per hour, and another 1½ hours to go the remaining 120 miles at 80 miles per hour. Car B, however, took only 4 hours to cover the 240 miles at 60 miles per hour.

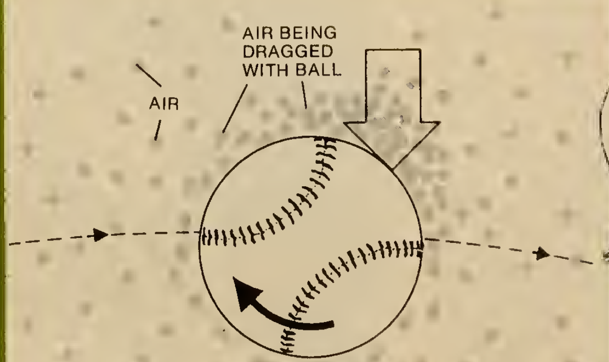
For science experts only: Symbols like the one shown



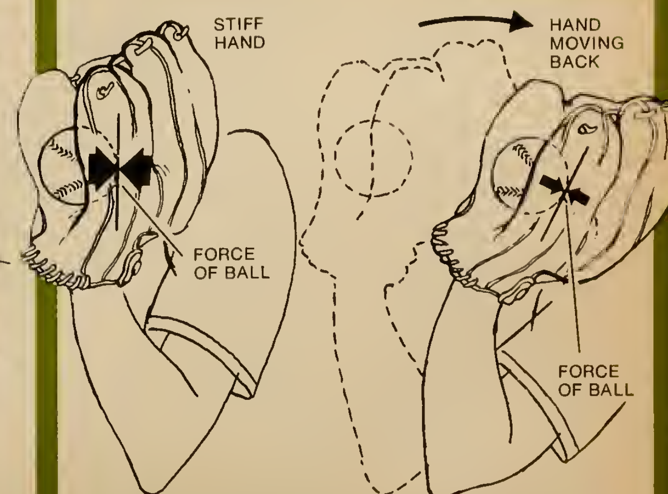
■ **When you go to a baseball game, you probably take along such things as pennants, candy bars, and a few friends. Chances are that a physical scientist going to a ball game would**



As soon as a baseball leaves the pitcher's hand, gravity begins pulling it downward. Even a fast ball will drop about 2½ feet by the time it reaches the batter. That's why the pitcher's mound is built up 15 inches higher than home plate, and why a good pitcher always aims the ball a little higher than where he actually wants it to cross the plate. (In a softball game, should the pitcher's mound be higher than home plate? Why?)



When a pitcher throws a curve ball, he gives it some extra spin. The diagram shows a bird's-eye view of the spinning ball and the surrounding air. The surface of the spinning ball drags a little air around with it, and the air that it drags forward on one side of the ball piles into the air just ahead of the ball *(see diagram)*. This pile-up of air tends to push the ball away, toward the side of the ball where the air is being dragged backward instead of forward.



Watch the shortstop catch a line drive, and see how his arm moves back a little with the ball. If the ball is hit very hard, his whole body may move back a little. Letting his arm or body "give" spreads the force of the ball striking the shortstop's glove over a longer time, and over a greater mass (his whole arm or body) than stopping the ball with a stiff hand would. So his hand feels less shock.

bring along pencil, paper, and slide rule, and tell you quite a few things about the game that neither you nor the players probably knew before.

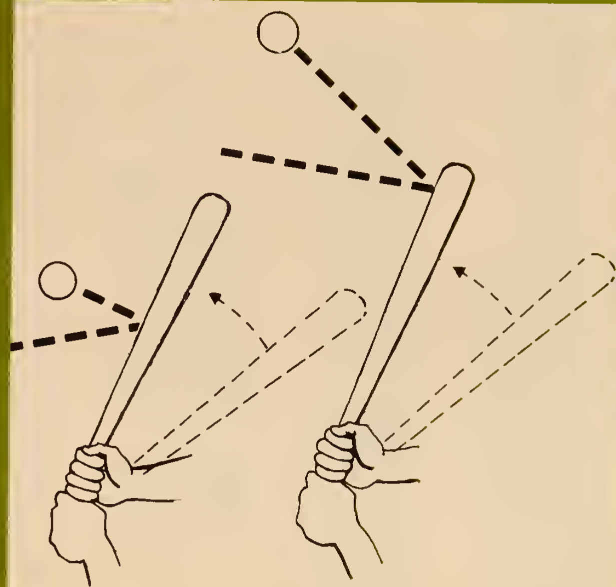
What the physicist could tell you is how physical "laws" help determine what happens on the ball field. Regardless of who the players are or which team he wants to win, the physicist knows that certain things must happen whenever a ball is hit, thrown, or caught, or whenever a player is moving on the field.

This doesn't mean that you have to know physics to play baseball well, or that a physicist could play baseball any better than someone else. But knowing a little more about how things happen during the game probably helps the physicist to enjoy it a little more. Maybe these examples of the physics of baseball will help you to enjoy the game a little more, too ■

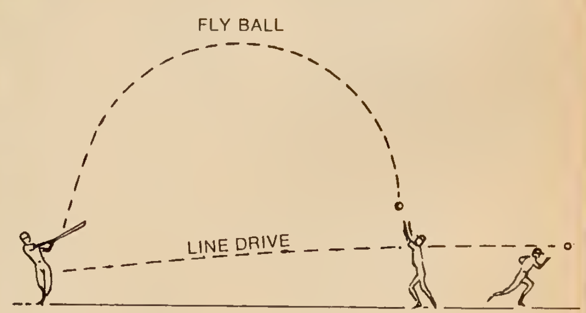
Adapted by permission of G. P. Putnam's Sons from Baseball-istics *by Robert Froman. Copyright © 1967 by Robert Froman.*

Sportscasters talk about a runner's "rounding" the bases because that's just what he does. *Inertia* tends to make a moving object keep going in a straight line. In order to make a sharp turn at each base, a runner would have to stop, turn, then start again. There's no time for that, so the runner follows a curved path around the base while keeping most of his speed.

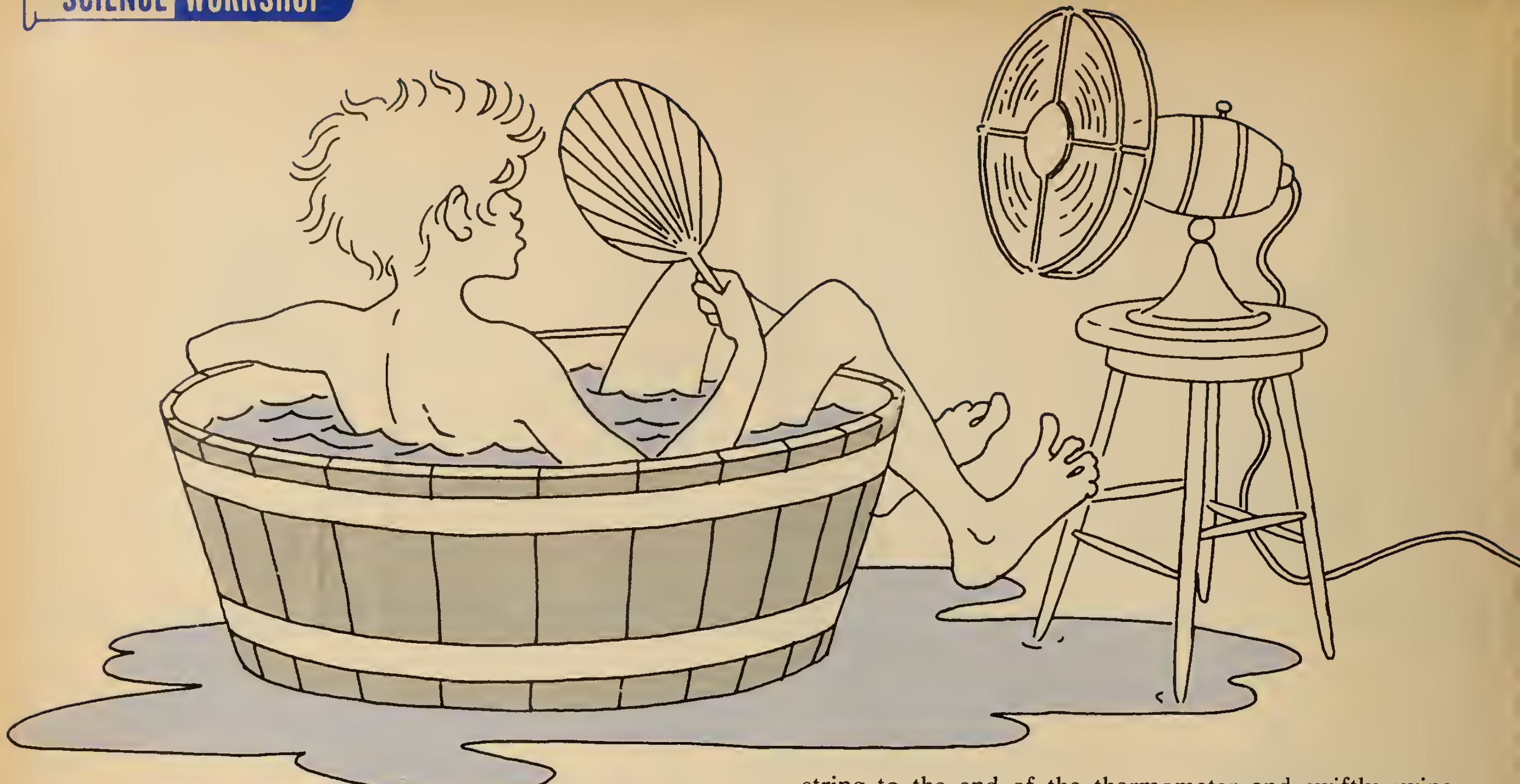
When a runner slides into second base, do you think he's doing it so he can get to the base faster? Sliding may help him to avoid being tagged by the second baseman, but its main purpose is usually to slow the runner down. The runner uses *friction* between the ground and his clothes or body to reduce his speed and help keep him from going past the base.



If a batter hits a ball squarely near the heavy end of his bat, the ball will fly off faster than if it is hit squarely at the middle of the bat. Can you figure out why?



A fly ball is usually easier to catch than a line drive. A lot of the energy given to a fly ball by the bat is used up in making the ball go high into the air against the force of gravity. So the ball doesn't travel as fast or as far from the plate as a line drive hit with the same force. By the time the ball comes down, the outfielder may be waiting for it.



KEEPING COOL

Find out what makes moving air feel cooler than still air, and you can make a simple, inexpensive air conditioner.

■ On a summer day when you feel uncomfortably hot and you don't have an electric air conditioner to pump heat out of the air around you, what can you do to cool off?

Since moving air makes your skin feel cooler, you might look first for a breezy place outdoors or a drafty place indoors. Or you can make a breeze by fanning yourself with a folded newspaper or an electric fan. If you are in a moving car or bus, you can open a window to let air flow over you. When the air stops moving across your skin, though, the cooling stops, too. Do you think that air is cooler when it is moving than when it is still?

