nature and science

Volume 6, Numbers 1 - 17

1968 - 1969

nature and science

TEACHER'S EDITION

/OL. 6 NO. 1 / SEPTEMBER 16, 1968 / SECTION 1 OF TWO SECTIONS

PREVIEWS OF UPCOMING ARTICLES ON PAGE 4T

Nature and Science and...

...Your Pupils

■ Do your pupils think of *nature* as the world of birds and bees and flowers and trees—a "special" world that they can enter or leave at will? Do they think of *science* as men in white coats —modern alchemists devoted to making "new and better" things?

A great many people still think of nature and science in such erroneous ways as these, at a time when it is becoming apparent that the survival of man and many other living things depends on how well we understand the processes of nature—and on what we do with our understanding.

If your pupils have been reading *Nature and Science*, they know that the birds and bees and flowers and trees are all part of nature—but so are the earth and its seas of water and air, space with its planets and stars, and every living thing, including your pupils themselves.

They know that everything in nature is constantly changing; they know something about the forces that cause

(Continued on page 4T)

...You

■ There is more to *Nature and Science* than meets your pupils' eyes – this Teacher's Edition, for example.

It brings you additional background information about the subjects and concepts of some of the articles in the students' edition; it suggests topics for class discussion that will help your pupils relate what they learn to their own lives; it suggests classroom activities that will reinforce the understanding your pupils get from reading an article; and it recommends references for further information *you* might want.

For your convenience, the Teacher's Edition also provides the answers to the BRAIN-BOOSTERS in the accompanying students' edition, and suggests ways to help your pupils find the solutions for themselves.

Your pupils will get a lot out of *Nature and Science* without your help. But by using some of the suggestions in this Teacher's Edition, you can greatly enhance the value of *Nature and Science* to your pupils and to yourself as a teacher ■

ORNELL ALUMNI NEWS

GORDON HICKS

the classroom . . . out-of-doors, *Nature and Science* shows your pupils how to instigate nature and its forces in an amazing variety of ways.

10 WAYS TEACHERS ARE USING NATURE AND SCIENCE

1. To start children investigating natural phenomena on their own in a scientific manner.
2. To amplify and update concepts presented in texts and to spark lively and meaningful class discussions.
3. To develop children's skills in observing, formulating meaningful questions, investigating, and evaluating their findings.
4. For homework assignments and for classroom reading.
5. As a source of ideas for themes, small group investigations and reports, science club projects, science fair exhibits, weekend and vacation science projects.
6. For assignments that relate science to other subjects such as English, history, social studies, and the visual arts.
7. To stimulate interest of slow readers and for remedial reading instruction.
8. As extra educational nourishment for the fast learner.
9. As a springboard for field trips to zoos, museums, botanical gardens, a neighboring park, a nearby stream or woods.
10. As a "how to" guide for making, acquiring, and maintaining simple classroom "hardware" such as terrariums, aquariums, balances, sundials, homemade microscopes, bird feeders, etc.

Although many teachers use NATURE AND SCIENCE in conjunction with a textbook, several hundred teachers have discovered they can use NATURE AND SCIENCE as the main "text" for an informal yet effective science course throughout the year.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Wolves in Our Family

In past issues of *N&S,* Dave Mech, a biologist at Macalester College in Minnesota, has pointed out the role of wolves as predators of large mammals such as moose, deer, and caribou. He has also described how the wolf's "bad" image has continued despite evidence of the animal's good effects in nature.

Through destruction of habitat and by hunting, trapping, and poisoning, wolves have been wiped out in most of the United States. Lately there have been suggestions that wolves be re-established in areas such as Yellowstone National Park. The park has too many elk; wolves would probably help bring the elk herd into a better balance with its food supply.

Studies of wolves in their natural surroundings have shown that these predators have a beneficial effect on prey species. Wolves (and other predators) tend to catch the individuals in a population that are least fit, especially those that are diseased or old.

Reintroducing wolves in certain national parks and other wild areas would help prevent the threatened extinction of this valuable species in the original 48 states. It would help also to ensure that scientists could go on learning about the complex social life of wolves.

Topics for Class Discussion

- *What did Dr. Mech's discoveries tell him about the behavior of all wolves?* Very little. As the author points out, he could not be sure that all wolves would act as his did. They were raised in unnatural conditions. Also, scientists are cautious not to generalize from observations of a few individuals.

- *Why did the wolf pups fight with each other?* This behavior led to the establishment of an *order of dominance.* Your pupils may be able to name other kinds of animals that have a similar social system. One of the best-known examples is the "peck order" of chickens.

- *Why did Lightning become unfriendly toward strangers?* Evidence from Mech and other observers suggests that wolves form their lifetime social ties during the first few months of life. After that, they are wary of strange wolves. This behavior helps unite the pack and reduces conflicts between packs so that each group has its own territory in which to hunt.

For Your Reading

For further information about wolf behavior, see the article "The Social Organization of Wolves," in the May 1968 issue of *Natural History* magazine.

Dating the Past

Your pupils will probably agree that we have to know how things have changed in the past if we are to make reasonable predictions about how they are likely to change in the future. We can only find out what happened in the past, however, by investigating the remains of past events that are left in our present-day world.

To learn very much from remains, though, we have to be able to *order* them in time—find out which came first, second, third, and so on (*relative* dating), and if possible, *when* each one appeared (*absolute* dating).

Topics for Class Discussion

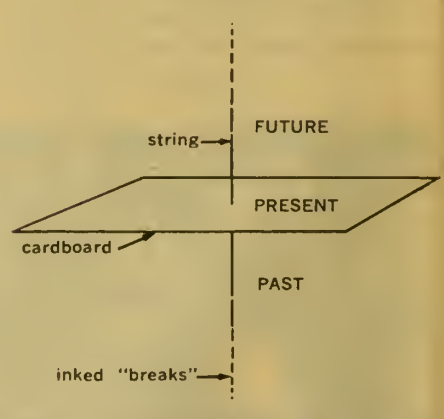
- *What part does dating play in the "Ice Age" mystery* (see page 12)*?* Relative dating of layers of glacial drift disclosed that ice sheets advanced and retreated four times in the past million or so years. If these advances can be dated absolutely, it may help us discover what caused them.

- *Can you think of some different kinds of remains, what clues they might give to past events, and how they might be dated?* Tracks in sand show what kind of animal or machine was there recently—probably since the last high tide or high wind.

Objects in a refuse heap—packages, clothing, tools, toys, and so on—might show what kinds of things people used in past years. If the heap has not been stirred up, an object's position in the heap suggests its relative age. A date printed or stamped on an object suggests the absolute age of objects at the same level in the heap.

- *Can you think of some problems that might arise in dating by the methods described in the chart?* Rock layers may have been broken, raised, or lowered by earthquakes, or worn completely away by erosion in some places. No tree of the same species grown under the same weather conditions and

(Continued on page 3T)



Make or draw this "model" of time to help your pupils visualize time as a line extending (we don't know how far) into the past and future, and the present as a "thin slice" of time in which we live. We can only find out about the past by studying what is left of it in the present.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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 measure time without a clock?

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HOW LONG IS A MINUTE?

Wolves in our family

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PICTURE CREDITS: Cover by Laurence Pringle; p.3, top by Dave Mech, bottom by Charles Bjorgen, from Minneapolis *Star;* pp. 4-5, top left by Charles Bjorgen, from Minneapolis *Star,* others by Laurence Pringle; pp. 6-12, 14-16, drawings by Graphic Arts Department, The American Museum of Natural History; p.11, photo by David Webster; p.12, courtesy of U.S. Army Cold Regions Research and Engineering Laboratory; p.13, by Christopher Schuberth; p.16, photo by *Newsday,* Long Island.

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 September, October, December through March; monthly November, April, May, 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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I wanted to learn more about the behavior of wolves, so I was delighted when we had a chance to raise...

Wo

■ I never thought I'd be a member of a wolf pack.

But I was. It wasn't exactly like a wild wolf pack, for besides two wolves, it included four children, my wife and me, and a dog. Still, it was enough like a real pack so that I was able to learn a few things about the early family life of wolves. And that's just what I wanted to do.

It all began in May 1967 when I got a call from the director of the zoo near our home in Minnesota.

"How'd you like to raise a couple of wolf pups?" he asked.

I had studied wolves in the wild and was writing a book about them. Raising some pups would teach me more about wolves, and this would help me with the book. "That would be great," I replied. Then we began to get ready for our new guests, which we decided to name "Thunder" and "Lightning."

Learning from the Pups

The first things we needed were baby bottles, for the pups were still nursing milk from their mother when we got them. They were only 10 days old. About all they could do was whine, move their heads from side to side, and suck strongly on a nipple. They could neither see nor hear. If they had been born in the wild, they would have stayed at the bottom of their den in the ground for another 10 days.

From the beginning, of course, I made notes about everything the pups did, and how they grew and changed. I realized that just raising two young wolves was not going to teach me all there was to know about wolf pups. But I did expect to gain two important things from this study.

First, I would find out what *some* wolf pups are capable of. I couldn't be sure that all wolves would act the same way as mine. Nevertheless, I could learn what wolf pups *can* do and how they *can* grow.

Second, raising a pair of wolves would give me ideas and questions to investigate. I knew that as I watched the pups grow and change, all sorts of new thoughts would come to me. If they seemed important enough, I could raise more pups some day and test my ideas further. This is the way many scientists work.

ves in our family

by Dave Mech

The wolves had floppy ears and "pugged" noses when just a few weeks old. Later they played rough-and-tumble games with the Mech children. When the photo below was taken, Lightning weighed 60 pounds and had sharp adult teeth. She never bit any of the children. The photo on the cover shows Lightning greeting the author's wife, Betty Ann Mech.

Thunder and Lightning grew and changed rapidly. At rst all they did was drink and sleep, but within three days fter we got them, their eyes opened. Both wolves then tarted to walk and tumble about. When they were three reeks old, they began to hear, and soon they were running nd playing. Each already had several teeth. In the wild, ne pups would just be venturing out to the mouth of their en for the first time.

At this stage, the wolf pups looked like roly-poly teddy ears *(see photo)*. They were soft and furry, their noses rere "pugged," and their ears were floppy. Our four hildren, ages 3 to 7, had completely fallen in love with nem, and our dog had adopted them as if they were her wn. It looked as though we were going to have one big appy pack.

Vho Is the Boss?

Then suddenly a strange thing happened. At 27 days f age, Thunder and Lightning began fighting. After each eeding, the pups would rush toward each other. One rould put its paws over the neck of the other and force down. Then each pup would try to bite and chew the ther's back as hard as it could.

Usually we stopped these fights. However, one time I let nem continue—just to see what would happen. The pups ought for 10 or 15 minutes, and it seemed to me that they night die from exhaustion. The fur on the back of each rolf was ragged from the chewing, and there was blood howing. I separated them for the night.

(Continued on the next page)

The next day the pups again tried to get to each other and fight. Our whole family spent the day keeping them apart. Lightning, the female, often attacked Thunder, even though Lightning was smaller and usually ended up geting the worst of the battle.

After another day of trying to keep the pups apart, we decided that our only solution was to give one of them back to the zoo. The next day, when the pups were 30 days old, we got ready to return one of them. First, however, I put them together for one last time, to take their pictures.

Thunder and Lightning rushed right to each other and began fighting in their usual way. But this time, something unusual happened. When Thunder pressed Lightning to the ground, she did not fight back. Instead she rolled over on her back and whined. At the same time, Thunder stopped his attack and stood stiffly over her with his tail straight up in the air.

Suddenly, I knew what had happened. The pups had finally decided which one was boss. In any wolf pack, each wolf knows just how many others he can boss, or *dominate,* and which members of the pack can boss him. The leader of the pack can dominate any other wolf in the pack. The one at the bottom of the "ladder" can be bossed by all the other wolves in the pack.

This *order of dominance* leaves little room for fighting, for each wolf knows its own place. If several wolves come upon a piece of meat too small to share, for example, the animal with the highest *rank* in the group automatically gets to eat it.

But somehow there has to be a way that each wolf learns just what rank it has in a pack. Usually young wolves find this out by playfully fighting with their packmates. As the pups wrestle, chase, and play other games with each other, they eventually learn which wolves they can beat and which ones can beat them. But this is all done through play.

That's why the actions of Thunder and Lightning were so surprising. Their fighting wasn't a bit playful; it was deadly serious. Still, it finally taught each animal just which one was boss. As soon as I saw Thunder stand over Lightning with his tail straight up, I could see that their problem—and ours—was solved. From that moment on there were no more fights between our pups. Every time they met after that, they did the same thing: Thunder showed that he was *dominant,* and Lightning showed that she was *subordinate,* and they got along perfectly.

The pups that had been born with Thunder and Lightning and were being raised by their parents in the zoo did not fight like ours. I realized that what our pups did was very unusual and probably had something to do with their being raised without adult wolves around. The very fact that this was unusual, however, may someday help us

find out much more about how the order of dominance forms in a wolf pack. Often scientists learn a great deal from seeing how animals act under abnormal conditions.