You can find out by using an inexpensive alcohol or mercury thermometer. Note the temperature shown by the thermometer in still air, then hold it in the breeze from an electric fan. If you don't have an electric fan, just tie a string to the end of the thermometer and swiftly swing it around in circles through the air. Does the temperature go up, or down, or stay the same? Do you think that moving air alone cools your skin?

The Water Treatment

Another way to cool off is to go swimming, take a shower, or wet your skin in the spray from a hose or sprinkler. If the water is cooler than your body, some of your body heat will be used up in heating the water on your skin. You may have noticed that when your skin is wet, a breeze sometimes cools it so much that you get a chill. Do you think this would happen if the water were warmer than your body to begin with?

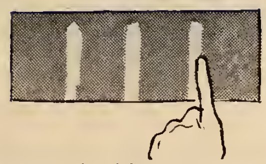
Spread some lukewarm water (warm to your touch) on the palm of one hand, keeping the other hand dry. Swing both hands through the air swiftly in large circles. Which palm feels cooler?

Use your thermometer to find out whether moving air really changes the temperature of a moist object. Soak a strip of thin cloth in lukewarm water and wrap it around the bottom of the thermometer. Wait for the liquid in the thermometer tube to stop moving. Note the temperature, then hold the wrapped thermometer in the breeze from a fan or whirl it around through the air on a string for a few minutes. What happens to the temperature? Does the cloth feel as wet as it did before the air moved across it?

You might think that the moving air simply blew the water out of the cloth. It probably did blow off a few drops, but it also carried away many particles of water too tiny for you to see. The tiniest particles of any substance are called *molecules,* and they are always moving around in the substance. In a liquid, some of the fastest-moving molecules are always escaping from the surface of the liquid to become a gas. If the gas can move away from the liquid, the liquid slowly disappears. This is called *evaporation.* Since the *fastest-moving* molecules in a liquid are also the *warmest* ones, the liquid tends to get cooler as they escape from it.

Do you think that moving air across the surface of a liquid makes it evaporate faster? If so, why?

PROJECT



Make some streaks of water, rubbing alcohol, and cooking oil side by side on a strip of aluminum foil (see *diagram*). Make the streaks all the same size. Which liquid evaporates first? Which stays the longest? Can you predict from your findings which liquid will produce the greatest cooling effect in moving air? You can compare their cooling effects by rubbing one liquid on each palm and swinging your hands in wide circles, or by using your thermometer with strips of cloth dipped in the different liquids.

Homemade Air Conditioners

In parts of the world where the air gets very warm and few if any people have electric air conditioners, the cooling effect of evaporating water is put to work. The photograph above shows the windows outside a classroom at the Regional College of Education in Ajmer, India.

Some Things To Think about and Look for

1. Why is it helpful to perspire on hot days?
2. How do animals that have few sweat glands, such as dogs, keep cool on a hot day?
3. Under what conditions will clothes dry fastest on a clothesline?
4. How does the water that falls as rain get into the air?
5. If a fan does not cool the air, why does it make you feel cooler?
6. Can you explain why open bottles of water and alcohol have the same temperature even though alcohol evaporates faster?
7. After a rain, look for some puddles around your house. Can you predict which ones will disappear fastest? Will it matter whether they are in the sun or shade? How about those that are protected from the wind and those that aren't? Will wide shallow ones evaporate faster or slower than narrow deep ones?

The straw panel covering the righthand window of this building in India is soaked with water every hour or so, during the day. Can you guess why?

One window is covered with a panel made of straw. The straw is soaked with water every hour or so. This lowers the temperature in the classroom—which might be well over 100 degrees Fahrenheit—to a more comfortable level.

Can you explain how it works? If you used one in your house, in which window would you put it? What would you do when the wind changed direction?

You can see how such air conditioners work without making such a big one. Find the temperature of the air in your kitchen, or outside near a clothesline if the wind is blowing. If you do the experiment inside, you can use a strong fan to make a wind. Hang some wet straw, hay, newspaper, or cloth strips in front of the fan or on the

clothesline. Leave a little space between the wet strips so the air can get through. What happens to the temperature of the air as it passes through the wet material? Would the air conditioner work better if you used alcohol instead of water? How about cooking oil?—ROBERT GARDNER

PROJECT

See if you can design experiments to find out how each of the following factors affects the speed at which a liquid evaporates:

Temperature	Amount of liquid exposed to the air
Movement of air (wind)	Kind of liquid
Humidity (moisture in the air)	

Remember that you will need at least two set-ups in each experiment so you can compare the results. For example, to test the effect of air movement, you could place some liquid in front of a fan and an equal amount in another place where the temperature and humidity were the same, but there was no wind.

Many fish play follow-the-leader for most of their lives. Why and how they do it are parts of . . .

The Great Fish Schooling Puzzle

by Steven Morris

■ An airplane pilot flying over the ocean spotted what looked like a grey cloud moving under the surface of the water. As the "cloud" moved, it turned, speeded up, slowed down, but never broke apart.

Later, a fishing ship dropped nets around the "cloud," and hauled up hundreds of tuna.

These were members of a fish *school*—a group that always travels together. All the fish in the school were the same kind and about the same size. While swimming, they all stayed near each other, and the distance between them changed very little.

Thousands of kinds *(species)* of fish—large and small, fresh-water and salt-water—spend their lives in schools. Some schools may have a million fish, others only a few. How do so many fish travel through the ocean without bumping into each other? How do they stay together? These questions are part of the mystery of fish schooling.

Dr. Evelyn Shaw, a scientist at The American Museum of Natural History who studies the lives of animals, tried to discover at what age fish first form schools. One summer when she was working at Woods Hole Oceanographic Institute on Cape Cod, in Massachusetts, she began watching the young fish that stayed in the shallow waters near shore. She could see that many of them *schooled*, or swam together. But she could not tell when they first began schooling, because the youngest fish were too small to be seen among the other animals and plants. She would have to continue her investigation in the laboratory.

Dr. Shaw kept eggs of some silversides fish in a laboratory. After they hatched she watched the young fish swim in a doughnut-shaped tank with a space three inches wide for them to swim in *(see diagram)*. A one-way mirror was around the tank so that the fish couldn't see out, but Dr. Shaw could see in.

Too Young for Schooling

The tiny, newly-hatched silversides did not school. Often one of the tiny fish would swim toward another's head or tail, but when it got to within about a fifth of an inch it would suddenly turn and dart away. After a while, when the fish had grown to about one-third of an inch, one *fry* (very young fish) might swim near the tail of another, and they would swim along in the same direction for a second or two. But if they approached head to head or at an angle, each would dart off fast in the opposite direction.

Soon there came a time when the fry would never approach head to head, but only head to tail; then they would swim in the same direction for five or 10 seconds. When they got a little bigger they took on a new habit. A fry would approach the tail of another and both would vibrate their whole bodies briefly from side to side. Then the two would swim off, one a little behind and to the side of the other, for half a minute to a minute. Sometimes three or four others would join them, forming a small school. When the fry grew a little more, the size of the schools also grew to 10 or so fish.

Dr. Shaw suggests that this early schooling may be due partly to the way fry look to each other. As one fry approaches another head-on, it sees an oval mass (the head) and bright black spots (the eyes) getting bigger and bigger. The startled fry swims away fast. But when a fry approaches the tail of another fry, it sees a less frightening pattern: a small silvery stripe and a transparent tail, swishing gently back and forth. The fry follows this object. The leading fry may see, out of the rear of its eye, only a shadowy picture of the follower. Neither becomes startled or tries to get away.

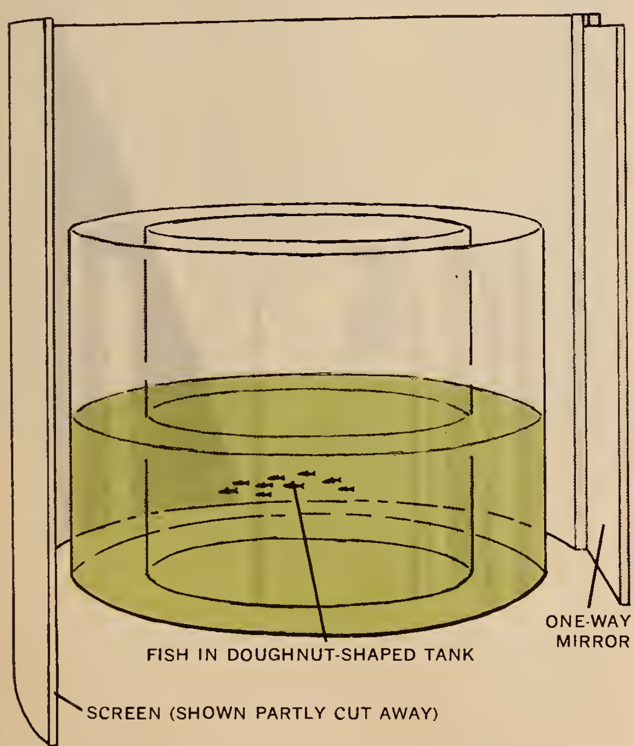
At first these early schools were ragged. Sometimes fry would be a third of an inch apart, at other times more than an inch. But as the fish grew, the spacing in their schools evened out, and there was less shifting about in the school.

How Fish See To School

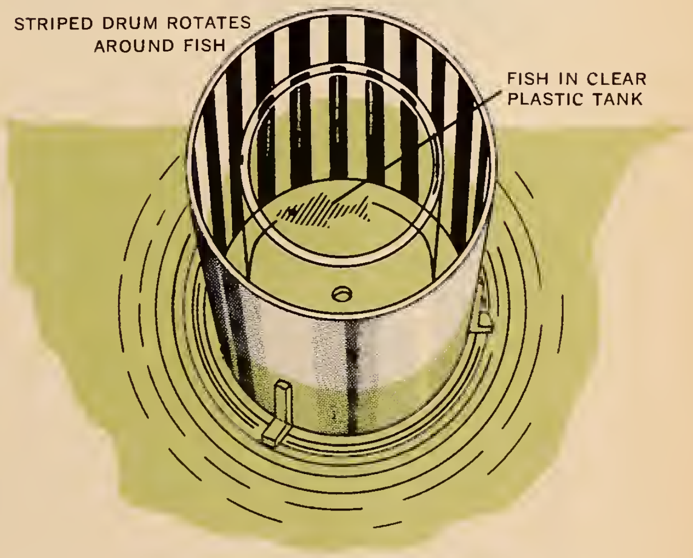
To find out if fish really use their eyes to find out where to swim, when to turn, and in what direction, here is what Dr. Shaw did. She would put a single fry in a narrow glass tube, and put the tube in the same tank with a fry that could swim around freely. The freely swimming fry could see the caged one, but it could not smell or hear it or find it in any other way.

If the free-swimming fry was below the age at which fry ordinarily school, it did not go near the caged fish. But when Dr. Shaw put caged fry in with fry that had just recently reached schooling size, the free-swimming fry would approach the tube and swim alongside the caged fry for two or three seconds. If the free-swimming fry was older, it kept swimming alongside the caged fish for up to a minute before wandering off.

This experiment showed that sight is important for schooling, but it seems that sight is not enough. It may be that some signal from the caged fish—such as vibrations—is needed to *keep* the other fish swimming alongside it. The caged fish couldn't give this signal through the glass.



Dr. Shaw used a tank like this to study fish schooling. The fish swam around the center of the "doughnut," and Dr. Shaw could watch them through the mirror.



Other experiments showed that if two fish are blinded in different eyes, they will swim aimlessly when their sightless eyes are turned toward each other. But they will school if they approach each other from the side of their "good" eyes. Fish that are blind in both eyes never school.

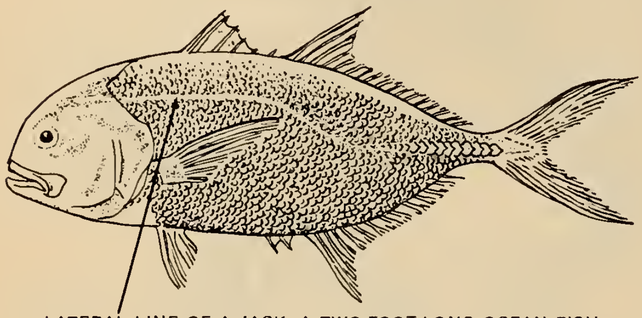
Could it be that movement alone is enough to start a fish schooling? Dr. Shaw put fish into an aquarium that had a striped drum rotating outside it *(see diagram)*. She saw that when the drum stood still the fish swam about aimlessly. But when the drum turned, the stripes moved, and the fish swam in the direction the stripes were moving. The faster the drum moved, the faster the fish swam. They seemed to try to keep up with the moving stripes.

No scientist has come up with evidence that hearing or smell helps schooling, Dr. Shaw said. But she pointed out that fish have one detection system that humans don't have.

(Continued on the next page)

The *lateral line* is a set of long nerves that runs from head to tail along each side of a fish and around the head *(see diagram)*. "We think these nerves feel small movements of the water," Dr. Shaw said. "It may be that the lateral line helps keep the fish in the school at a certain distance from each other."

Dr. Shaw said fish that spend their early lives with other fish always seem to start schooling at about the same age. But she wondered whether a fish that had never seen another fish would know how to school. To find out, she



LATERAL LINE OF A JACK, A TWO-FOOT-LONG OCEAN FISH

raised a lot of fish in separate containers, one fish to each, then put them in with schooling fish. She tried raising 400 silversides in this way, but a strange thing happened. Only four of these silversides lived long enough to grow up.

"We never saw the others eat," Dr. Shaw said. "We think they starved to death."

When the four that lived were put in aquariums with other fish, they joined the schools right away. But they bumped into the other fish, and sometimes swam away from the school. After four hours, though, they were so good at schooling that you could not tell them from the fish that had lived with others all their lives.

Does Schooling Help Fishes Survive?

Scientists have often found that the ways of behaving that have become common among animals of a species are those that give that kind of animal the best chance of surviving. With this in mind, scientists have tried to figure out how schooling may help a species of fish to survive.

One idea is that the presence of so many fish in a school confuses a bigger fish so much that it doesn't capture and eat as many of the smaller fish as it would if there were fewer of them. Experiments with goldfish seem to back this up. When many water fleas (tiny shrimp-like animals) are put into their tank, goldfish attack them wildly, but capture and eat fewer of the water fleas than when a smaller number are put into the tank. On the other hand, many *predatory* fishes (that eat other fish) also travel in schools, and Dr. Shaw doubts that this kind of protection is important for them.

Another possible clue is the fact that so many of the fish that Dr. Shaw tried to raise in individual tanks died. Aquarium keepers know that a fish that doesn't eat can often be coaxed to feed if some other fish are eating near it. And fish that feed in the company of others seem to grow better. But Dr. Shaw doesn't believe this explains why so many kinds of fish school. After all, she said, many fish that do not school also eat and grow well.

Most schooling fish do not have to find and attract mates. They simply shed their eggs and sperm by the millions in the water at the same time and swim away. When a sperm from a male meets an egg from a female, a new fish forms. This seems like a good explanation for fish staying together, but Dr. Shaw has found some schools in the ocean that are made up only of males or of females.

There are many ideas about why fish school, and many of them may be at least partly correct. Dr. Shaw's next project will be to test one of the newer ideas. Some scientists have suggested that schooling helps fish move through the water. Perhaps the lead fish stir up the water so that it is easier for the fish behind them to push through.

Dr. Shaw believes that one way to find out how much energy fish use in swimming and other activities is to measure the amount of oxygen they use. She plans to put

Sometimes Dr. Evelyn Shaw uses scuba equipment to observe fish schools in the ocean. Most of her studies are done in laboratories at The American Museum of Natural History.

fish in tanks with water that has as much oxygen dissolved in it as it can hold. After a while she will measure how much oxygen is left in each tank. In this way, Dr. Shaw may be able to discover whether a fish swims with less effort in a school than when swimming alone. Whatever she finds out, however, there will still be plenty of questions about the schooling of fishes for interested students to explore ■

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WHAT'S NEW

by
Roger George

If there's life anywhere in our solar system besides the earth, the likeliest place is Mars. Not that Mars offers ideal living conditions. It's a cold, dry planet with a thin atmosphere that contains little oxygen. But some scientists believe that certain living things could survive in the harsh environment.

Recently, scientists of the National Aeronautics and Space Administration created a miniature version of Mars in a laboratory. They tried to imitate the conditions believed to exist on the "red planet." Simple forms of life from the harshest environments on earth—polar regions, deserts, volcanic craters, mountain tops—were then tested under these conditions. Dozens of kinds *(species)* of bacteria, several types of fungi, and many microscopic desert organisms were able to survive. This suggests that some living things may be able to exist on Mars.

Pollution is a problem in the Soviet Union as well as in the United States. Soviet scientists are especially upset by what's happening to Lake Baikal, in Siberia. The world's deepest freshwater lake, Baikal is more than a mile deep in some places. Its cold, mineral-free water is the home of many animals and plants that are found nowhere else. These living things are now threatened by pollution. Wood pulp, used in making paper, is produced near the lake, and wastes from the process are dumped into the water.

Russian scientists want the dumping stopped before the lake is badly polluted and its animals and plants destroyed. But to pipe the wastes elsewhere would cost a lot of money. So Russian scientists are gloomy about the future of Lake Baikal. They know, as do many American scientists, that conservation often takes a "back seat" when a lot of money is at stake—whether it's American dollars or Russian rubles.

If a rattlesnake strikes itself by mistake, will it die from its own poison? It might, writes Dr. E. M. Reilly, Jr., in *The Conservationist.* Rattlesnakes have some resistance to their own poison, but large doses of it can kill them.

A snake that accidentally bites itself might let go, though, before it pumps a full dose of poison through its fangs. In that case, the snake might live. Its ability to survive would also depend on the strength of the poison, and on the size and general health of the snake.

Lights on the earth have been photographed from the moon, a quarter of a million miles away. A photograph was taken by a television camera aboard the Surveyor 7 spacecraft. The two lights photographed were a powerful form of light called *laser* beams. The beams were shone toward the moon through telescopes 500 miles apart—one at Table Mountain Observatory in California, and the other at Kitt Peak National Observatory in Arizona.

Tourists share the blame for the wearing away of some coral reefs off northeastern Australia. The tourists aren't damaging the coral directly. They are collecting large sea snails called *tritons,* which are valued for their beautiful spiral shells. Australian scientists explain why collecting the shells is harmful to the reefs:

Triton snails eat starfish. Some of the starfish eat coral polyps, the tiny animals that build coral reefs. When tritons are taken from the reefs, more starfish survive to eat the coral polyps. As a result, there are not enough polyps to replace the coral that is worn away from the reefs by the ocean water. Thus the tourists, who come to admire the Australian coral reefs, are helping to destroy them.

Nothing has worked very well in the battle to save the American elm tree. American elms have been killed off in large numbers by the Dutch elm disease. First observed in Holland, the disease is caused by a fungus that is carried from tree to tree by bark beetles.

Now scientists have a new weapon: a tiny wasp. The wasp has been brought to the United States from Europe, where it has saved most of the elms from the disease. The wasp lays its eggs in the bark of an elm tree near the larvae (young) of the bark beetle. After hatching from the eggs, the wasp larvae feed on the juices of the much larger beetle larvae, eventually killing them. The wasps reproduce three times as often as the bark beetles, and their larvae depend solely on bark-beetle larvae for food. Early tests show that these wasps are a promising weapon against the Dutch elm disease in the United States.

The world's largest hovercraft, or air-cushion vehicle, has a test run in the ocean off England. High-pressure jets of air forced downward from the underside of the craft keep it skimming just above the surface of the water. Built by the British Hovercraft Corporation, the craft will soon carry 250 passengers and 30 cars at a time across the English Channel. The huge propellers that push the vehicle forward can also be turned from side to side to help steer the vehicle.

Using This Issue...
(continued from page 2T)

page 11). Their findings, thoughts, and plans for investigations can then be compared and evaluated in class discussion.

Topics for Class Discussion

• *Why does evaporation from the surface of a liquid lower the temperature at that surface?* As explained in the article, the molecules of a liquid that escape into the air from the surface are the ones that move around fastest because they are the warmest molecules in the liquid; the molecules left behind are the cooler, less active molecules. Point out that adding heat to a liquid speeds up the motion of all of its molecules, making them bump into each other more often and fly farther apart when they collide *(see "How Hot Can It Get?",* N&S, *Dec. 6, 1965).*

When the molecules that escape into the air can move away, the liquid slowly disappears, or evaporates. In a thermometer, the liquid is sealed inside a tube, so the molecules cannot escape. Instead, when heat speeds up the collision of the molecules and makes them bounce farther apart, the liquid expands, or spreads out—in this case, rising up the tube.

• *Where does the heat that causes evaporation come from, and what happens to it?* The air touching the surface of a liquid supplies heat energy that helps cause evaporation. This heat energy is changed into *kinetic* energy, or "energy of motion" as it makes the molecules at the surface of the liquid move around faster. When air is moving swiftly across the surface of the liquid, the air that has lost heat to the water at the point of evaporation is continually being replaced by more warm air, making the liquid evaporate faster than when the air is still.

• *Why is it helpful to perspire on hot days?* Your pupils can probably guess that the evaporation of moisture emitted from their sweat glands cools the skin, and to some extent, the body itself. *Why is it helpful to wear clothing made of loosely woven materials in the summer?* Air can circulate more freely through such garments, speeding up the evaporation of perspiration from the skin. *Why are people with high fevers sometimes given an alcohol rubdown?* Your pupils have probably discovered that alcohol evaporates faster than water, producing an even greater cooling effect.