Games Wolves Play

Once our pups settled things between them, we had no more trouble raising them. They began eating meat when only a few weeks old, and grew and changed rapidly. At about 50 days of age, they started howling whenever they heard fire sirens. Their fur grew much longer, and the animals very much disliked heat. They always lay in the shade and often dug shallow beds in the cool soil. This probably explains why wolves in the wild usually travel and hunt at night during the summer—to escape the heat.

Gradually the pups became more and more attached to our whole family, including the dog. They followed everybody around the backyard, and played a lot.

From the first few weeks of age the pups would grab fuzzy things such as slippers and would growl, and shake and chew them. When they grew older, the wolves would take any newspaper or cardboard box they could find and shred it into little strips. One day I put on some old ragged

ightning got along well with all of the members of ie Mech family "pack," including Turpie, the dog l). Although Lightning sometimes was allowed in ie house (2), she slept outdoors, even in the winter. y raising the wolf pups, Dave Mech (3) got ideas or further studies of wolf behavior.

clothes and wrestled with the pups. As I rolled around the ground with them, they grabbed and tugged at my clothing and began peeling shreds of it off me. This reminded me very much of scenes I had seen in the wild where a pack of wolves had pulled a moose down and were tugging and ripping at it.

That's when I realized what these games were. In the wild, this kind of play would have helped the pups practice the patterns that they would use in killing and eating their prey. Instead of peeling cardboard boxes, they would be stripping fur or feathers off dead animals that their parents brought them.

It began to occur to me that wolves really aren't born with a "killing instinct." Instead, they seem to have certain *behavior patterns* that when practiced and put together during the usual life of wolves would lead to killing. Maybe someday I could raise some wolves without ever letting them practice these patterns. Then, when adults, would they ever learn to hunt and kill?

Another thing that our wolves did that looked like play was really a kind of greeting. Whenever anyone approached a pup, the animal would leap at his mouth and try to nip and lick it. This is just what one wolf does to another when they meet. Our children soon learned to cover their faces with their arms when the wolves tried to greet them.

These greetings, and other forms of playful contact, help wolf pups become attached to each other and to the adults in their pack. Such contacts also build similar *social ties* between the adults and the pups. I know that our pups really felt attached to our family, and our family to them. We realized this especially when Thunder died at the age of three and a half months from a disease called *distemper*.

No More Friends

But we still had Lightning. By the time she was four months old, she began looking more and more like an adult wolf. She weighed 37 pounds, and her feet and head were almost as large as those of adult wolves. Her fuzzy puppy fur was almost covered by a new coat of long gray hairs. She also lost several of her puppy teeth as her adult teeth began to come in.

Along with all those changes, Lightning also began acting differently. So far, she had been open and friendly to any person or dog who came into the yard. But when she was about five months old, Lightning became afraid of strangers, both humans and dogs. She also started to threaten strange dogs that ventured into neighboring yards. With dogs and people whom Lightning knew, however, she stayed just as friendly as ever. Other people who have raised wolves at home and in zoos have also noticed this behavior.

These changes in the wolf's behavior make me believe that wolf pups in the wild form their social ties during the first few months of life. In that period about the only wolves they meet are members of their own pack. So the pups can only form feelings of attachment to those animals. By the time the pups start traveling widely enough to meet strange wolves, they can no longer make social ties very easily. Instead, they become unfriendly or fearful towards the strangers. This is probably what keeps each pack separate from others in the wild. By staying apart, each group of wolves can hunt for food in a different area and find enough to eat.

Of course, it would be very hard to learn these kinds of things about wolves by studying them in the wild. This is why the study of wolves raised in captivity is so important. The wolves in our "pack," Thunder and Lightning, gave me many new ideas about wolf behavior that I want to investigate further ■

A good book on wolves, illustrated with many black and white photos, is: **The World of the Wolf,** by D. Pimlott and R. Rutter, J. B. Lippincott Co., Philadelphia, 1967, $4.95.

Climbing Water

With some common kitchen equipment you can investigate how liquids are "soaked up" in certain materials.

by Robert Gardner

■ How does a towel "soak up" water, or a blotter "pull up" ink? How can you empty a pail of water without pouring? Here are some ways to investigate and find answers to these questions. Perhaps you will also find some new questions of your own that you will want to explore.

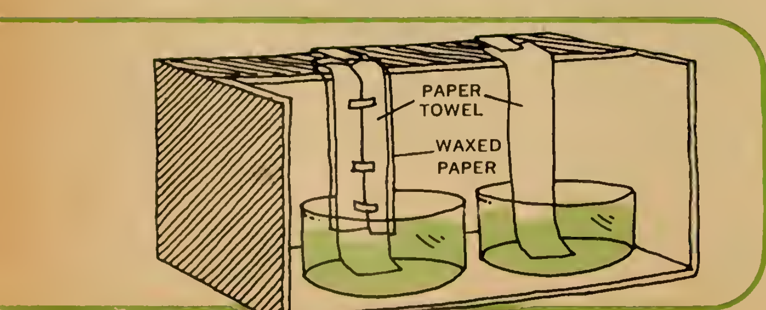
Cut a strip of paper towel or blotter paper about an inch wide and a foot or more long. Hang the strip so that one end dips into some water colored with a few drops of ink or food coloring. You can use some tape to hang the strip from a cabinet over the kitchen counter. Or you could stick it to a chair if you put the water container on the floor. You might even use a cardboard carton to make a "water soaker-upper" testing laboratory like the one shown on this page.

Watch what happens after the strip is dipped into the water. Leave the strip in the water for several hours, then look at it again. What has happened? Try the same thing with different kinds of cloth, paper, blotters, string, and other materials you think might work. What differences do you see?

Now, repeat the investigation using two paper strips, but cover one of the strips with a piece of waxed paper. You can seal the edges of the waxed paper together with sticky tape. One end of the cover should be open so the paper strip can dip into the water *(see diagram)*. Compare how the water rises in the covered and uncovered strips.

Can you explain why you got different results when the strip was covered? If not, try this: Wet two paper towels, and hang one in the air. Place the other one in a glass jar and cover it. Which towel dries faster? Why? Do you see now why water rises to different heights in the covered and uncovered strips?

But what causes water to climb up a paper towel, a piece of cloth, or a blotter at all? What enables it to "defy" gravity this way?

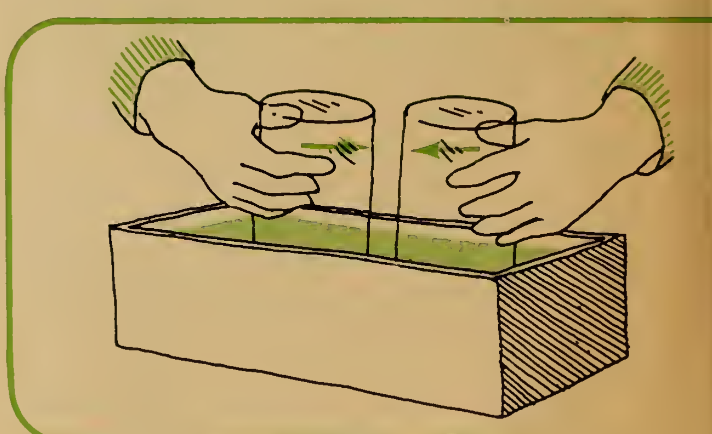


The Spaces Where Water Climbs

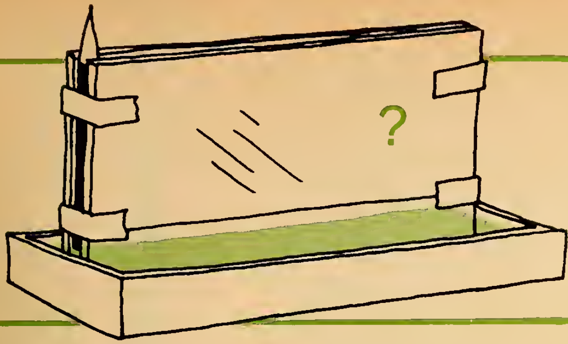
Tear a piece of paper towel, blotter, or cloth, and look at the edge through a strong magnifying lens or a microscope. You will see many tiny threads, called *fibers*. These fibers are packed together so closely that we usually don't notice them. You know that if you dip the material into water, the water will seem to "climb up" its fibers. If you look carefully with a microscope you can see that the water actually "climbs up" the narrow spaces *between* the fibers.

Does it matter how closely the fibers are packed together? It's hard enough to see the small fibers; how can you see the tiny spaces between the fibers without a microscope? Well, you can't, of course, but you don't have to. You can find out what water does in narrow spaces by doing something that you can see.

Take two straight-sided drinking glasses and place them in a tray of colored water. You can use a pie or cake pan as a tray, or you can make one by cutting a milk carton the long way *(see diagram)*. Bring the sides of the two glasses very close together. As you do so, watch what happens to the water level in the narrow space between the glasses.



If you can get two pieces of flat glass, you can do this another way. (Be careful not to cut your fingers on the edges of the glass!) Put a thin strip of wood between the plates at one end and tape them at both ends to form a thin



wedge-shaped space *(see diagram)*. Can you predict what will happen when you place this device in a tray of water?

What Makes Water Climb?

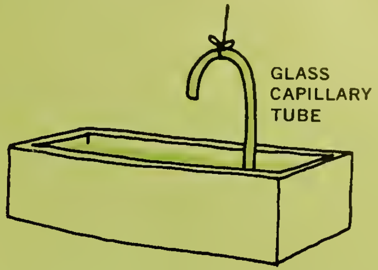
The rise of water in a narrow space or tube is called *capillarity*. It is caused by two forces working together. One force, called *adhesion*, attracts water to glass, wood, cotton, paper, and certain other substances. The other force, called *cohesion*, attracts water to water, helping to hold a portion of water together.

When water is in, say, a narrow glass tube, adhesion makes the water pile up higher next to the glass than at the center of the tube. You can see this by looking at the

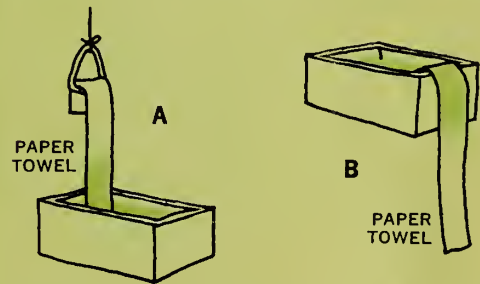
surface of the water in a drinking glass *(see diagram)*. Cohesion makes the rising water pull some more water up with it, and then adhesion makes the water next to the glass rise still farther. The water will continue to climb until the forces that pull the water up the tube are equal to the force of gravity that tends to pull the water down ■

PROJECT

A man once thought he could use capillarity to build a perpetual motion machine. He built a device like the one shown below. Will it work?



You don't need the tiny bent capillary tube that is shown in the diagram to find out if it will work. You can use the many tiny "capillary tubes" in a paper towel. As you have found, the water in a single strip of paper toweling evaporates quite fast, so you had better fold a paper towel a number of times to reduce the amount of water exposed to the air. You can check to see if the perpetual motion machine will work by arranging the towel as shown in Diagram A. To speed things up you might wet the towel before dipping one end in the water.



What will happen if you let the towel hang over the edge of the tray so that the end of the towel is below the level of the water in the tray, as in Diagram B? What can you do to make the water run out faster? How high must you raise the end of the towel to make the water stop running?

Can you explain why the perpetual motion machine didn't work?

INVESTIGATIONS

- Do you think that some liquids are more strongly attracted to paper fibers than other liquids? Try dipping strips of paper towel, all the same size and shape, into different liquids—soapy water, cooking oil, salt water, rubbing alcohol, and water. Do all the liquids rise to the same height? Might the results be different if each strip of towel were shielded by a wax paper tube? Why?

- Put some water drops on glass, waxed paper, aluminum foil, formica, and so on. Can you guess from the shapes of the drops which of these materials attract water more strongly? Do you think water would rise higher in a capillary tube made of glass or one the same size made of wax? (You might use some wax paper and two straight-sided drinking glasses to investigate that question.)