• *How do animals that have few sweat glands, such as dogs, keep cool on a hot day?* Perspiration through their tongues removes some body heat, and a coat of fur helps insulate their bodies from heat in the air around them. They also drink a lot of water if it is available, and avoid moving around any more than necessary.

• *Why do open bottles of water and alcohol have the same temperatures even though the alcohol evaporates faster?* The cooling effect is found at the surface where the evaporation is taking place; the rest of each liquid is kept at room temperature by the air around the bottles.

Investigations

Here are some ways to find out how various factors affect the rate of evaporation *(Project, page 11).*

• *Temperature.* Use two pie tins of the same size. Heat one on a hot plate or heated radiator a few minutes, then add the same number of drops of water to each tin. (The water in the heated tin will evaporate first.)

• *Movement of air. (See Project.)*

• *Humidity* (moisture in air). Place an equal number of drops of water in two glass pie plates at the same temperature. Soak a paper towel in water, squeeze it until no water is dripping, then stretch it across the top of one of the plates and fasten it with paperclips. Place a dry paper towel over the other plate as a control. When the water has evaporated from the "dry" plate, some water will be left in the "wet" one. Moisture evaporating from the wet cloth makes moist, or *humid*, air collect under the cloth, slowing down the evaporation of the water drops. (Ask your pupils whether they think a wet-straw air conditioner *(page 13)* would work well in a humid climate.)

• *Amount of liquid exposed to air.* Pour equal amounts of water into a bottle and a wide-mouthed jar. Let them stand uncovered, overnight, then measure the amount of water left in each container.

• *Kind of liquid.* The Project on page 10 shows how to do this.

Brain-Boosters

Because this is the final issue of the school year, the answers to Brain-Boosters in this issue are printed on page 7 of the student's edition. Occasionally we are asked why this is not done throughout the school year. We believe that the ready availability of answers tends to discourage the reader from investigating and thinking to find the answers for himself.

This year, for the first time, we have been publishing the answers here in the accompanying Teacher's Edition, together with ideas for classroom use suggested by David Webster, "Mr. Brain-Booster" himself. Have you found them helpful?

Mystery Photo. If your pupils try this, using dry cells connected in series, as shown in the photo, they may be able to see the light dim very slightly when it is placed in the water, indicating that a little current is taking the short route through the water between the two bared wires.

Emphasize to your pupils that faucet water contains impurities that enable it to conduct electric current, particularly when the "electrical pressure," or *voltage*, is high. People have been electrocuted in the bathtub when they tried to switch on a light, or a radio fell in the water, and the current flowed through the water to and from their bodies.

Fun with numbers and shapes. Some of your pupils may think that the race should end in a tie, because both cars seem to have an average speed of 60 miles per hour. But if you have someone figure out car A's average speed on the blackboard, the class will see that it is $\frac{240 \text{ miles}}{4.5 \text{ hours}} = 53\frac{1}{3}$ miles per hour.

For science experts only. Have your pupils bring in some weather maps from the newspapers and see whether they can find any of the symbols and learn what they mean.

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VOL. 5 NO. 17 / JULY 8, 1968

SPECIAL ISSUE

INVESTIGATING INSECTS AND THEIR WAYS

nature and science

VOL. 5 NO. 17 / JULY 8, 1968

CONTENTS

This special issue was prepared with the advice of Miss Alice Gray, Scientific Assistant in the Department of Entomology, The American Museum of Natural History.

PICTURE CREDITS: Cover, Jerome Wexler; pp. 2, 3, 5, 7, 10-12, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, top: Harry Beede, bottom: Annan Photo Features; p. 6, top: William J. Jahoda, bottom: N. E. Beck, Jr., both from National Audubon Society; p. 7, top photo: Dorothy Semorile, bottom photo: Louis Quitt, from National Audubon Society; pp. 8-9, bee by Lee Jenkins, fly mouth parts by N. E. Beck, Jr., butterfly by Ray Glover, mosquito by John Gerard, crickets by Hugh Spencer, fly wings and moth by G. T. Hillman, all from National Audubon Society; pp. 12-13, Margaret Anderson; pp. 14-15, photos 1 and 4 by N. E. Beck, Jr., photos 2 and 3 by Lynwood M. Chase, all from National Audubon Society.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITORS** R. J. Lefkowitz, Steven W. Morris; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen
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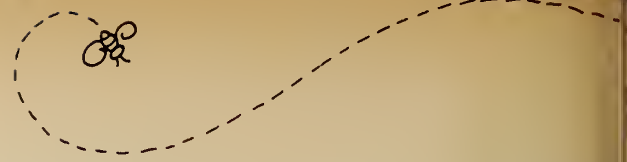
NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly October, December through April; monthly September, November, May and July (July special issue). Second Class postage paid at Garden City, N.Y. 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, N.Y. 10024.

SUBSCRIPTION PRICES In U.S.A. 95 cents per semester per pupil, $1.65 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 $4.95 per school year. Single copy 25 cents. Single subscription per calendar year (17 issues) $3.50, two years $6. In CANADA $1.05 per semester per pupil, $1.85 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition, $5.75 per school year. Single subscriptions per calendar year $4, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11531. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530



■ The best time to learn about insects is during the summer, when you can find a hundred kinds, even in a vacant city lot. You can enjoy exploring the small worlds of the insects, and possibly learn something about them that nobody knew before.

As an experienced scientist will tell you, an important part of a research project is choosing the right subject. It should be something you can investigate thoroughly in the time you have, and with the help and the equipment you can get without too much trouble and expense. Insects are so near at hand, so abundant, and so various, that anyone can find something about them to investigate with no equipment but a notebook and his own senses. The tools and equipment you'll need for many explorations and experiments are waiting in your kitchen, cellar, and garage.

Find a Question To Answer

The best way to find an insect project is to go where the insects are and watch them. Ask yourself questions about the things you see: "There is a bee in this flower. What is it doing here? Where will it go next? Does it visit only flowers of this one kind? How can it tell the difference between kinds of flowers? By their color? Their shape?

Looking for a Project?

Some schools require boys and girls to prepare a "science project" during the school year, when many kinds of insects aren't available. Perhaps you can arrange for your summer investigation of insects to be next winter's project. If so, be sure to plan your study, keep careful records, and collect all of the insects and other materials you'll need for a school "science project."

You might observe a single kind of plant, such as milkweed or goldenrod, to see what kinds of insects live on it.

Summer is the Time to Study Insects

by Alice Gray

You can find plenty of insects in either the country or the city. Using your own senses and some simple equipment, you can investigate their lives and perhaps discover something new to science.

Their scent? Can a bee see colors? Are they the same as the colors we see? Can it smell? Where is its 'nose'? How many flowers will a bee visit before going home? How heavy a load can it carry? Where is its home? Will it come back here to these same flowers again? How far can a bee fly? How fast? How does it find its way?"

Some questions you will not be able to answer. Others you can answer easily. When you have asked a question you would really like to answer and believe you can answer it by observation or experiment, you have found your research project.

The difference between insect watching and insect research is planning. An insect-watcher looks at everything, learns a little about a lot, and forgets most of it. A scientist decides in advance what he will look at and sticks to that. He learns a lot about one thing, and writes it all down so he can't forget it.

When you have chosen your project, set it down in the form of a question. Think how you can go about finding an answer, and write that down too. Then carry out your plan, and keep notes of everything you do and what you discover. In the end, either write out the answer to your original question or say that you have not been able to learn it. In either case, you will have found out something about insects and more about how to conduct an investigation. (You'll find suggestions for studying ants, mantises, and other insects elsewhere in this issue.)

Where Insects Live

Each kind of insect tends to live in a particular kind of place, or *habitat.* You might try to learn what kinds of insects you can expect to find in particular habitats. What lives under stones, on a lawn, in rotten logs, under a compost pile, in a cellar, on the banks of a pond, in the mud at the pond's bottom, in a forest clearing? When you have looked under a hundred stones and listed every creature you found there, stone 101 is not likely to cover many surprises. (The books listed at the end of this article will help you identify the insects you find.)

When you think you know what to expect in the various habitats near you, try looking in them at different times of day. Are the insects that visit a flower bed at sunrise the same as the ones you see there at mid-day? What insects are there at night? Take a flashlight and look. To list the hours during which various insects visit flowers would be a fine investigation.

Another good project would be to find out how many kinds of insects live on or near one kind of plant. Try to discover what each kind of insect does for its living. There will be the insects that eat various parts of the plant, insects that eat the plant-eaters, parasites that prey upon the others, and perhaps parasites of the parasites. There may be galls made by insects *(see "The Mysterious World*

(Continued on the next page)

Look for insects in such habitats as rotting logs. Besides insects, you may find spiders, sowbugs, and earthworms. Examine several logs. Do the kinds of animals vary with the amount of decay?

Time To Study Insects (continued)

of Plant Galls," N&S, February 5, 1968), and sometimes insects that simply use parts of the plant as shelters. To see them all, you will have to examine your plant often, at different times of day and throughout the summer, until the plant dies or frost puts an end to insect activity. Even a dead or dormant plant may attract insects not found there in its growing season.

Follow the Cycle of an Insect's Life

Perhaps you have already tried keeping an insect pet. To record the whole life cycle of an insect species is a fine research project. You can begin with insects at any stage of their life cycle *(see "How Insects Grow Up," page 5)* and follow them around to the same stage in the next generation.

To raise an insect from egg to adult, you must give its different stages the kind of food and living conditions that they would have in the wild.

Keep notes on the length of each stage and on the highest and lowest air temperature each day, because temperature has a great effect on the rate at which insects grow and on the length of their lives. (If you have many insects of the same kind you can try rearing some at each of several different temperatures and seeing the difference.) Keep notes on the sort of cage in which you keep your insects, what they eat, anything interesting that they may do, and the time of day at which such events as hatching, molting, and feeding take place. If possible, take photographs or draw pictures of the insect at its different stages of development, and of its activities.

Success in this project will depend upon your being able to supply your insects with the right kind of food and with a cage in which the temperature, humidity, light, and perhaps other conditions are like those of the animals' natural home. Be sure to note all of these things when you catch your insects.

Keeping your notes and records complete may be the hardest part of your project. It is so easy to put it off until you have forgotten just what you wanted to write down. It might be easier if you do not keep a notebook. Instead, write each observation on a 3-by-5-inch file card, dated and marked with a number that you assign to each species of insect. (The article on page 16 tells how to go about identifying insects.) Carry a supply of cards and a pencil in your pocket. When you get home, it will be simple to put each card with others of the same number in a file box. Then everything you have observed about each species you are studying will be together in one place.

The last step of any research project is to write a report telling what you investigated, how you went about it, and what you discovered. You can wait to do this until the season for field work is over, but don't neglect it altogether. It is one way in which you can both keep and share the discoveries you made during your investigations ■

■ For further help in investigating the lives of insects, look for these books in your library or bookstore: **The Question and Answer Book of Insects,** by Alice Gray, Golden Press, New York, 1963, 50 cents (paper); **Discovering Insects,** by Glenn Blough, McGraw-Hill Book Company, New York, 1967, $3.50. To identify insects, see: **Field Book of Insects,** by Frank Lutz, G. P. Putnam's Sons, New York, 1948, $4.50; **Insects,** a Golden Nature Guide, by Herbert Zim and Clarence Cottam, Golden Press, New York, 1951, $1 (paper); **The Insect Guide,** by Ralph Swain, Doubleday & Company, Inc., Garden City, New York, 1952, $4.95; **How To Know the Insects,** by H. E. Jaques, Wm. C. Brown Co., Dubuque, Iowa, 1947, $2.50.

How Insects Grow Up

■ A young insect is much smaller than an adult insect of the same kind. Sometimes, but not always, it is also very different in shape, lives in a different place, and eats different food.

For insects, a leathery skin takes the place of a skeleton of bones. The muscles are attached to the inside of it. An outside skeleton works best when it is like a suit of armor, made up of hard plates with joints between them. That is just what most insects have.

Insects Change Their Skins

A suit of armor doesn't stretch much. As the insect grows, a new and larger skin is formed beneath it—all wrinkled up with tiny folds to make it fit inside. Then the insect swallows a lot of air (or water, if it is a water insect) and blows itself up like a balloon. The old skin splits down the back. The insect then drags itself out of its old skin, and the new skin is stretched tight. This process of skin changing is called *molting,* and the skin which comes off is said to have been *cast.* Some insects molt only a few times in their lives; others as many as 20 times or more.

Female insects produce eggs. A few species carry the eggs inside their bodies until the eggs hatch, so that the young seem to be born, like puppies. Most kinds of insects lay their eggs where the young will find the right kind of food and a good place to live when they hatch out.

Most kinds of insects grow up in one of two ways. When they are hatched, the young of grasshoppers, cockroaches, stink-bugs, and many others look almost exactly like their parents, except that the young have no wings. The wings begin to show as little "pads" on the back when the insect has molted two or three times, and get bigger at every molt, reaching full size when the insect is mature.

Young insects like this are called *nymphs.* They live in the same places as their parents and eat the same kind of food. Scientists call this kind of growing-up *incomplete metamorphosis.* "Metamorphosis" is a Greek word that means "a change of shape."

Complete metamorphosis is the scientist's name for development like that of butterflies, beetles, flies, and many other insects whose young don't look anything like the parents. A young butterfly is a caterpillar. A young beetle is a grub. A young fly is a maggot. At this stage in their lives, the young are called *larvae.*

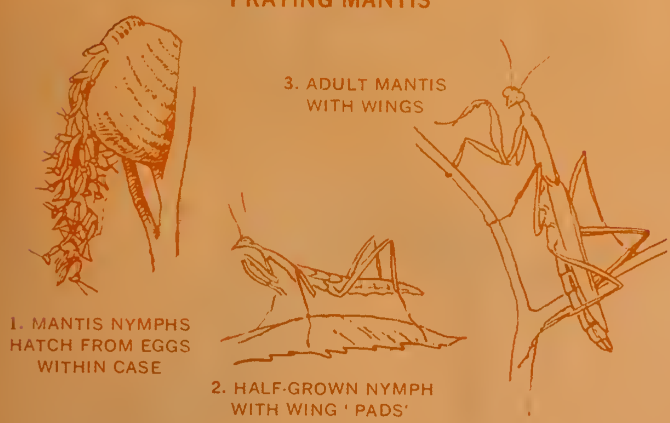
A larva may or may not live in the same place and eat the same food that the adult of the same insect eats. Ladybugs do; both stages live on plants where there are plenty of small, soft insects for them to eat. Butterflies don't. Almost all caterpillars eat leaves; the adults have mouths like sipping straws and can feed only on sap, juice, the nectar of flowers, and other liquids.

During the time an insect is changing from a larva into an adult, it takes still another shape—the *pupa.* If you have ever cut open a moth cocoon to look inside, you know what one pupa is like. A pupa cannot eat. It is almost always unable to move far or fast, so it is protected either by its color and form or by using a shelter, such as a cocoon or an underground cell.

—ALICE GRAY

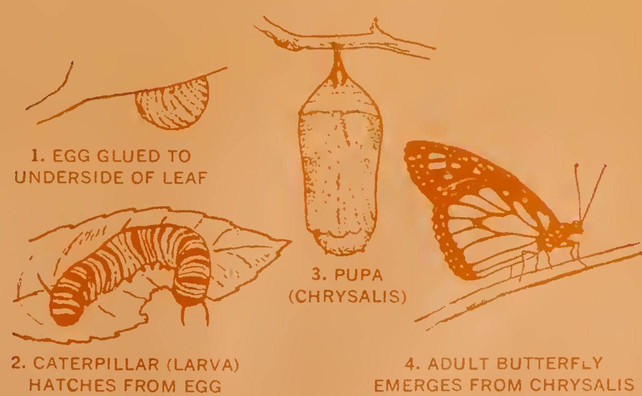
Incomplete Metamorphosis

PRAYING MANTIS



Complete Metamorphosis

MONARCH BUTTERFLY



That "Menace," the Mantis

by Dorothy Semorile

Of all the insects on earth, some of the most fascinating are the praying mantises, scarey-looking but harmless insects you can study this summer.

■ Some insects carry deadly diseases. Some can give you a painful sting. But insects that often frighten people more than dangerous kinds of insects do are a harmless group—the praying mantises.

These insects scare people because of their appearance *(see photos).* They have been called "garden dinosaurs." In one sense, they are like *Tyrannosaurus* and other meat-eating dinosaurs. Mantises are hunters to the insect world. Each mantis eats hundreds of insects during its life, which lasts only a few months.

Why a Mantis "Prays"

There are about 1,800 species of mantises in the world, and 19 in the United States. A common kind in some parts of the United States is the Chinese mantis, which may grow to be six inches long. Some other species are much smaller. In parts of the southern United States mantises are called "muleskinners." In Germany they are called "devil horses." Some people call them "saints," "rear horses," or "praying flowers." The Greeks called them "prophets."

The name "praying" mantis comes from the way that mantises often hold their powerful front legs *(see photo, right).* Actually, the spiny forelegs of a mantis are held this way to be ready to catch food. The other four legs are used for walking, climbing, and jumping. When disturbed, a mantis may flap its wings and rear up like a spirited horse. Mantises are probably the only insects that can turn their heads far enough to look over their shoulders.

Life for each mantis begins in the fall when an adult female lays about 200 eggs in a case that looks like a cocoon. Some autumn you may discover a female making her egg case. She starts by hanging upside-down on a branch about two feet from the ground. From the tip of her abdomen comes a sticky substance which she whips into a foamy froth. Weaving her tail back and forth, she deposits her eggs as she builds the case. It takes about an hour. Then the female walks off, leaving her family to fend for itself.

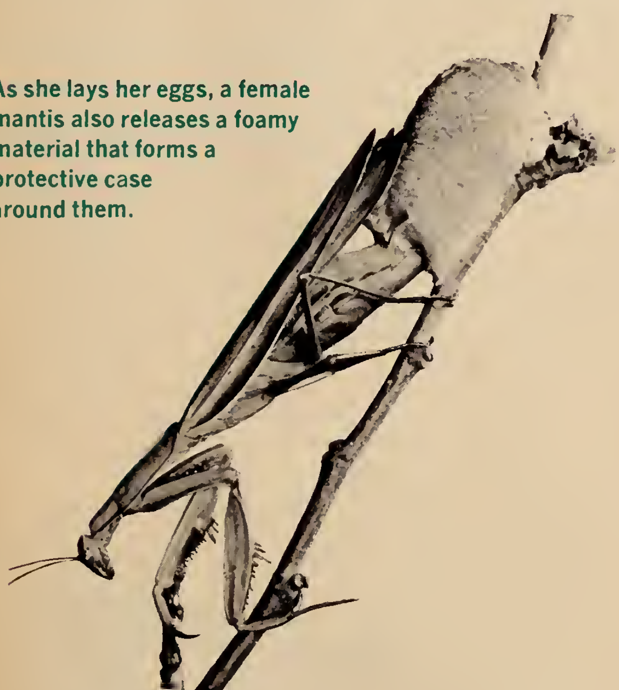
Mantises catch and hold food with their spiny forelegs. They eat many kinds of insects, including other mantises.

Claws on the tips of its legs enable a mantis to cling to the smooth skin of a girl's hand.

When the first cold days of winter arrive, the adult mantises die. The eggs survive in their insulated case. They hatch in the spring or early summer. Only a few of the young that hatch live to become adults. Many are eaten by birds, lizards, snakes, and other enemies.

How Many Molts to a Mantis?

You might try to trace the development of some mantises in your neighborhood. (You can usually find



As she lays her eggs, a female mantis also releases a foamy material that forms a protective case around them.

them in gardens or weedy fields.) Watch to see how they catch their food. You may find them on the same bush day after day for a week or more. Then they may disappear for a day or two. They haven't left. They've gone to a protected place to shed their outgrown skins. This is their *molting* time *(see "How Insects Grow Up," page 5)*.

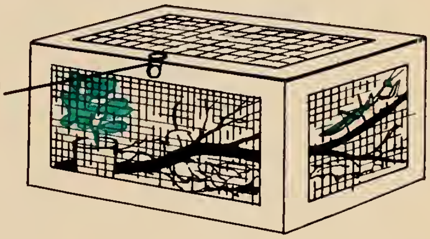
They slip very slowly out of their skins, then hang upside-down waiting for their new skin to dry and for their muscles to become firmly attached to it. (An insect's skin is really a sort of outside skeleton.) If you look around, you may find a ghost-like mantis skin hanging from a leaf.

After a mantis has molted three times, its wings begin to appear. Usually by the fifth molt it is ready to fly. Some mantises molt more than five times.

You may want to catch a half-grown mantis and keep it for awhile. You can make a cage of wire screening *(see diagram)*. A few leaves on the floor, a stick or branch to climb,

You can make a mantis cage from a cardboard carton, about 24 by 18 inches. Cut openings like these in the carton, then staple or sew wire screening over the openings.

To make latch, wire two buttons (one on lid, one on box), then loop rubber band around them.



and a potted plant in the corner will complete its housing needs. When you water the plant, sprinkle some drops on the leaves for the mantis to drink. Mantises need live food, or food that you move to make it seem alive. You can feed your mantis live insects (such as mealworms from a pet shop) or bits of meat that you can wiggle on the end of a broom straw.

One mantis will probably be all you can keep. You may not be able to get enough insects to satisfy more than one. If you keep two together, one will eat the other. Let your mantis go in the early fall. Mantises usually die of old age by late November ■

PROJECTS

- A mantis must keep its eyes and antennae clean so that it can detect its prey and its enemies. Watch to see how a mantis cleans itself.