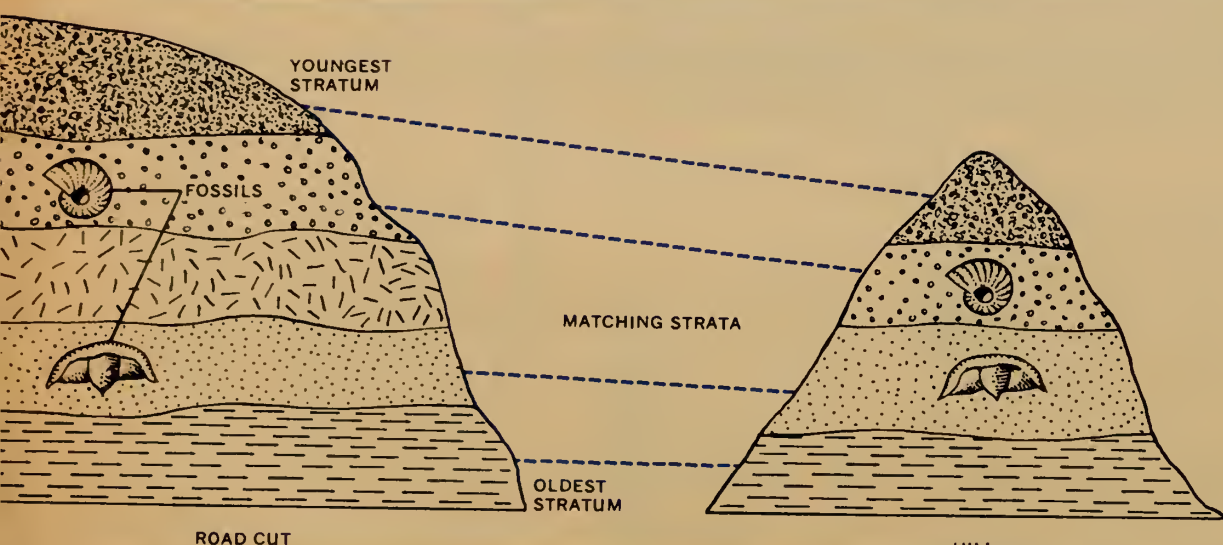
- Does the width of a strip of paper towel affect the height to which a liquid rises through it? To find out, you might test strips of paper towel or blotting paper of different widths (say from ¼ inch to 3 inches) in colored water.

Dating the Past

■ Humans began writing and keeping records only a few thousand years ago. The earth formed four and a half billion years ago, and many great events happened even before man existed. Huge mountains were thrust up, then worn away. Dinosaurs lived for millions of years, then disappeared.

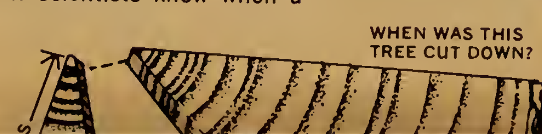
Humans have always wondered about the earth's past. Besides trying to find out what happened in the earth's long history, it is important to find out when things happened. When was Antarctica free of ice? When did the first birds develop? When did humans first reach North America? To answer these questions, scientists have searched for ways to find the age of rocks, fossils, and other clues from the past. This WALL CHART shows a few of the methods for dating the past that have been discovered so far.

Some ways of dating give scientists a fairly accurate "absolute" date: "A glacier was in this area 13,600 years ago." Other methods give only "relative" dates: "This layer of rock is older than the one above it." By using several methods and by combining information from them, scientists have learned a great deal about the earth's past ■

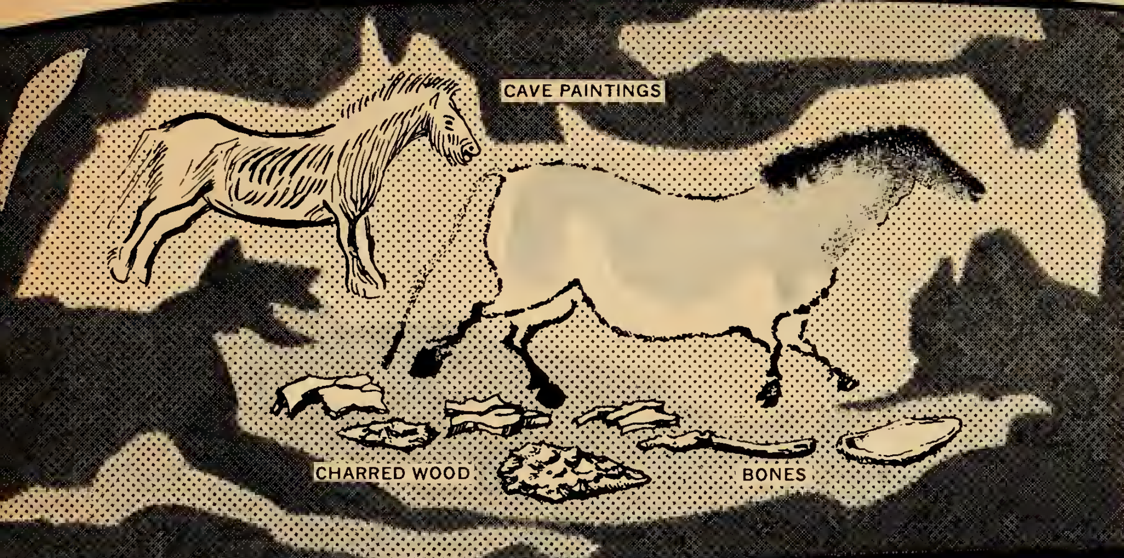


The rocks and soil that are worn away by wind and water are carried to the bottom of rivers and oceans. The layers of sand and mud build up and, over a long period of time, turn into *sedimentary rock*. Later these layers of rock are pushed up and become dry land. You can see them along road cuts, river valleys, and mountainsides. Usually the bottom layer is the oldest, the top youngest. The kinds of fossils in a layer of sedimentary rock tell its relative age, because scientists know how animals and plants have changed down through the ages. The absolute age can be found if the layer of sedimentary rock lies between layers of lava, or other rock that can be dated "absolutely" by the uranium-lead method *(see below)*.

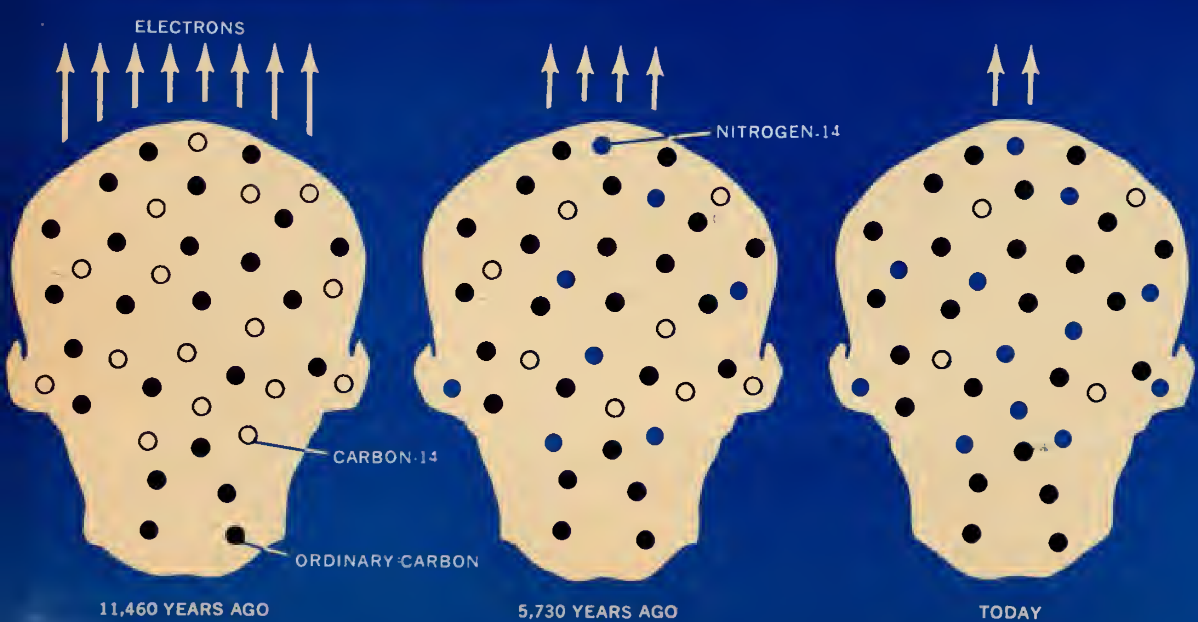
Each year a tree adds a new ring of wood to its width. Dry years produce narrow rings; wet years, broad rings. These ring patterns can be used to find the age of trees that grew in areas with similar weather. If scientists know when a certain tree started to grow or when it was cut down, they can match its ring pattern with the rings of older trees to find their ages.



heavier particles settle first, the finer ones on top of them. The heavy and fine particles from each summer's melting form a new double layer each year, called a *varve*. The varves can be counted and used to date the deposits left by glaciers as long as 15,000 years ago. Varves of known age can be used to find the age of varves from another area.



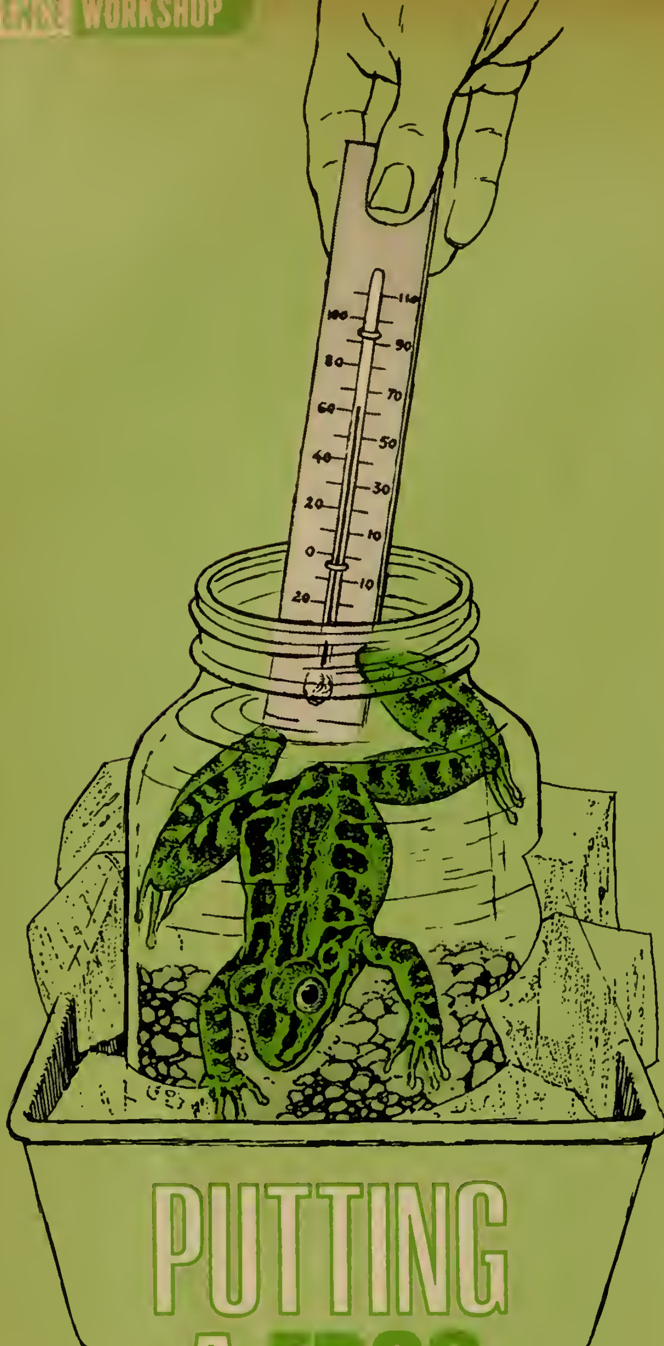
Sometimes an object from the past cannot be dated directly by any of the methods scientists have found. But the object's age can be figured out if it is found with another object that can be dated. This method has been used with the cave paintings in France and Spain. Scientists can't find the age of the paintings directly. But by using the carbon-14 dating method (*see below*), they can find the age of materials left by the painters in other parts of the caves. From this evidence, scientists believe that the paintings were done at various times between 20,000 and 12,000 years ago.



A plant or animal takes in carbon from the earth's atmosphere until it dies, and stops taking in carbon. A tiny fraction of this carbon is a kind called *carbon-14* (C-14). The atoms of C-14 in the plant or animal's remains gradually *decay*, or give off an electron and change into atoms of another element called *nitrogen-14* (N-14). It takes 5,730 years (possibly 40 years more or less than that) for half the C-14 atoms in the remains to decay. (This period of time is called the *half-life* of C-14.) Then it takes another 5,730 years for half the C-14 that is left to decay. and so on (*see diagrams*).

Scientists compare the number of electrons being given off by carbon from a piece of fossil bone or wood with the number being given off by a sample of "fresh" C-14. They can then figure out how many half-lives of C-14 have passed since the fossil was part of a living animal or plant. This only works for fossils up to about 70,000 years old. Can you guess why?

Uranium is an element that changes into the element *lead*. Uranium has a very long half-life. By measuring the amounts of uranium and lead in a rock, scientists can date rocks that are nearly three billion years old.



PUTTING A FROG "TO SLEEP"

■ If you visit a pond or stream today, you'll find it alive with animals such as dragonflies, blackbirds, and frogs. But the shortening days of autumn will trigger many changes. Within a few weeks, in the northern parts of North America the dragonflies will be dead, the blackbirds will have migrated south, and the frogs will have burrowed into the mud at the bottom of their ponds.

Each kind of animal meets the cold, bare winter in different ways. This article tells how you can investigate the way a frog is adapted to survive the winter. For this investigation you will need at least one live frog. You can probably catch one from a pond, or buy one from a pet shop. You'll also need a one-quart wide-mouthed jar, enough gravel or mud to fill the jar about two inches deep, a cake pan, some water, ice cubes, and a thermometer.