- This fall, you might try to mate mantises by putting a pair in a cage. You can tell females from males by the females' bigger size and fatter abdomens. The diagram shows how the abdomen tips of the sexes differ. Females sometimes eat their mates after breeding. Perhaps you may be able to watch a female make her case.

FEMALE

MALE

BELOW A BEE'S KNEES, on its rear legs, are stiff "hairs" that hold pollen. The arrow points to one of these pollen baskets. Look on the front leg of a honeybee for its "antennae cleaner"—a small, hairlined notch through which the antennae are drawn for cleaning.

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INSECTS BITE, CHEW, CUT, SIP, AND BORE into things for their food. You'll find a great variety of mouthparts. The sucking mouthparts of a housefly (1) have a sponge-like end. Many moths and all butterflies (2) have a long tube that can be uncoiled and used like a straw to sip up nectar from flowers. A female mosquito (3) pierces skin with six sharp needles, then sucks blood up a groove of its upper lip and into its body. Watch a grasshopper to see how its mouthparts work.

A CRICKET'S CHIRPS come from its wings. To "sing", a male cricket raises its wings and rubs them together, so that the hard sharp edge of one front wing scrapes over a file-like ridge on the underside of the other. A female cannot "sing", because her wings lack the hard ridges of the male. Look for a cricket's ears—little drum-like surfaces on the lower parts of its forelegs. You can identify a female cricket by its long egg-laying ovipositor (see *arrow*). How do other kinds of insects make sounds?

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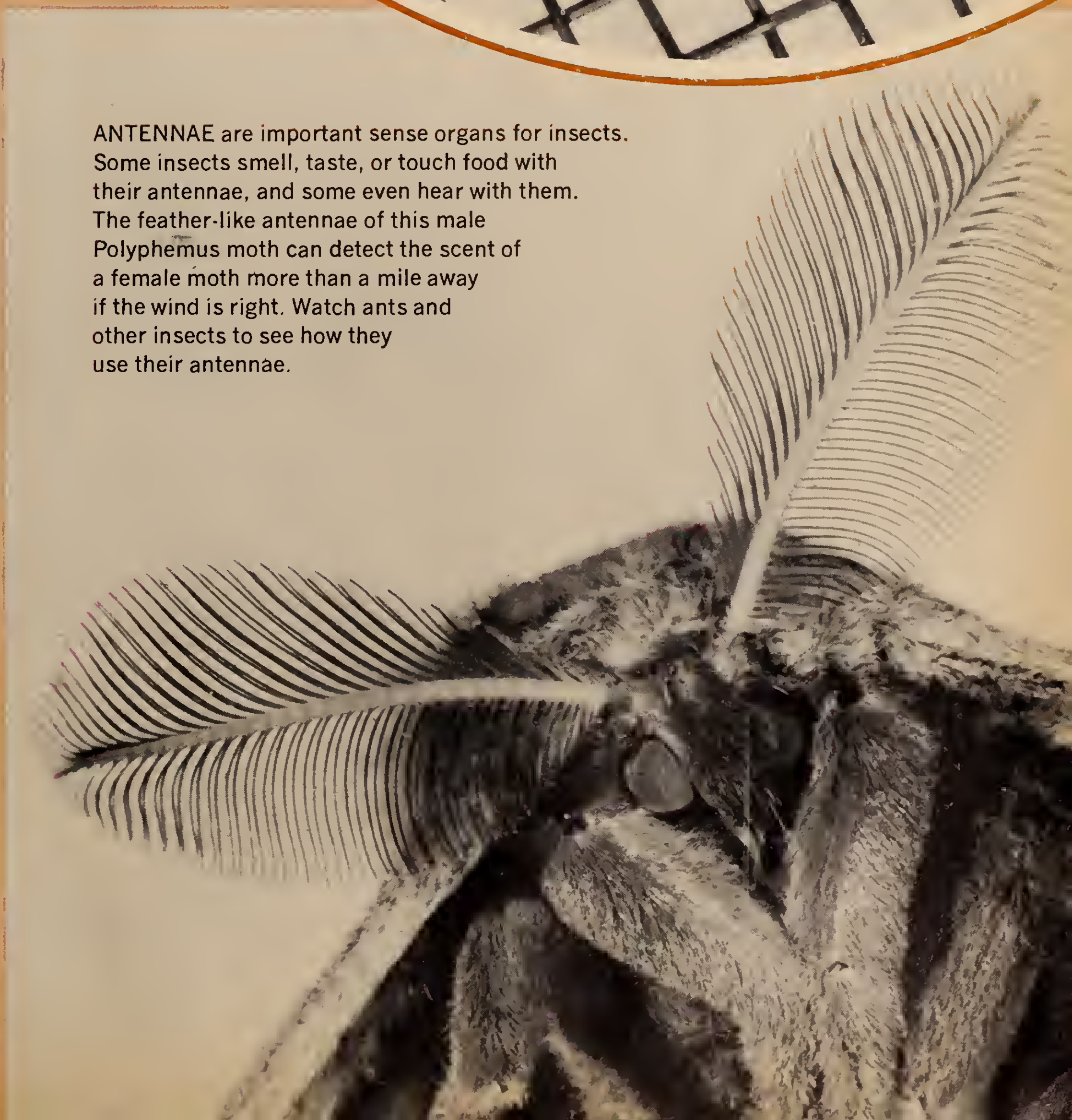
LOOK CLOSELY to see a housefly's "balancers", or *halteres* (*see arrows*). They are attached to the thorax like wings and move up and down in flight. The halteres help the fly keep its balance. See what happens if you cut off one or both halteres, then let a fly go.



ANTENNAE are important sense organs for insects. Some insects smell, taste, or touch food with their antennae, and some even hear with them. The feather-like antennae of this male Polyphemus moth can detect the scent of a female moth more than a mile away if the wind is right. Watch ants and other insects to see how they use their antennae.

The flash signals of Fireflies

■ Do you know how a firefly uses its flash? These fascinating insects—they are beetles, not flies—use the lamp built into their underside to attract mates. The flashes are signals. With practice, you can learn the flash codes of fireflies and perhaps attract them with a flashlight.

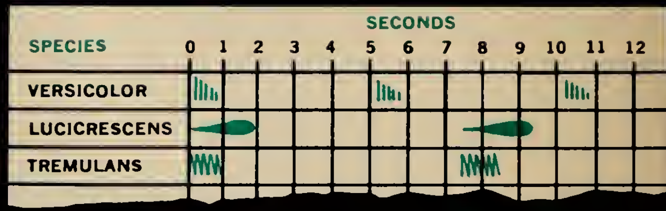
Fireflies that flash during flight are almost always males. The female answers from the ground or from a perch on grass or leaves. Her flash is a little different. When a male sees it, he flies to the female. Only females ready for mating give the right signal, and these signals are answers to the flash of a male of the same species.

The many species of fireflies look so much alike that it is hard to tell them apart, but they are easy to recognize by their behavior. They live in different places and are active at different seasons of the year and at different hours of the night. If you see two or more species flying at the same time, you will notice that they flash different signals. There are long flashes and short ones, single flashes or groups, flashes that are close together or spaced far apart. There are bright lights and dim ones; steady, flickering, and fading lights; and lights of very slightly different colors. You may be able to notice other differences.

Scientists use a sort of picture-writing to record the flash signals of fireflies. You too can make a collection of the signals of the fireflies you see.

It is hard to watch a clock and an insect at the same time, so get a clock with a very loud tick and *listen* to it instead. Make a table like the one shown, with one square for each two ticks (one second). Draw a line for each flash—tall for a bright flash, shorter for a dimmer flash; narrow for a short flash, broader for a longer flash *(see table)*. The time between flashes (empty squares) is sometimes more important than the length of flashes.

Flash signals made by male fireflies of three different species of the genus *Photuris* would look like this:



Versicolor makes five short flashes—the first bright, then each one dimmer—and then remains dark for about four seconds. *Lucicrescens* makes one flash that changes from very dim to bright and lasts two seconds, then it is dark about 5½ seconds. *Tremulans* makes a bright, flickering flash for one second, then is dark for 6½ seconds.

When you make a record, write down the date and the time of night, the place where you saw the fireflies, the color of the light, and any other things you observe.

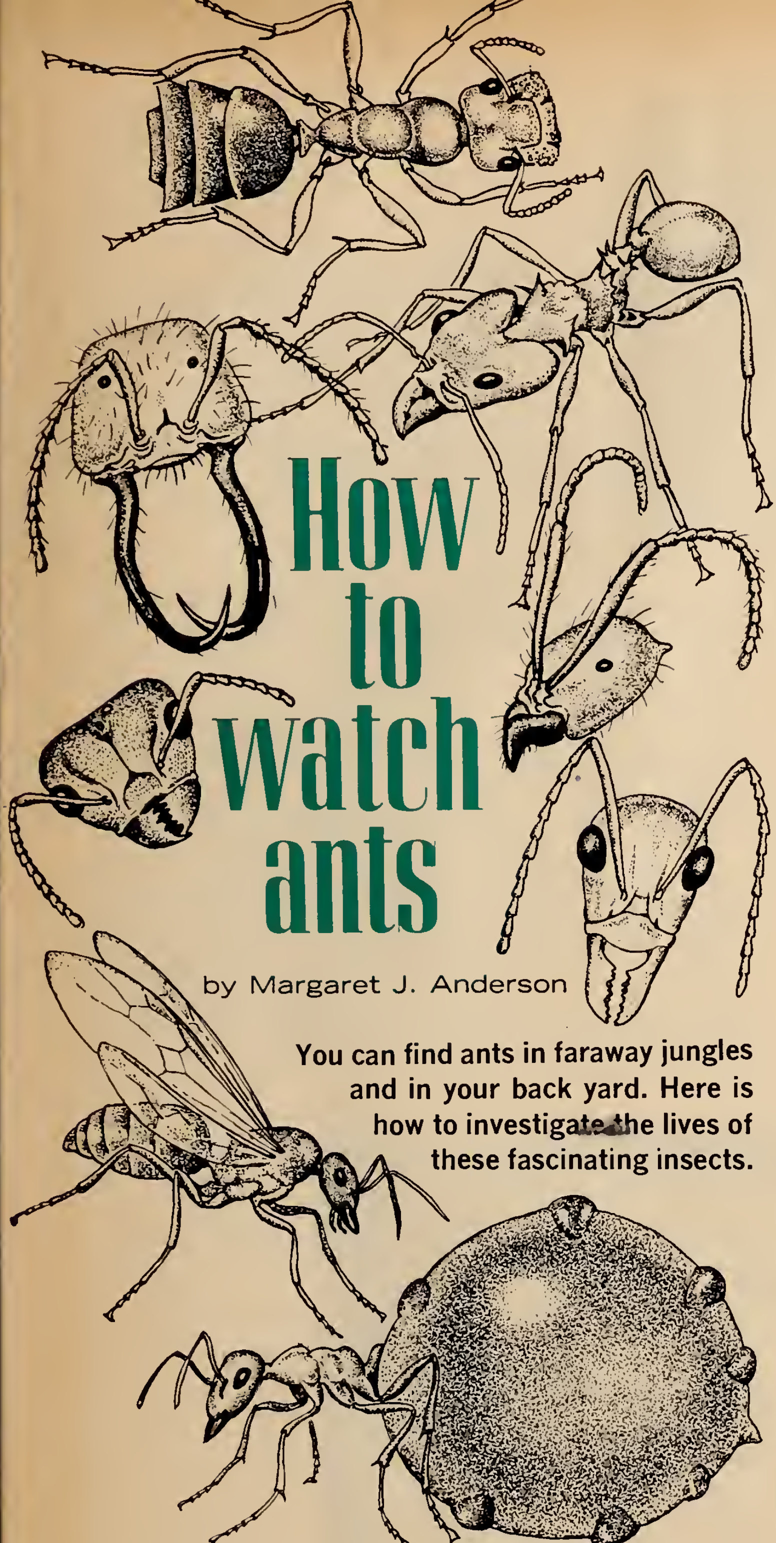
You will want to record the flashes of females as well as those of males of the same species. The females are harder to find, and not all of them look like beetles. Some are wingless and look more like grubs. These are called "glow worms." A female that has already mated may flash, but she will not give the right signal for attracting males. To be sure that the signal you record is the true mating call, and that the male and female you watch belong to the same species, watch a flashing female until a male comes to her. When you think that the male has seen her, but pays no attention, find another female.