As the Temperature Drops...

Put the gravel into the jar and then fill the jar with water to within an inch of the top. Put the frog into the water. It will dive to the bottom, then come up to the top. Next place the jar in a cake pan. Take the temperature of the water and write it down. Continue taking the temperature of the water every few minutes as you pack ice cubes around the jar and observe the frog's reactions.

Watch the way the frog behaves as the water cools. Look at its throat. Is its pulse quick or slow? Does its pulse get faster or slower as the water cools?

After a while, the frog will go down to the bottom of the jar. It may try to push itself down into the gravel. Why do you think it is doing this?

After several minutes the frog may stop moving. Look at its throat to see if there is a pulse. Be sure to record the temperature of the water at this time.

Now take the jar out of the pan of ice and put it in a warm place. Watch the frog closely as the water warms. At what temperature does the animal begin to show signs of life? How long does it take for the frog to recover fully from the effects of the cold?

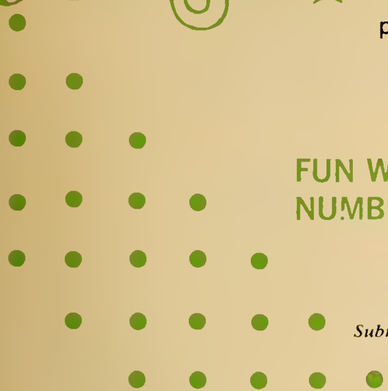
Winter Is on the Way

This fall, observe the changes in different kinds of plants and animals to see how they are adapted to the change of seasons. See if different kinds of animals change their ways of getting food. You may discover that all of the adults of some species die in the fall. How does the species survive to another year?

This investigation will give you an idea of how a frog reacts to the cold temperatures of autumn and winter. Frogs and many other kinds of animals survive winter by going into a deep, death-like sleep called *hibernation*. The heartbeat and pulse of a hibernating animal slow down so that they are hardly noticeable. If the animal is to live through the winter, however, it must hibernate in a place where the temperature around it stays above freezing. That is why frogs burrow into mud and leaves at the bottom of ponds.—ANTHONY JOSEPH

BRAIN BOOSTERS

prepared by **DAVID WEBSTER**



FUN WITH NUMBERS AND SHAPES

Arrange the dots into a square by changing the position of only six dots.

Submitted by Morgan Merritt, Anchorage, Alaska

WHAT WILL HAPPEN IF . . .

. . .the smaller test tube is released?

FOR SCIENCE EXPERTS ONLY

What causes the tops of ice cubes to bulge upward?

MYSTERY PHOTO

What is this truck carrying?

CAN YOU DO IT?

Stand with your right side touching a wall. Can you now lift your left leg without falling over?

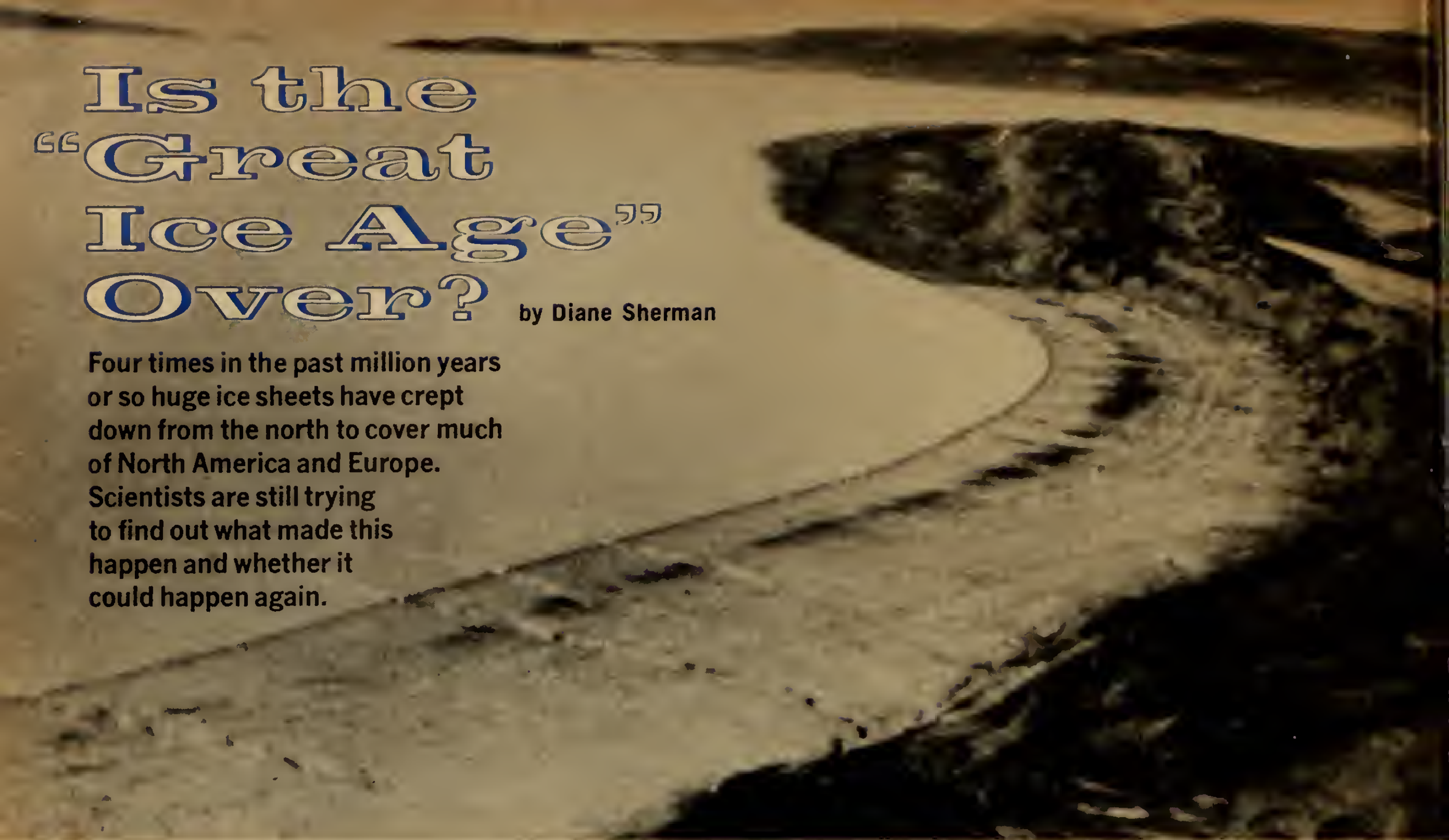
JUST FOR FUN

Make a dime dance on top of a pop bottle. Put the empty bottle in the refrigerator for about half an hour; then take it out and cover the top of the bottle with a dime. Hold the bottle in your hands until the dime begins to jiggle up and down. Can you guess why it does?

Is the "Great Ice Age" Over?

by Diane Sherman

Four times in the past million years or so huge ice sheets have crept down from the north to cover much of North America and Europe. Scientists are still trying to find out what made this happen and whether it could happen again.



This photo shows an edge of the huge glacier—up to two miles thick in places—that still covers most of Greenland. The ice sheet is slowly melting, leaving behind it a pile of rock and soil, called a *moraine*.

■ Can you picture a huge ice sheet several miles thick, extending across a whole continent? If your home is in the northern part of the United States, or in Canada, such an ice sheet, or *continental glacier,* may have covered the spot where you live *(see map).* Four separate times in the past million and a half years or so ice sheets have covered much of North America and Europe for thousands of years at a time. They last began to melt back into the Arctic regions about 15,000 years ago.

Will glaciers ever creep down from the north again and cover much of the land with mile-high blankets of ice? We don't know enough yet to say. Scientists hope to find the answer by studying the clues left behind by ice sheets of the past.

Discovering the "Great Ice Age"

For a long time, the clues that the glaciers left on the surface of the earth puzzled people. They were puzzled, for example, by huge boulders resting in places where they didn't seem to belong. These boulders, called *erratics,* are different in color, texture, and composition from any nearby rock. Often the nearest rock like a particular erratic is hundreds of miles away. Some people believed that erratics had been moved by giants, witches, or devils.

Then there was the soil in North America and Europe. In the southern parts of both continents, the soil is made of the same materials as the rock underneath. But in the north, the soil is a mixture of gravels, clay, sand, and rounded stones of different kinds. This mixture is called *drift,* because people once thought it had drifted over Europe during the flood of Noah's time, described in the Bible. But no one could figure out how water could have made *striations*—the long, straight, parallel scratches sometimes found on very hard rocks in northern Europe and America.

In 1821, a Swiss engineer named Ignaz Venetz sug-

On this map you can see how much of North America was covered by ice sometime in the past million years. The arrows show the directions in which the glaciers spread out.

gested that Europe might once have been covered by a huge glacier. He had watched mountain glaciers near his town and seen how they carried rocks (erratics) down into the valleys. He saw how glaciers left piles of stones and rubble (drift) behind when they melted back each summer. He had noticed rocks sticking out of the ice, making long, parallel scratches (striations) in rocks at the sides of a narrow valley.

At first people just laughed at Venetz's theory. Then a young Swiss named Louis Agassiz became interested. A summer studying glaciers in the Alps convinced him that there *had* been huge glaciers in the past, covering thousands of square miles of land. Gradually, other scientists began to accept Agassiz's idea of a "Great Ice Age."

How Scientists Tracked the Ice Sheets

Geologists (scientists who study rocks for clues to the earth's history) learned to trace the movements of a long-ago glacier by the clues it left behind. For example, a glacier must have passed over a place where it could pick up a particular kind of rock in order to drop "erratic" boulders of that kind farther along its trail. Scratches in rock show which way the glacier was moving. *Moraines,* which are big piles of drift that were left stranded when the glaciers melted, show how far the glaciers came.

Digging deep into the earth, geologists found layers of drift that were separated by layers of soil. This showed that glaciers had covered the land and then melted back more than once, with long periods in between when plants again grew in the soil. The thickness of the different layers, and the kinds of fossil plants and animals found in them, gave geologists a rough idea of how old the layers might be.

Putting many different kinds of evidence together, geologists have discovered that the *Pleistocene Epoch,* as the "Great Ice Age" is called, probably began between one and two million years ago. Four times in that period glaciers in North America and northern Europe grew for thousands upon thousands of years. Each time they formed ice sheets that crept southward a few hundred feet a year, covering much of the two continents. Once the ice began to melt, it retreated far to the north within a few thousand years. For thousands of years between these ice sheets, the climate was again warm—sometimes even as warm as it is today.

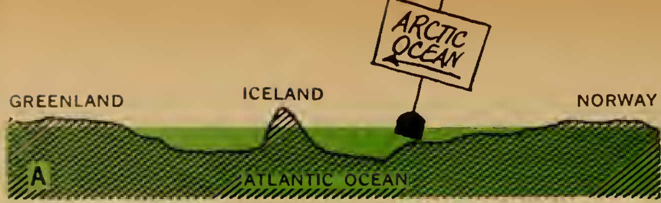
How a Glacier Grows

Much of the story of the Pleistocene ice sheets has been pieced together, but we still don't know what caused them. By studying modern glaciers, scientists have learned that they form on top of mountains whenever more snow falls in winter than melts in summer. When this happens year after year, the snow gets deeper and its weight packs down the bottom layers and turns them into ice.

Eventually the pressure of the snow and ice melts the ice at the bottom, and the glacier begins to move. It spreads slowly outward, carrying loose rocks and soil with it, flowing over low hills and around mountains. As long as more snow falls each year than melts, the glacier keeps growing and spreading.

Scientists have suggested many ideas to explain the advances and retreats of the Pleistocene ice sheets. A few years ago, Dr. Maurice Ewing and Dr. William J. Donn, geologists at the Lamont Geological Observatory in New York, proposed that they were caused by changes in the ocean currents. *(Continued on the next page)*

The boulder in the top photo is an *erratic*—a rock that was picked up in one place by a moving ice sheet, then left somewhere else. The parallel grooves, or *striations*, in the rock shown below were made by rocks sticking out of an ice sheet that passed over this rock. Both photos were taken in Central Park, in New York City.



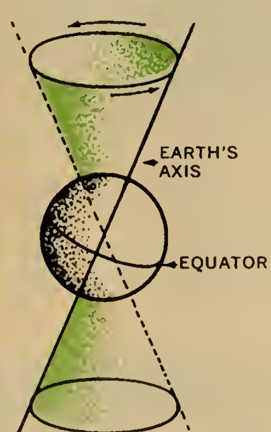
One theory suggests that warm water that flows through the shallow opening between Greenland and Norway *(Diagram A)* evaporates and falls as snow that builds up glaciers. When the sea level drops, warm water is cut off from the Arctic Ocean *(Diagram B)*. The Arctic Ocean freezes over, and without moisture for more snow, the glaciers shrink.

Is the "Great Ice Age" Over? (continued)

Warm water, they said, flows into the Arctic Ocean through a narrow, shallow opening between Greenland and Norway. This keeps the Arctic Ocean free of ice. As ocean water evaporates and then falls on the glaciers as snow, the sea level gradually gets lower. When the sea level drops below the opening, warm water can no longer flow over the land that connects Norway and Greenland.

With no warm water coming in, the Arctic Ocean gets colder, eventually freezing over. When this happens, there is no moisture for new snowstorms, and the ice sheet begins to melt. Gradually the water released from the glacier raises the sea level. Once more the land between Greenland and Norway becomes submerged, and warm water begins to flow into the Arctic Ocean, slowly melting its ice. Then the cycle begins again.

Still another theory points out that the tilt of the earth's axis changes in several ways over long periods of time, and so does the shape of the earth's path around the sun. At certain times, these changes work together to put the earth and the sun in a position that makes the winters warmer and the summers cooler—an ideal climate for the growth of an ice sheet.



Changes in the tilt of the earth's axis and in the earth's path around the sun may help cause glaciers to grow at one time and melt at another. One way the earth's axis gradually changes its tilt is shown in this diagram. This motion, called *precession*, is completed once every 26,000 years.

This theory couldn't be tested very well in the past because geologists haven't been able to tell just *when* the different advances of the ice sheet took place. Recently, though, geologists at Lamont have used new ways of dating the layers of material that has been deposited on the ocean floors in the past. Their findings seem to show that the oceans were at their present levels about 120,000 years ago and again about 80,000 years ago. Between those times, and again sometime in the past 80,000 years, the sea level was much lower—probably because much of the sea water was frozen in ice sheets.

According to Dr. Wallace S. Broecker, a geologist at Lamont, the new times suggested for the last two advances of the ice sheet were also the two most recent times when the earth and sun were in a position to make winters warmer and summers cooler. If this was what caused the ice sheet to advance each time, Dr. Broecker suggests, then ice sheets may again engulf much of North America and Europe roughly 80,000 years from now.

One of these two theories may explain why glacial periods alternated with warmer periods during the Pleistocene. But what started the cycle in the first place?

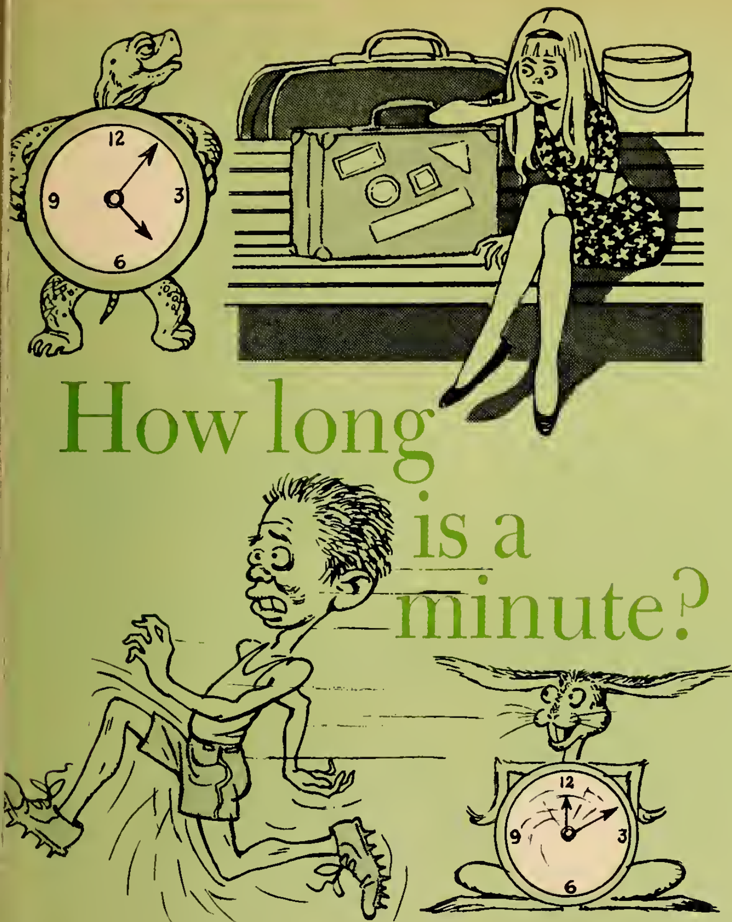
What Could Have Cooled the Earth?

Perhaps the amount of heat sent out by the sun may have dropped for long periods in the past; scientists know that it varies somewhat over short periods of time. Or perhaps part of the sun's heat was blocked from the earth by dust clouds in space, or by dust and ash thrown into the earth's atmosphere by volcanoes. (So far, though, geologists haven't found any traces of the dust or ash in rock layers that were deposited at those times.)

Another possible cause of lower temperatures may be a change in the amount of carbon dioxide in the earth's atmosphere. This gas helps to slow down the escape of heat from the atmosphere into space. Plants need carbon dioxide to grow, and some scientists think that at times there may have been such a tremendous growth of plant life that much of the carbon dioxide may have been removed from the atmosphere, causing the earth's temperature to drop.

Many scientists believe the "Great Ice Age" was probably caused by a combination of small things. A slight drop in yearly temperatures could probably help start a glacier, and temperatures normally vary a few degrees.

Most glaciers have grown smaller during the last century. Greenland's ice sheet is melting, and so is Antarctica's. As the ice returns water to the oceans, the sea level is slowly rising. It may be that we are entering a warm period that will last for millions of years. Or we may be enjoying a warm period before the glaciers come again. Someday, perhaps, we will know the answer. In the meantime, scientists will keep looking for clues to the long-range weather forecast ■



How long is a minute?

■ Can you guess when one minute has passed? Ten minutes? Half an hour? Does time seem to pass slower or faster when you are doing different things? Here's a way to test your time-guessing ability and find out some of the things that affect it.

You'll need a clock or a watch with a second hand to measure your guesses accurately. (An electric clock is best, because it doesn't "tick.") When the second hand reaches "12" on the dial, turn away from the clock. When you think 60 seconds have passed, turn back and see where the second hand is. Was your "guess minute" shorter than a "clock minute" or longer? By how many seconds?

Write "Trial 1" on a slip of paper, followed by "–10" if your guess was 10 seconds too short, or "+10" if it was 10 seconds too long. Make several more trials and see whether practice improves your time-guessing ability.

You might try counting seconds—"one, two, three . . .". Does that bring your guess closer to a clock minute? Try counting "thousand-and-one, thousand-and-two, thousand-and-three," and so on, instead of just "one, two, three." Does that help? If so, can you guess why?

Try guessing a longer period of time, say five minutes, *without* counting. Start by writing down the exact clock time in minutes when the second hand passes "12." When you think five minutes have passed, record the clock time in minutes and seconds, and figure out how close your guess was. Try guessing 10 minutes, or even half an hour. Can you guess short periods of time more accurately than longer periods?

Slow Time, Fast Time

You have probably noticed that when you are waiting for time to pass, it seems to creep along rather slowly. This is likely to make you guess that five minutes have passed in less than five minutes by the clock. If you are doing something, time will probably seem to pass faster. But how much faster? Try guessing five minutes while you read another article in this magazine, while you read a page in a dictionary, while you watch a TV show, or while you perform a household chore (such as making beds or washing dishes). Does your ability to guess time change with the kind of thing you are doing during that time? Can you explain why?

Try to think of other things that might affect your ability to guess the passing of time. How about music? Try guessing five minutes as you listen to music from a phonograph or radio. Does lively music seem to make time pass faster for you than slow music? Can you guess time more accurately on a busy street or in a quiet room? In the morning when you get up, or at night when you go to bed?

If you take time to investigate, you may find many different things that "speed up" or "slow down" the passing of time for you ■

INVESTIGATION

Give some friends and members of your family the five-minute guessing test. Test one person at a time, in the same quiet room, if possible. Try to test each person exactly the same way. Have the subject sit with his back to you and the clock, and try not to do anything that gives him a clue. Keep a record of each test on a separate card, as shown below.

When you have tested a number of people, see what you can find out by comparing their test results. Did most of them guess short of five minutes? Did most of the females guess about the same way? How about the males? Did most of the females seem to guess more accurately than most of the males? Did a person's age seem to affect the way he guessed the passing of time? You can probably think of many more questions to ask and try to answer by sorting and comparing the results of your tests.

SUBJECT: R.J.L. **SEX:** Male **AGE:** 22 **DATE:** Sept. 16, 1968

	START	END	GUESS	ERROR
Trial 1	3:35:00	3:38:50	3 min. 50 sec.	–70 sec.
Trial 2				
Trial 3				

WHAT'S NEW

by
Roger George

A leaky roof has led to the first discovery of a meteorite in the United States since 1961. At a warehouse in Denver, Colorado, workers were looking for the cause of a leak in the ceiling. They found a small hole in the roof, and just below it, a dull black, rounded stone about the size of a child's fist. Experts identified the stone as a meteorite.

As a meteoroid falls through the earth's atmosphere, friction heats it to temperatures of about 4,000°F. (The streak of light that you may see is called a meteor.) Most meteoroids burn up completely, but sometimes a part of a meteoroid may fall to the earth as a meteorite. If the Denver meteorite had fallen just a few yards away from the warehouse, it would have landed in a vacant lot and might never have been discovered among ordinary rocks there.

If smokestacks blew smoke rings, air pollution could be reduced, says Dr. Timothy Fohl of the Massachusetts Institute of Technology, in Cambridge. Smoke blown in rings from factory stacks would travel much higher than smoke released in the usual way. And the higher the smoke rises before it starts to spread out in the air, the less air pollution there will be at the earth's surface. Dr. Fohl suggests that a device could be installed in a smokestack that would shoot smoke rings 15,000 feet into the atmosphere.

Smoke damage and air pollution are alarming problems in the United States, especially around cities (*see photo*). Smoke is harmful to our throats, noses, and lungs. It also poisons plants. Cleaning up from smoke damage alone costs Americans billions of dollars a year.

Hit over the head with a heavy club, Dr. Robert F. Cade hardly blinked. Dr. Cade, a professor at the University of Florida Medical Center, in Gainesville, was wearing a new kind of football helmet that he designed. Between the helmet's plastic outer shell and its foam sponge lining there are eight small plastic bags. The bags contain oil, and they are connected by tiny passageways.

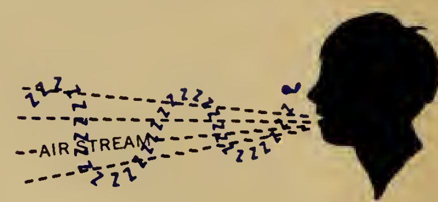
A blow at one point on the helmet squeezes the bag underneath that point, making oil flow from that bag into the surrounding bags. The flowing oil absorbs part of the force of the blow. Dr. Cade's tests show that the effect of the blow can be reduced by half—a comforting thought for football players.

Venice is sinking into the Adriatic Sea at the rate of a foot each century. This ancient Italian city is built on 120 mud islands nestled in a sheltered lagoon. The sea water between the islands forms a network of 177 canals. Lined with magnificent buildings, the canals serve as streets.

Scientists and engineers are trying to find out why the islands of Venice are sinking and what can be done about it. Gates could be built across the canals to keep the water level in the canals below sea level. But the gates would block the rise and fall of the tides, which now clean the canals twice a day and make sewers unnecessary. Also, the fish that live in the canals might not be able to survive in water that couldn't circulate between the sea and the canals.

This summer's mosquito bites were no accident. Each mosquito had the same method of attack, according to Dr. R. H. Wright of the British Columbia Research Council in Canada.

Dr. Wright and his fellow scientists have found that the carbon dioxide in the air a person exhales excites a mosquito. The mosquito then flies toward the person, moving in a zig-zag pattern through the stream of air coming from the person *(see diagram),* until it is close enough to see the "target."



If a person is protected by a mosquito repellent, however, the odor of the repellent may cause the mosquito to veer away from the stream.

"Dry" water may quench your thirst sometime in the future. Scientists have recently created "powdered" water, made by surrounding tiny droplets of water with a water repellent material. This coating around each droplet prevents it from combining with others to form a pool of liquid. The result is a dry, white powder that is easy to store yet can become "wet" water again by squeezing, heating, or adding another substance that releases the water from the powder.

There are many possible uses for "dry" water. For example, a "dry" water supply could be set aside for emergency use. "Powdered" water could also be used for drinking and cooking in places where pure water is scarce. Perhaps it could be used by astronauts in space.

This is New York City, smothered in smog. Though smog contains many dangerous gases, it is mainly smoke that we see. Smoke is made up of tiny bits of carbon, ash, oil, and other particles. The biggest particles fall to the ground as grime and soot; the rest hang suspended in the air until wind or rain remove them. A possible new way of reducing one kind of smoke pollution is described on this page.

USING THIS ISSUE...
(continued from page 2T)

of known age may be available to match ring patterns with those of a log from an ancient hut. Or outside layers may have been stripped from the log before use.