Watching females may give you a surprise. They may be trapping a dinner. There are female fireflies that flash the mating signal of another species. They attract males of that species and eat them. They do not eat the males of their own species, however.—Alice Gray

See if you can make the same signal as that made by a firefly. Cover the bulb of a small flashlight so there is only a tiny gleam, then copy the female flash. If your imitation is good enough, male fireflies will fly to you.

Fireflies seem to make flash signals that are not mating calls, but nobody knows how they are used, or if they have any use at all. Perhaps you can find out.

For more information about fireflies, look for this book in your library or bookstore: **Fireflies,** by Bernice Kohn, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1966. $3.50.



How to watch ants

by Margaret J. Anderson

You can find ants in faraway jungles and in your back yard. Here is how to investigate the lives of these fascinating insects.

■ There are many kinds of ants in the world. There are ants that tend huge underground mushroom gardens, weeding and fertilizing them. There are army ants that march through jungles killing small creatures in their path. And there are the ants in your back yard. They, too, lead strange and interesting lives.

You probably have disturbed an ants' nest under a stone and seen the ants scurrying underground, carrying their young to safety. You may also have seen the mound of the wood ant or the fire ant busy with workers.

Ants are called *social* insects because they live together in large groups, each ant doing its own job. They need each other. The most important ants in the group, or *colony,* are the queens. They are usually bigger than the others and their job is to lay eggs—hundreds of thousands of them during their lives.

The eggs hatch into tiny *larvae,* and after a few weeks the larvae become *pupae (see "How Insects Grow Up," page 5).* This is a resting stage during which the body changes. Then the adult ant finally emerges.

Living with the queens are many worker ants. Some have the job of washing and feeding the queens. Some work in the "nursery," caring for the young. Some do housework, others look for food. There are scouts and soldiers, and in some nests there are doorkeepers with heads shaped like corks to stop up the door holes!

In the summer you find ants with wings in the nests. These are both males and females. One day, when the weather is right, these winged ants all fly from the nest and the male and female ants may mate in the air. The female ants are then ready to start a nest of their own. If you see some of these flying ants land you can watch a strange sight. The new queen either bites off her wings or rubs against a stone till they fall off. She is going to spend the rest of her life underground, where she will have no use for wings.

Things To Watch for

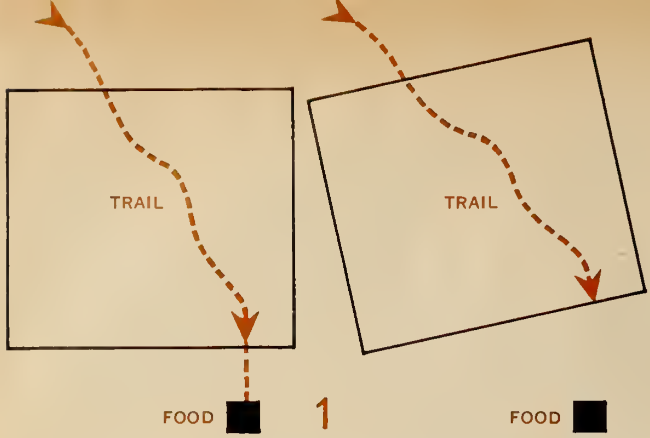
You can learn a lot about ants from watching them outdoors or in an artificial ant nest. One of the most puzzling things about the ants in a colony is how they communicate with each other, and how each knows its own job.

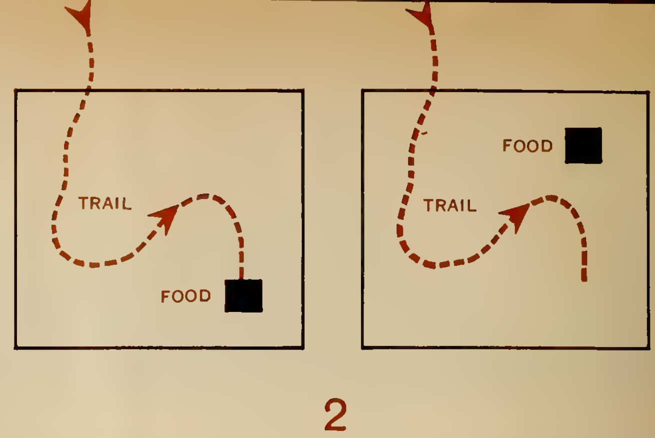
Start ant-watching close to a nest where there are a lot of ants hurrying about. Mark an ant so that you can recognize it again. You can do this with a very fine-tipped brush and some colored nail polish. Mark the ant on its *thorax* (the middle section of the body).

Pin a dead fly in the path of the marked ant. Does the ant go to the nest for help? Does it lead ants back to the food or has it "told" the others where to find food? Now take a bigger piece of food, such as a caterpillar, and divide it into two pieces, one bigger than the other. Pin these each in the path of ants out looking for food. Does the same number of ants come from the nest to each bit of food, or do more ants come to the larger piece? Do the ants follow the same route out from the nest to the food as they do on the homeward journey?

One way an ant can give another ant directions is by leaving a scent trail. The ant presses its body against the ground and leaves a slight smell that another ant can follow. Ants use their "feelers" to detect this smell. Scientists

(Continued on the next page)





Once ants have established a trail across a sheet of paper, turn the paper (Diagram 1) and see what happens. Try a similar test by moving food from the end of an ant trail to a new position on a sheet of paper (Diagram 2).

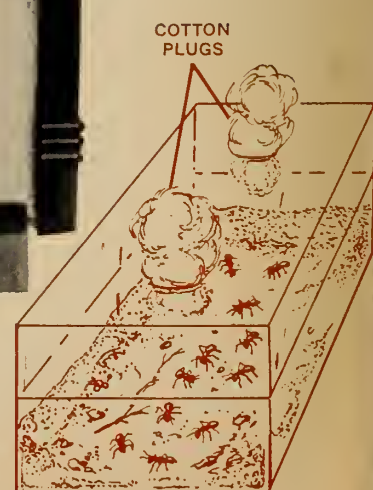
How To Watch Ants (continued)

have found that they can make an artificial ant trail using formic acid. Another way to make an artificial trail is with the body of a freshly killed ant.

Rub your finger across an ant road and watch how the ants react when they come to that place. Another way you can investigate an ant trail is by placing a sheet of paper so that the ants cross it to a piece of food. Then turn the paper to a different angle *(see Diagram 1)*. Do the next ants that come along cross directly to the food, or do they follow the trail to the edge of the paper? Try placing food on a piece of paper and wait for some ants to find it. Now move the food to another part of the paper *(see Diagram 2)*. Do late arrivals go to the food in its new place, or do they go where the food was before you moved it? In other words, are the ants attracted to the food itself, or are they just following a trail that has been left for them?

Ant Farming

In order to learn more about ants and their ways you can keep them indoors in an artificial nest. You can buy an "ant farm" in a pet shop or a variety store, or you can use a shallow plastic box with a tight-fitting lid. Make two holes in the lid to let air into the nest. (You can do this by holding a nail in a pair of pliers, heating the tip of the nail, and using it to melt the holes in the plastic.) Use cotton to plug the holes. This keeps the ants in, but lets air through. You can remove the cotton plugs when you want to feed and water your ants.



You can buy an "ant farm" or make your own home for ants from a shallow plastic box *(right)*. Air enters the box through the holes but the cotton plugs keep the ants in. For a long-lasting ant colony you will need to find a queen ant *(see text)*.

This ant colony is in a jar of sand with a "moat" of water around it. The ants come up through the hole in the cardboard. The wooden rods lead to "feeding stations" where different kinds of food are offered.

Another simple type of nest is made in a glass jar. Fill the jar with damp sand and set it in a pan of water so that the ants cannot escape (like a castle surrounded by a moat). On top of the jar put a piece of cardboard with a small hole in it. This is the feeding station. You can seal it in place with a ring of modelling clay round the top of the jar. The ants will come up from the nest in the sand to forage for food just as they do outside.

You can easily find a few ants for your jar but these would be workers. To keep your colony going you need a queen, and finding a queen isn't easy. Try digging into a nest. As you dig, the disturbed queens go deeper into the tunnels. You can recognize the queens by their size. They are bigger and often shinier than the workers. Have a plastic bag or a jar ready for your ants, and if you miss the queen take a selection of workers, larvae, and pupae. Before trying to put your catch into its new nest it's a good idea to put the bag or jar of ants in the refrigerator for an hour so that the ants are less active, and therefore easier to handle.

Another way you might try to colonize your jar or ant farm is to leave it, with food in it, at the entrance to an ants' nest for a day. The ants will make trails to the food. Then leave a hose running gently for long enough to flood the ant colony. The ants will begin to leave their nest and some will follow the trails to your jar. Some ants will arrive carrying pupae, some with larvae, and when you see a queen arrive you can turn off the hose.

The harvester ants or tiny black garden ants are the best kinds to collect. Fire ants sting and some ants bite. The books listed at the end of this article will help you identify ants.

Feeding Your Ants

Your ants will, of course, need food and water. Add a few drops of water each day to keep the sand moist but do not feed your ants more than about twice a week. Uneaten food will get moldy and can kill the colony. Honey, peanut butter, tiny bits of fruit, hamburger, or a dead fly make fine meals for your ants. You can test other foods to discover what they like.

You can use the jar nest to try some feeding investigations with your ants. You can, of course, watch how they react to different types of food. Or you can make separate feeding stations *(see photo)* and see if the ants are more attracted to some foods than to others. I used "Tinkertoy" rods to connect the small feeding stations to the main nest *(see photo)*. They have notched ends which clip easily onto the cardboard. You can then fasten the rod at the other end with modelling clay. How long do the ants keep coming to the feeding station after you have wiped it clean?