Objects found together may have been deposited at different times, by men, other animals, wind, or rivers. Or the soil may have been disturbed by farmers or road builders.

If plant or animal remains are more than 70,000 years old, too little C-14 is left in them to be measured.

- *Why can't living plants or animals be dated by C-14?* As C-14 in a living organism changes to N-14, it is replaced by C-14 from the atmosphere. Not until the organism dies does the C-14 in it begin to decrease.
- *Why can't sedimentary rock be dated by the uranium-lead method?* It is made up of particles eroded from other rocks formed long before. If one of these particles *could* be dated in this way, the age would be that of the "parent" rock, not the sedimentary "step-parent" rock.
- *Are there other dating methods?* Yes. There are other *radioactive* elements besides uranium that change into lead or some other element. Each has a different half-life, and can be used to date rocks millions or billions of years old.

Archeologists use a method called *typology* to determine the relative ages of objects such as clay pots or ivory harpoon tips by their shapes. They assume, for example, that pots of simple shapes were made before men learned to make pots of fancier shapes.

References

For you or your more advanced pupils: *Calendars to the Past,* by Gordon C. Baldwin, W. W. Norton & Company, Inc., New York, 1967, $3.48; *Science and the Secret of Man's Past,* by Franklin Folsom, Harvey House, Inc., Irvington-on-the-Hudson, N.Y., 1966, $5.

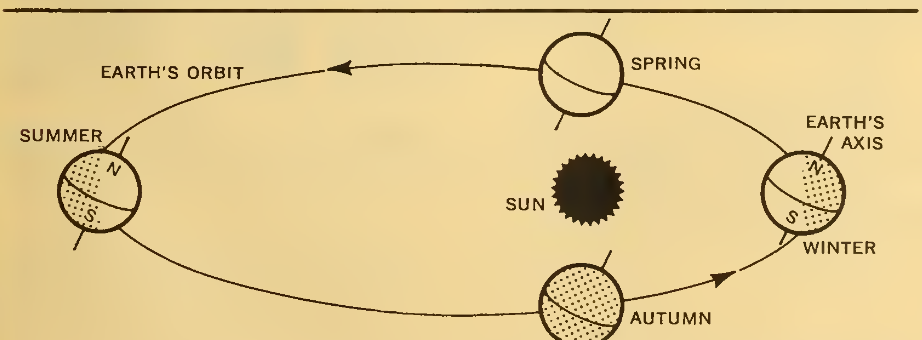
Putting a Frog "to Sleep"

Although results may vary with the species of frog and other factors, the author found that frogs usually dive to the bottom and try to burrow there when the water temperature reaches about 44° to 46°F. If you have mud in the bottom of the jar the frog will probably bury its head. The mud will be stirred up, however, so gravel is suggested as the bottom material if you want to observe the frog's attempt to dig under.

By the time the temperature drops to 41°F or lower, the frog will probably appear dead, with its body relaxed and no visible throat pulse.

Activity

- Your pupils might test the effect of cold temperatures on adult insects such as grasshoppers, crickets, and ladybugs. The insect can be put in a container and refrigerated. Can all insects be revived after being chilled for some time? Some insects, such as ladybugs, hibernate in winter, while others die, leaving eggs or other immature forms to survive the winter.



IS THE "GREAT ICE AGE" OVER? Showing your pupils how the earth's tilt and its position in orbit combine to produce the seasons (see *diagram*) may help them understand how the gradual changes in the tilt of the earth's axis (see *page 14*) and in its path around the sun might combine to make summers cooler for thousands of years at a time, favoring growth of ice sheets. When the northern hemisphere is tilted toward the sun, heat reaches more of the hemisphere, more directly (summer).

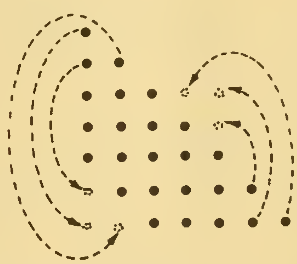
Brain-Boosters

Mystery Photo. The three long forms are racing "shells" that are used in rowing races. The canvas wrappings protect their smooth finish. The boats' oars can be seen on a rack beneath the boats. Can your pupils think of other unusual things they have seen carried on trucks?

What will happen if? With a small test tube that just fits inside a larger one, you can demonstrate that when the smaller tube is released, atmospheric pressure forces it up into the larger tube as water drains out between the two tubes. If the larger tube is more than half-filled with water, however, the smaller tube will merely fall out. (Hold it over a pan of water to cushion the fall.)

Can you do it? No one can stand that way, because it leaves his *center of mass* unsupported against the downward pull of gravity (*see "Where's Your Balancing Point?",* N&S, *Nov. 13, 1967, page 13*).

Fun with numbers and shapes. The diagram below shows one way to make a square by moving only six dots. Can your pupils find other ways to solve the problem, or make up similar dot-arrangement problems?



For science experts only. As water freezes into ice, its volume increases by about 10 per cent. Since the middle part of an ice cube is the last to form, the extra volume of ice is pushed up at the center.

No "bump" forms at the center of a frozen-over lake because a lake is not frozen solid.

Just for fun. The heat from one's hands warms up the cold air in the bottle, making it expand. The expanding air forces its way past the dime blocking the opening of the bottle, making the dime move up and down for a short while.

N & S AND YOUR PUPILS
(continued from page 1T)

these changes and how changes in one part of nature bring changes in other parts.

They know that science is the process of investigating nature and finding out how it works. They have learned how scientists of different disciplines study parts of nature from different points of view. And they have found that they, themselves, can investigate nature and its forces in an amazing variety of ways.

All these things, and more, your pupils have gained by reading articles in *Nature and Science* that catch and hold their attention, are easy to read, and present the concepts of nature and science in clear, accurate, and lively text and illustrations.

Nature and Science takes your pupils on SCIENCE ADVENTURES with scientists of the present and past; reveals SCIENCE MYSTERIES that your pupils may someday help to solve; shows them how to investigate many different parts of nature and poses questions that they can investigate for an hour, a day, or even a lifetime.

Nature and Science encourages your pupils to find out more about their world and to relate what they learn to their own lives.

It stimulates their imaginations and challenges them to think beyond the printed page; to identify "Mystery Photos" and solve scientific puzzles that provide a lot of instructive fun. It keeps them informed of current discoveries about nature. It summarizes basic scientific concepts and natural relationships for them in WALL CHARTS and other illustrations that are easy to follow and a delight to see.

Nature and Science shows your pupils that science is not just for "scientists," but for everyone who seeks to understand himself and his environment. It helps them see that they must learn to *live with* nature, rather than try to "master" it or even to just ignore it, if men are to survive at all ■

PREVIEWS OF SOME ARTICLES IN PREPARATION FOR COMING ISSUES

LIVING WITH THE ABORIGINES A young anthropologist and his wife find out how these primitive people can survive in the dry, barren, Western Australian desert.

THE SEARCH FOR BETTER TREES Foresters are trying to develop "dream" trees through the use of genetics.

THE DASHING DINOSAURS? Dinosaurs have long been pictured as slow, sluggish reptiles. A controversial study suggests that many dinosaurs may have galloped about.

TELESCOPES IN THE SKY An astronomer who helped lift two telescopes above the earth's atmosphere by balloon tells how their failures may help make satellite-borne telescopes more successful.

HOW AND WHY DO WE DREAM? Clues from eye-movements and brain waves of sleeping persons may be bringing scientists nearer a solution to this age-old mystery.

RX FOR RHINOS A zoo doctor reveals how he copes with such problems as sick snakes and finding the right food for young gorillas.

FROM THE LIGHT OF THE STARS Roy A. Gallant, award-winning writer of science books for children, tells how scientists find out what the stars are made of.

HOW DO PIGEONS FIND THEIR WAY? Observing homing pigeons from airplanes, biologists have learned something about the mysteries of bird navigation.

THE PHYSICS OF FASTENERS A WALL CHART shows how we use natural forces to hold things together.

LIFE ON A PACIFIC ISLE Naturalist Alan Anderson tells how he investigated the surprisingly complex community of plants and animals on a tiny ocean island.

THE EARTH IS A GIANT MAGNET What makes it so is a mystery that scientists are trying to unravel.

SCIENCE WORKSHOPS: Raising spiders and studying their behavior...Exploring density in a liquid laboratory ...What makes watery sap rise up a towering tree—or a celery stalk?...Adventures with a barometer...How does yeast "work" in foods and in cooking?...Making sense of measurements with peanuts, pennies, and probability...Be a bacteria hunter...

THE EARTH'S UNSTABLE CRUST A special issue examines the forces that seem to cause earthquakes, build mountains, and push the continents away from each other.

LIFE IN A CITY A timely look at the ecology and technology of cities—how cities are planned (or unplanned), why some kinds of plants and animals thrive in cities while others die out, how cities affect their own weather, and how to study the lives of common city animals.

SURVIVAL IN THE ARCTIC This special issue explores how and why men, polar bears, and many other forms of life exist in the arctic, and tells what scientists are trying to learn about life there.

nature and science
TEACHER'S EDITION

VOL. 6 NO. 2 / SEPTEMBER 30, 1968 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Recent Life Science Books for Your Pupils

by Barbara Neill

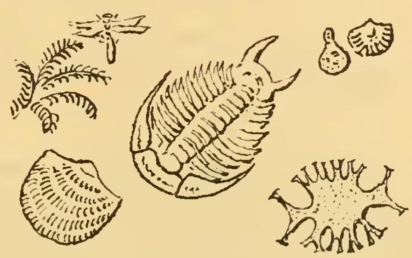
The Struggle for Life in the Animal World, by Shelly Grossman (Grosset and Dunlap, 128 pp., $4.95). Outstanding photographs taken by the author during four years of travel portray the natural world of North America and the lives of its animal inhabitants. The text is accurate, easy to read, and suitable for a sixth grader. The ecologies of a number of different communities are explored. The land requirements of animals, their numbers, competition, relationships with each other and with man are explained in a way that should awaken the reader to a better appreciation of the interdependency of life everywhere.

The Mighty Human Cell, by Patricia Kelly (John Day Co., 128 pp., $3.86 in library binding). In order to simplify a complex subject for children, a writer must know it thoroughly. In this case the author is trained in cytology and is working in the field. The result is a consistently readable book which explains so well the functions of cells that children will gain a clear understanding of the workings of the whole human body. The necessary technical words are accompanied by an explanation and pronunciation guide, and there is a glossary. A fascinating book for grades five and up.

Strange Fishes of the Sea, by Olive L. Earle (Wm. Morrow, 64 pp., $2.95). In the ocean depths there is a little fish called the great gulper that has an expandable stomach and a long spiny tail with a light organ at the tip; in the Sargasso Sea there is a fish whose ragged fins and many appendages match perfectly thc surrounding plants. Sawfishes, sea horses, stonefishes, and swellfishes are some of the other odd fishes in this book for 8- to 12-year-olds. The book will entertain children, and may arouse their curiosity to learn more. Illustrated with the author's drawings.

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York.

Wonders of Fossils, by William H. Matthews III (Dodd, Mead & Co., 64 pp., $3.25). Fossils fascinate many children and this good introduction to the subject should be just right for those from the fifth grade up. It tells of the many ways fossils are formed and of their significance to geologists and other scientists. The various kinds of fossils are discussed, and they are grouped scientifically with their classification explained. The last two chapters are devoted to finding fossils and making a worthwhile collection of them. There is an excellent bibliography.



Science Explorer: Roy Chapman Andrews, by Jules Archer (Julian Messner, 191 pp., $3.50). Roy Chapman Andrews was a scientist with an explorer's energy and temperament, and his life was a

(Continued on page 8T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 7T.)

The Case of the Deep Ocean Trail
A mysterious trail found 10,000 feet below the Pacific Occan has set scientists off on a search for the unknown animal that made it.

● **Brain-Boosters**

● **Living with the Aborigines**
In this SCIENCE ADVENTURE, a young anthropologist's wife tells how she and her husband began to investigate the lives of these native Australian people.

● **Visit to a Plant Factory**
This WALL CHART gives your pupils an inside view of how a plant functions.

● **How Dense Are You?**
Your pupils will have fun comparing the densities of different materials and objects (even the human body) in this investigation.

The Ways of a Spider
By observing and collecting spiders and their webs, your pupils can learn about the lives of these tiny animals.

How Leaves Change Color
A botanist explains what causes the colorful changes in leaves that your pupils will see this fall.

IN THE NEXT ISSUE

Part 2 of "Living with the Aborigines": gathering food in the desert ...How Aborigines used boomerangs and why some boomerangs return...SCIENCE WORKSHOP and WALL CHART on the autumn dispersal of seeds...Exploring drops.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Living with the Aborigines

Getting to know people who are in some way or other different from oneself is one of the most satisfying experiences a person can have. It is also useful, because people who live in different ways can usually learn something from each other. And it is probably beneficial to our species, because people who understand each other tend to respect each other, even if they don't agree about everything. This article will give your pupils insight into both the problems and benefits of getting to know someone "different" from oneself.

Suggestions for Classroom Use

- Have some of your pupils who have moved from one place to another try to describe their feelings and experiences in making new friends. Can they think of some things that people in the "new" place did differently from the people they lived among before? How did they go about getting acquainted? Did they invite people they had just met into their homes? Or share some candy with them? Or show them a new game or skill?

  Did they learn about something from their new friends—games, books, TV shows, foods, and so on? Did their feelings about the people in the new place change as they got to know them? Have your pupils compare their reactions with those of Mrs. Gould as she got to know the Aborigines.
- Have your pupils compare vacation trips on which they stayed with the same people a week or two with trips on which they kept traveling from place to place. In which case did they get to know the people in a new place best? Even when they spent two weeks, say, with the same people, did they find out much about how those people live every day?
- Ask your pupils whether they act the same way and do the same things when they have guests in their home as they do at other times. Or do they act differently to "please" their guests —or perhaps to "impress" them? Can they relate these experiences to the Goulds' living for months with the Aborigines? (An anthropologist can find out more about a group of people's everyday habits when he has been with them long enough for them to think of him as a group member.)

Topics for Class Discussion

- *Why are these people called "Aborigines"? Aborigine* is a general word meaning a people—or other animal, or plant—that has lived in a certain area "since the beginning." No one knows exactly when the Australian Aborigines reached that continent, but it was at least 20,000 years ago, long before Europeans settled there in 1788.
- *Are the American Indians aborigines?* Yes. Their ancestors came to North America from Asia at least 15,000 years ago.
- *Why was Dr. Gould so interested in finding out how the Aborigines made and used stone tools?* For over a million years before metals were used, men depended on tools of stone (which were used to make tools of wood or bone). Today when archeologists unearth stone handaxes, knives, scrapers, and so on, they can only guess about how the tools were made and used. Knowing that a few of the Aborigines still had this skill, Dr. Gould was anxious to see it demonstrated first hand, before the secret died out with its owners.

Visit to a Plant Factory

All life on earth depends on green plants and their ability to change energy from the sun into food energy through the process of *photosynthesis*. People tend to think that milk, meat, bread, fish, and other foods come from stores; but it all comes from green plants, either directly or indirectly.

Comparing a plant with a factory is a useful device for teaching about the food-making process in plants. Point out to your class, however, that a plant is like a factory only in a limited sense. It is a living organism, the product of millions of years of evolution, and can build, repair, and reproduce itself.

Activities

- You can demonstrate the flow of liquids up the stem of a plant by setting a fresh stalk of celery (with leaves on) in a glass of water colored with food coloring. Make a fresh cut at the bottom of the stalk and leave it overnight. The color will move up the stalk to the leaves. If you look at sections cut from the stalk you can see the colored *xylem* tubes. (Do your pupils suppose the water would rise to the tip of the stalk if you put the leafy end in the colored water?)
- To see root hairs, soak some radish seeds overnight, then keep them on a wet blotter in a dark place for two or three days. Primary roots will grow directly from the seeds, and other roots will grow from them. With a magnifying glass you will be able to see the fuzzy root hairs at the tips of the larger roots.

How Dense Are You?

After your pupils have feigned insult from this title and run out of wisecracks about "intelligence tests," they may be surprised to learn that *density* is a scientific concept describing the closeness with which matter is packed

(Continued on page 7T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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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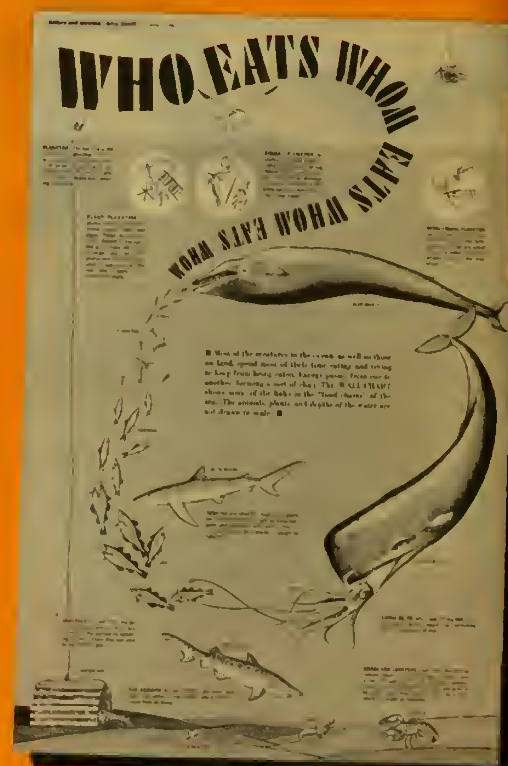

nature and science

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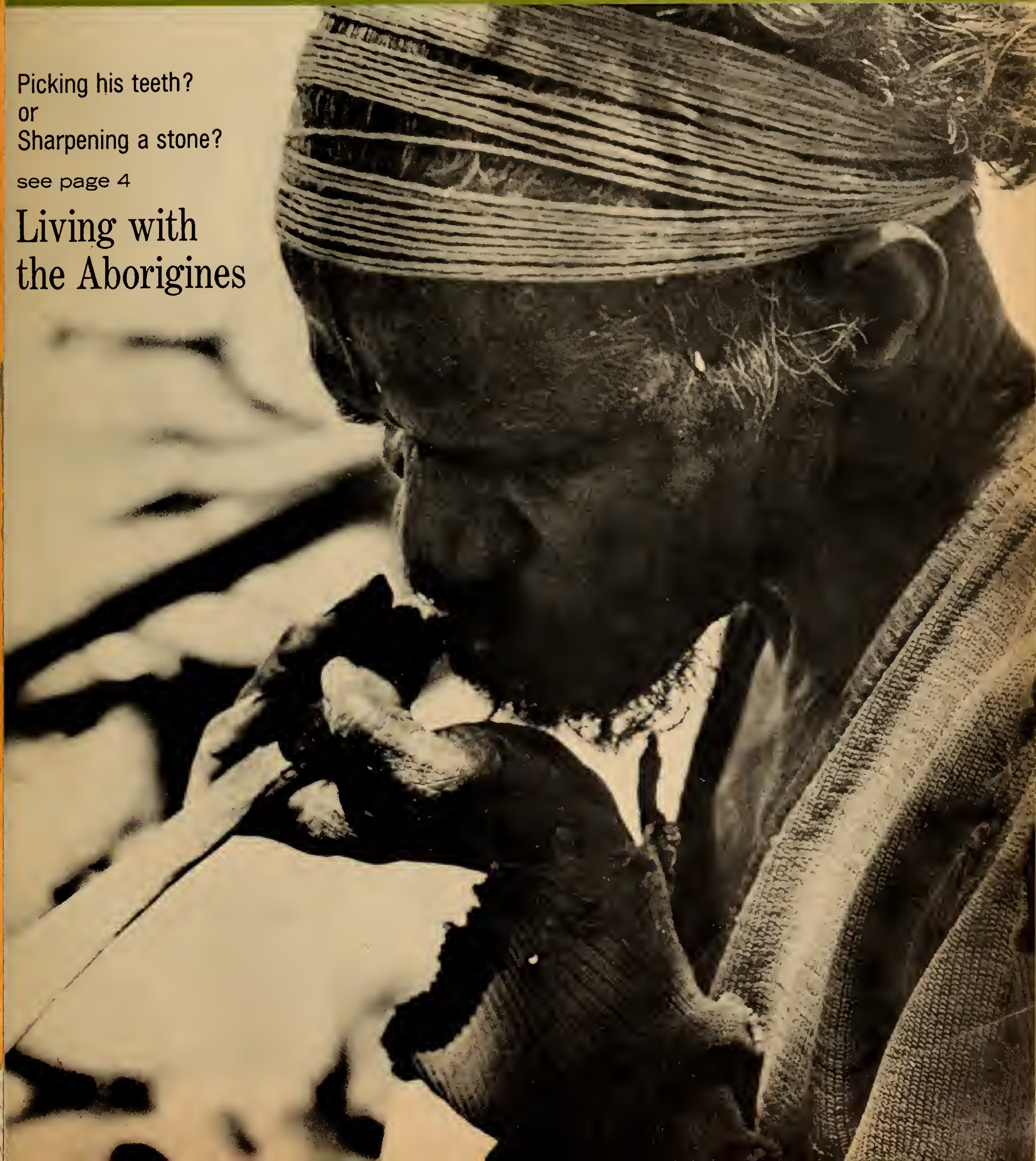
What animal made those strange tracks on the ocean floor?

see page 2

THE CASE OF THE DEEP OCEAN TRAIL



Picking his teeth?
or
Sharpening a stone?

see page 4

Living with the Aborigines

nature and science

VOL. 6 NO. 2 / SEPTEMBER 30, 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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The Case of the Deep Ocean Trail

■ About 10 years ago an underwater camera on a Russian research ship took a photograph *(Photo 1)* of the sea floor 10,000 feet under the Pacific Ocean. The curving "tire tread" marks appear to be the trail left by a deep-water animal. But what animal is it?

Two Russian experts admitted they didn't know. But they thought the trail looked like other unidentified trails photographed by British explorers in the Atlantic Ocean at almost twice the depth of the Russian photo.

Today scientists are still searching for the animals which leave these strange trails on the sea floor. In a recent issue of *Natural History* magazine, Dr. O. C. Farquhar, a geologist at the University of Massachusetts, in Amherst, wrote about some strange clues that scientists have.

These clues were found over a hundred years ago in the rocks of eastern North America. There, preserved in the rocks as *fossils*, are trails left by other mystery creatures half a billion years ago (*see Photo 2*). Dr. Farquhar compared these fossil trails with the new trail from the Pacific. He found that the shapes of the trails are similar. That means that the animals which made the old and new

Photo 1 shows the trail left by an unknown animal, 10,000 feet deep in the Pacific Ocean. The trail is about 4 inches wide. The fossil tracks in Photo 2, found in rocks of eastern North America, are between 5 and 6½ inches wide and were made half a billion years ago. At the left side of Photo 2 you can see a mark made by the animal before it started to move.

trails probably had similar bodies, including a tail which dragged along behind.

The trails are also about the same size. The new trail in the Pacific is about 4 inches wide, and the fossil trails from North American rocks are from 5 to 6½ inches wide.

The new trail in the Pacific was made in deep water in a soft ooze or sand. The fossil trails were found on dry land. But half a billion years ago, when these trails were made, a shallow sea covered much of the eastern part of North America. Later the sandy bottom of the sea hardened into sandstone, preserving the trails as fossils. So the old and new trails were made in *habitats*, or living places, that were alike in some ways.

Dr. Farquhar thinks these similarities between the old and new trails mean that the animals that made the fossil trails may have been the ancestors of the animal that left the tracks in the Pacific.

What Is at the End of the Trail?

One difference between the trails shown in the two photos is the egg-shaped imprint at one end of the fossil trail. The imprint probably is the mark left by the animal before it started to move. The photograph of the trail from the Pacific shows nothing like this egg-shaped imprint. But this may be because the photo does not show the beginning or end of the trail.

Donald W. Fisher, New York's State Paleontologist, thinks that the fossil trails may have been made by creatures that were related to the horseshoe crab (*see photo below*), which leaves a similar trail. If this is so, then the trail photographed in the Pacific may also be of some animal related to the horseshoe crab.

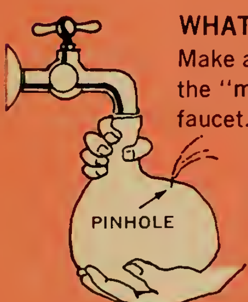
The identity of the mystery animal won't be known until the creature and its trail are seen at the same time, in the same place. As scientists explore the ocean, their underwater cameras may someday photograph the mysterious trailmaker itself ■

Two horseshoe crabs made these tracks in wet sand. Both the deep ocean trail and the fossil trail may have been made by some animal related to the horseshoe crab.

When the person who took this picture of the setting sun first saw the photo, he was surprised to see the eight crescent "moons" around the sun. Can you explain what might have made these bright marks?

MYSTERY PHOTO

prepared by **DAVID WEBSTER**



WHAT WILL HAPPEN IF?

Make a pinhole in a large balloon, and place the "mouth" of the balloon over the bathtub faucet. Turn on the water slowly and support the balloon as it fills with water. As the balloon becomes larger, what happens to the stream of water that squirts out of the pinhole?

CAN YOU DO IT?

Mix together a little salt and pepper. Can you separate the pepper from the salt?

Submitted by Gary French, La Mesa, California

FUN WITH NUMBERS AND SHAPES

Suppose that you and I had some pennies. If I gave you one of my pennies, we would each have the same number. If you gave me one of your pennies, however, I would have twice as many pennies as you. How many pennies do I have?

FOR SCIENCE EXPERTS ONLY

Can you figure out the secret message?