Color a drop of honey with blue food coloring liquid and allow only one or two ants to feed on it. If they are light colored ants you will be able to see the blue honey in their stomachs. Now remove the honey. After a while you will find that most of the ants are dyed blue. What does this tell you about the feeding habits of ants?

Use a magnifying lens to watch how ants tear a piece of food apart. Notice the way their jaws work and how large a piece an ant can carry.

If you introduce an ant from another nest to your colony, what sort of welcome does it get? If you take an ant out of your colony for a few days and then return it, do the ants treat it as an intruder?

Your ants' nest should be kept in the dark most of the time, so you should have a box to put over it. Or, you can tape red cellophane on the outside of the glass. This lets you watch the ants, but the nest will seem dark to them ■

■ Look in your library or bookstore for these well-illustrated books about ants: **The Story of Ants,** by Dorothy Shuttlesworth, Doubleday & Company, Inc., Garden City, New York, 1964, $3.95; **Ants From Close-up,** by L. Hugh Newman, Thomas Y. Crowell Company, New York, 1967, $6.95; **An Ant is Born,** by Harald Doering and Jo Mary McCormick, Sterling Publishing Co., Inc., New York, 1964, $2.95.

Insects build homes of many kinds. You can learn about some of these unusual shelters by exploring...

The Underwater World of the Caddisfly

by Margaret J. Anderson

A case made of small bits of plant stems is the home of the caddisfly larva in Photo 1. Notice the white, threadlike gills. Photos 2 and 3 show caddisfly cases made of different plant materials. Photo 4 is an adult caddisfly that has just emerged from its pupal skin.

■ Look down into a stream or pond and you may see a little cluster of stones walking around. It is probably the larva of a caddisfly and it's worth a second look.

The caddisfly larva lives in a case it has made for itself. The type of case varies with the kind of caddisfly—some are made of particles of sand and stone, others of sticks and leaves. As a rule the heavier cases belong to the caddisflies that live in fast-moving water. Caddisflies that live in still water have cases light enough to allow them to move freely. There are some kinds that make no cases at all.

Inside the Case

Once you've found a caddisfly larva, watch it closely as it moves about. The head and the *thorax* (the three segments bearing the legs) stick right out of the case as it creeps about *(see Photo 1)*. Pick up the case and gently try to pull the insect out. It has a good hold in there, hasn't it? In fact, if you keep pulling you may damage the larva before it lets go of its case. The best way to get it out is to slit the case open very carefully. Then you will see that the caddisfly has a pair of strong hooks at its hind end for holding firmly to the case. (Keep the insect moist while you work with it.)

Leave the larva in water with a fresh supply of building materials and it will make a new case. How long does it take? Perhaps you can get it to include tiny beads, pieces of broken shells, or fragments of glass.

The caddis case is made of a lining of silk (from glands inside the insect) to which the stones, twigs, or leaves are added. The case is a tube with a large opening at the head end and a small opening at the other end. This allows the water to flow through the case. The larva has *gills,* like little white threads, all the way down the body, and these must be bathed in water for the insect to breathe.

To see this movement of water through the case, put a larva in an open jar of water. Then put a drop of food coloring liquid in front of the head end and you will be able to see the colored water drawn into the case.

Collecting and Keeping Caddis Larvae

Adult caddisflies look like small, drab moths. They fly mostly at night and, when resting, fold their wings tent-like over their body *(see Photo 4).* They are related to moths but belong to a separate order of insects. The name of the order is *Trichoptera (trik-op-ter-a),* which means "hairy wing."

A good way to see the adults is to raise them from larvae. This also gives you a chance to learn something of their lives.

When you collect caddis larvae, notice the conditions in which they live in the wild. Does the insect live in a pond or in a stream? What is the temperature of the water? What sort of food supply is available? What materials does it use for its case? Is it resting on weeds or on gravel?

When bringing home the live caddis larvae, put them in a jar of damp water weed or moss and keep them cool. Don't carry them in a closed jar or they will die for lack of oxygen.

At home you should try to duplicate the natural home of the caddisfly. Keep them in an aquarium, in pans, or in wide-mouthed jars. The two most likely causes of trouble are the water temperature and lack of oxygen. You have

ADULT CADDISFLY *4*

to keep the water cool, near the temperature in the stream or pond. Perhaps there is a corner in the basement or in shade where you can keep the larvae.

If your larvae came from a pond they don't need as much oxygen as the ones that live in swift water. This is because there is more air trapped in the rippling water of a stream than in the calm waters of a pond. There are ways of getting more air into the water for your caddisflies. The best way is to use a "bubbler" like the ones used in fish tanks. You can also increase the air supply by using a shallow pan which allows a wide surface of the water to be in contact with the air.

If you can't use pond or stream water then let tap water stand uncovered overnight or longer. This allows chlorine in the water to escape as a gas.

Most caddis larvae are plant eaters. Many live on decaying plant material. Put some algae-covered stones, some water weed, and dead leaves into your pan, and find out what your species of caddisfly prefer.

The Ways of a Caddisfly

When you have your "rearing pans" set up you'll be able to make some observations on growth and behavior. You can, of course, watch a caddisfly build a new case. You'll find that some make a quick, rough case and then improve on it for the next day or two. What would the result be if you gave a stone-case builder only plant material? Or if you gave only sand to a species that usually uses pine needles?

If you work carefully with a blunt probe, like a toothpick, at the hind end of a larva you can chase it out of its case without damaging either the animal or its case. You'll find that the larva recognizes its case and returns to it. What happens if you offer it several empty cases, including its own?

If all goes well, the larva will become a *pupa,* the stage during which it makes ready to change into a flying adult. The pupating larva fixes itself to some object in the water, such as a plant or stone. It then forms a silk screen across either end of its case, sometimes adding a stone lid. There is still a flow of water through the case, but it is hard for enemies to get at the pupa. Some kinds of caddisflies leave the water altogether to pupate and are found in damp ground close to the stream or pond. This stage varies in length. Some species spend the whole summer as pupae, but most emerge as adults in two or three weeks.

Once you have pupae in your pans you should cover them. An old nylon stocking stretched over the pan makes a good cover. It would be a pity if the adult were to emerge and fly off without your ever getting a chance to see it! If you have an insect collection, you can add the adult caddisflies to it. Otherwise, let them go near a pond or stream where they can lay their eggs for another generation of these unusual insects ■

■ Look in your library or bookstore for the book **Caddis Insects**, by Ross Hutchins, Dodd, Mead & Company, New York, 1966, $3.25. It includes many photographs of the insects and their cases.

Killing and Preserving Insects

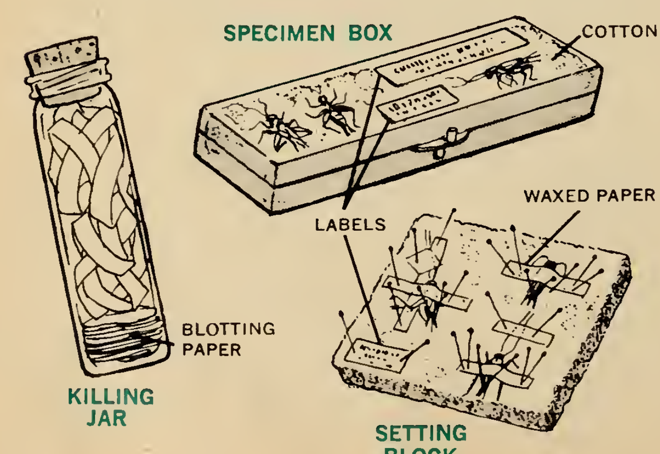
■ An important part of any insect research project is to identify the insects with which you are working. Unless you are already familiar with the species, you can almost never identify a live insect. You have to collect a few individuals of each kind, kill them, and preserve them so that you can identify them later with the aid of books *(see list on page 4)* and a magnifying glass. In the meantime, give each species a number that you can use in your records.

Make a label of stiff white paper for each specimen, jotting down the place where you caught it, the date, and your own name. Scientists call such facts "data," and a specimen without data has no scientific value, however beautiful and perfect it may be. You can also add any other information you have about the insect. Write very small with waterproof black ink.

To kill and preserve soft-bodied specimens like caterpillars (and very small specimens of any sort) drop them into little pill-bottles full of rubbing alcohol. You can probably get both bottles and alcohol at a drug store. Put the label right into the bottle with the specimen. (Several specimens of the same species caught at the same time and place may be kept in the same bottle, with one label.)

To kill and preserve larger specimens with hard-shelled bodies, you will need a killing jar, a setting block, and specimen boxes in which to keep them when they are mounted *(see diagrams).* A small olive bottle makes a good killing jar. In the bottom of the bottle, put about six layers of blotting paper, cut to fit so tightly that they will not fall out. When you are ready to use the jar, "load" it by pouring in about a teaspoonful of lacquer thinner or nail-polish remover. (If you use polish remover, be sure it is of a kind that contains no oil, because oil would probably damage your specimens.) The vapor that escapes from these liquids is very poisonous to insects (and not at all good for people).

If you expect to have many insects in the bottle at one time, put in a crumpled strip of paper towel to cushion the insects and to soak up the moisture they give off. Most insects will be "knocked out" very quickly, but leave them all in the jar at least half an hour to be sure they will not revive. If you want to collect butterflies and moths as well as other insects, have a separate killing jar for them. Some of the scales that clothe butterflies and moths come off in the jar and will stick to other insects.



Preserving Your Specimens

A scientist usually keeps his insect specimens on special pins which serve as handles, so he can turn a specimen over and look at it from any side. However, pinned specimens are easily damaged. You can get the same full visibility by mounting different specimens to show the top, bottom, and side views, and putting them into a protective transparent display box *(see diagram).* Ideally, you should have all three views of both male and female, a total of six specimens in each box, but you will not always be able to get that many.

Mount your insects as soon as you take them out of the killing jar, while they are still soft and easy to set in the positions you want. Any firm material into which you can stick pins will make a setting block. A piece of plastic foam is fine. So is a piece of balsa wood or even the flap of a cardboard carton. You will need some dressmaker's pins, or better, a packet of fine needles, and some small strips of cellophane or waxed paper.

Lay an insect on the block, arrange its legs and wings so that you can see them clearly, cover it with a piece of cellophane to hold everything in place, and pin the cellophane to the block. The idea is to press the insect as flat as you can *without crushing it,* and keep it that way while it dries. Leave it on the block for at least a week.

Any small shallow box of transparent plastic will do for a specimen box. Get a piece of clean surgical cotton from a drug store and cut it to fit the box exactly. Be sure it is no thicker than needed to press the mounted insects gently against the inside of the cover when the box is closed. Use forceps (tweezers) to handle the dried specimens. Arrange them on the cotton, with their labels beside them, and close the cover *(see diagram).* Your collection will be neat and easy to store if all of your boxes are alike.—ALICE GRAY