IFY OULOO KCA RE FUL LYYOUS HOUL
DBEAB LE TOF IGUR EOUTT HISM ESS AGE

JUST FOR FUN

Put an uncooked egg on a plate and spin it around as fast as you can. While it is still spinning, stop it for an instant with your finger. If the egg is let go immediately, it will start to spin again. This is because the insides of the egg keep spinning for a few seconds after the shell is stopped.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

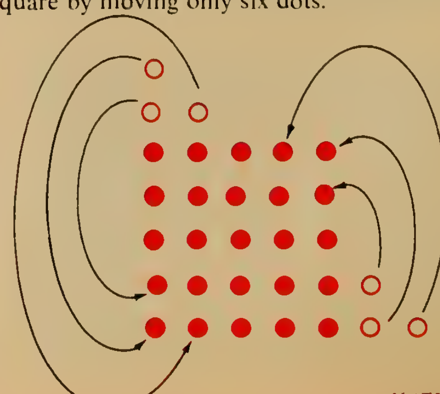
Mystery Photo: The truck is carrying three large racing shells that are used in rowing races. The boats are wrapped in canvas to protect their smooth finish. The oars are on the rack beneath the boats.

What will happen if? When the smaller test tube is let go, it is drawn slowly up into the larger test tube as the water drains out between the two tubes. Would the same thing happen if the larger test tube were three-quarters filled with water?

Can you do it? It is impossible to hold your left leg in the air while standing with your right side touching a wall.

For science experts only: An ice cube forms first around the outside; the middle becomes ice last. Since water expands as it freezes, some ice is pushed up in the center of the cube. Why doesn't a frozen lake have a large bump in the middle, too?

Fun with numbers and shapes: Here is how to form a square by moving only six dots.



A SCIENCE ADVENTURE

Living with the Aborigines

Part 1

A young scientist's wife tells how she and her husband made friends with some of these primitive people to find out how they and their ancestors managed to survive in the hot, dry Western Australian desert.

by Elizabeth B. Gould

Fresh from the desert, where they lived by hunting and gathering food, this family of Aborigines camped near a church mission. They were given cast-off clothing, waste materials for a shade shelter, and free government food.

■ When my husband and I went to Australia two years ago, we faced more than the usual problems people have when they go someplace new and try to make friends. The people we went to live with speak a different language and live by hunting and gathering food in a hot, dry desert; they have never seen an ocean or snow, or sat in a chair or slept in a bed. They are a group of people called *Aborigines* (ab-orij-in-eez), some of whom still live in the Gibson Desert of Western Australia *(see map).*

You might wonder why anyone would want to spend 15 months with people whose ways of living are so different from their own. My husband, Dr. Richard Gould, is an *anthropologist* at The American Museum of Natural History, in New York City. (An anthropologist is a scientist who studies how humans and their ways of living have changed down through the ages.) A few of the Aborigines still live in the way their ancestors did for centuries, and we wanted to find the answers to some questions that no one had asked these people, as far as we knew.

There wasn't much time left. Most of the native Australians had been moved to large government settlements where they could be taken care of and educated. Soon they would no longer need to know many of the things that made them different from any other people on earth.

Before going to Australia, we tried to prepare ourselves by reading books and talking with other anthropologists who had studied the Aborigines' way of life. We knew it would not be easy to live in the desert; we would have to carry our own food and water with us, because we wouldn't know how to find it ourselves.

In 1966 we flew to Perth, Australia, and began to gather our supplies together. We got a Land-Rover, a truck that can go through mud, over sand, and up steep hills. It had extra tanks that held 37 gallons of gasoline and 30 gallons of water. We bought a tent, sleeping bags and air mattresses, mosquito netting, lanterns, and all sorts of camping supplies.

Probably the most important piece of equipment was a two-way radio, which we could use to keep in contact with civilization or to call for help if we were in danger. To make a permanent record of our experiences, we took several cameras and a tape recorder. We bought hundreds of cans of food: meat, vegetables, fruit, milk—everything that comes in a can. It was not a very appetizing diet, but it was easy to carry and prepare.

Dust, Stars, and Kangaroos

From Perth, we drove toward a little town called Laverton, about 600 miles away (*see map*). The last 150 miles

(Continued on the next page)

were not paved, and we stirred up great clouds of dust as we drove. It was March, toward the end of the Australian summer, and the days were hot and uncomfortable. But the evenings were cool and pleasant and it was nice to roll out our sleeping bags and sleep under the cloudless sky that seemed crowded with unfamiliar constellations.

Toward evening kangaroos started to appear, hopping along and looking so ridiculous that we had to watch until they were out of sight. What was still new to us was a bother to Australians: kangaroos are a hazard to night driving; they often collide with cars.

At Laverton, we found a place to pitch our tent and spent the first day putting our camp in order. I was a little afraid of meeting the Aborigines—I didn't know if they would like me, or even talk to me. But they were our reason for being there, so we went to their camp.

There were about 350 Aboriginal people crowded together on a Government Reserve that was no bigger than a few city blocks. They lived in little *wiltja*, or shade shelters. These were once made of branches arranged in a semicircle, but were now made with old blankets and scraps of tin or canvas barely supported by crowbars and pieces of wood. The people sat around these shelters with their little fires in front of them, even in the intense heat.

The countryside surrounding the Reserve had been picked clean of firewood, and the whole place was very bare and dusty. When the wind blew, dozens of pieces of litter and garbage were picked up and whirled around the camp. Very thin *dingos,* or Australian dogs, sniffed and scavenged around the camp, and noisy crows swarmed overhead.

It was about the most depressing place I could have imagined. Where were the skilled hunters, the people who were clever enough to make their living in a parched desert? All I saw were people living in squalor and growing fat on the food given them by the government.

Meeting the Aborigines

I remembered, though, that these people hadn't been confined together like this all their lives. They could still teach us a great deal; they still must remember how to gather food and find water. So I went to meet them.

My husband had begun by showing an interest in the tools the men always carried with them—their spears and spearthrowers. He had asked about the designs on them, what kind of wood they were made of, and where those trees grew. Since my husband had a Land-Rover, he offered to take the men to find spearwood. But what could I find to talk about?

I saw a little group of young women sitting on a ragged blanket between two shelters. Armed with paper and crayons and some candy for the children, I went over to them. They politely moved over to give me some room on the blanket, and I sat down. They noticed me and they ignored me at the same time, it seemed. I felt awkward and foolish.

There were a few men sitting not far off, and one of them began to sing a fast, short song. The women roared with laughter! I was the only one who didn't get the joke, and I couldn't have felt lonelier. But I stayed and offered my paper and crayons to one of the women, indicating that I would like her to draw me a map of her "country."

The Aborigines have very close ties to their land. They know every waterhole and every natural feature of the landscape in the places where they usually hunt and gather food. They have memorized the waterholes in order, and they can draw "maps" which are merely circles connected by straight lines. Each circle, or waterhole, has a name, which I wrote down as they told me. Some of these women had been to a mission school and spoke a little English. We had learned something about their language from a

Making Tools o[f]

Dr. Richard Gould, shown leaning against a large termite hill in the desert, wanted to find out how the Aborigines made and used stone tools before the Europeans brought metal tools to Australia. One of the few Aborigines left who still know how to do this agreed to show him. He found a water-worn pebble and struck it with other stones and pointed sticks, chipping off flakes until the stone was fairly flat and thin-edged. Then he cemented it to the handle of a spear-thrower (*see photos at right*) with a lump of plant resin. To sharpen the edge, he chewed fine flakes off the stone with his teeth (*see cover photo*). It takes strong jaws and flat-topped teeth to do this, and the Aborigines get both through years of using their teeth as tools and eating gritty foods.

An Aborigine strips bark from a spear stick with his teeth.

book, so I could understand a little of what was being said.

I spent almost two hours trying to make friends, and I was uncomfortable most of that time. I felt like a curiosity in their world, and hearing so many new words and trying to remember what they meant was very tiring.

When I got up to go, I could scarcely stand up, much less walk! I had been sitting with my feet almost tucked under me, imitating their position, and both feet were asleep and prickly. Learning to live with the Aborigines, I thought, would take physical as well as mental efforts!

"America Must Be a Strange Place"

The first weeks were the hardest, with many surprises, disappointments, and discoveries. As we got to know the Aborigines better, we learned that they were very courteous and pleasant people, and they were quite willing to answer our questions. In return, they asked where we came from and why we wanted to know about them. They thought America must be a very strange place with no kangaroos or large emu birds or mulga trees.

But these Aborigines were not very happy people, because their way of life was changing so rapidly. They had been moved hundreds of miles from the land they loved, and they longed to go back to their homes. At the same time the Aborigines were learning about white people, and they, too, wanted to have things like cars and clothes and money.

We knew we would have to go farther into the desert to find Aborigines who were still hunting and gathering food on the land that meant so much to them. So after three months at Laverton, we packed up our camp and started for Warburton Ranges, a place 370 miles further up the dirt road. We were sorry to be leaving the Laverton people just as we were beginning to know them. We were sorry, too, that their lives had changed so much ■

In the next issue, Mrs. Gould tells how Aborigines living in the desert find enough food to survive.

tone and Wood—

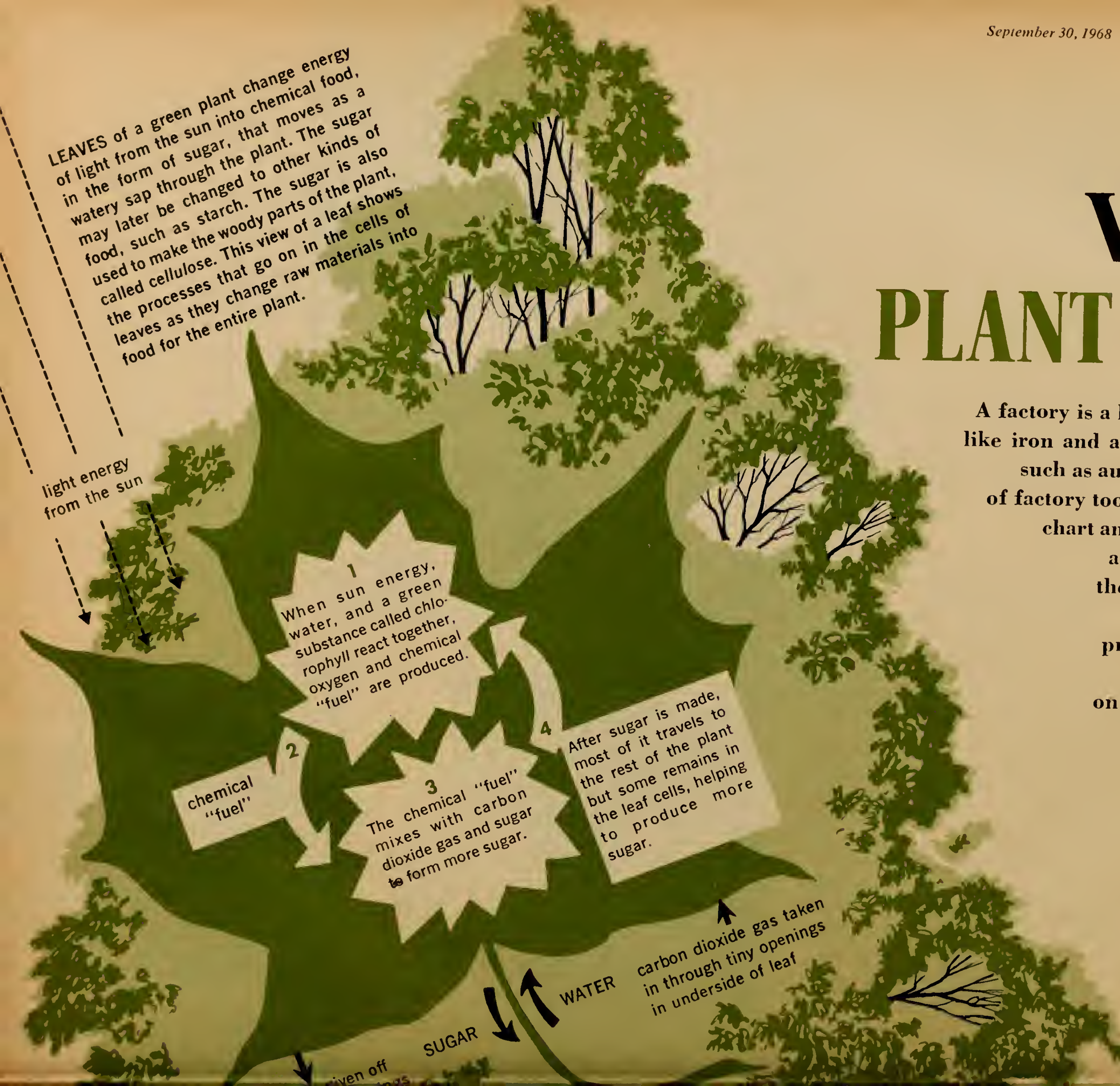
The thin, curved spear-thrower, shaped with stone tools from a piece of tree trunk, can also be used as a mixing tray or as a "clapper" for ceremonial dances. (This thrower has not yet been tipped with stone.)

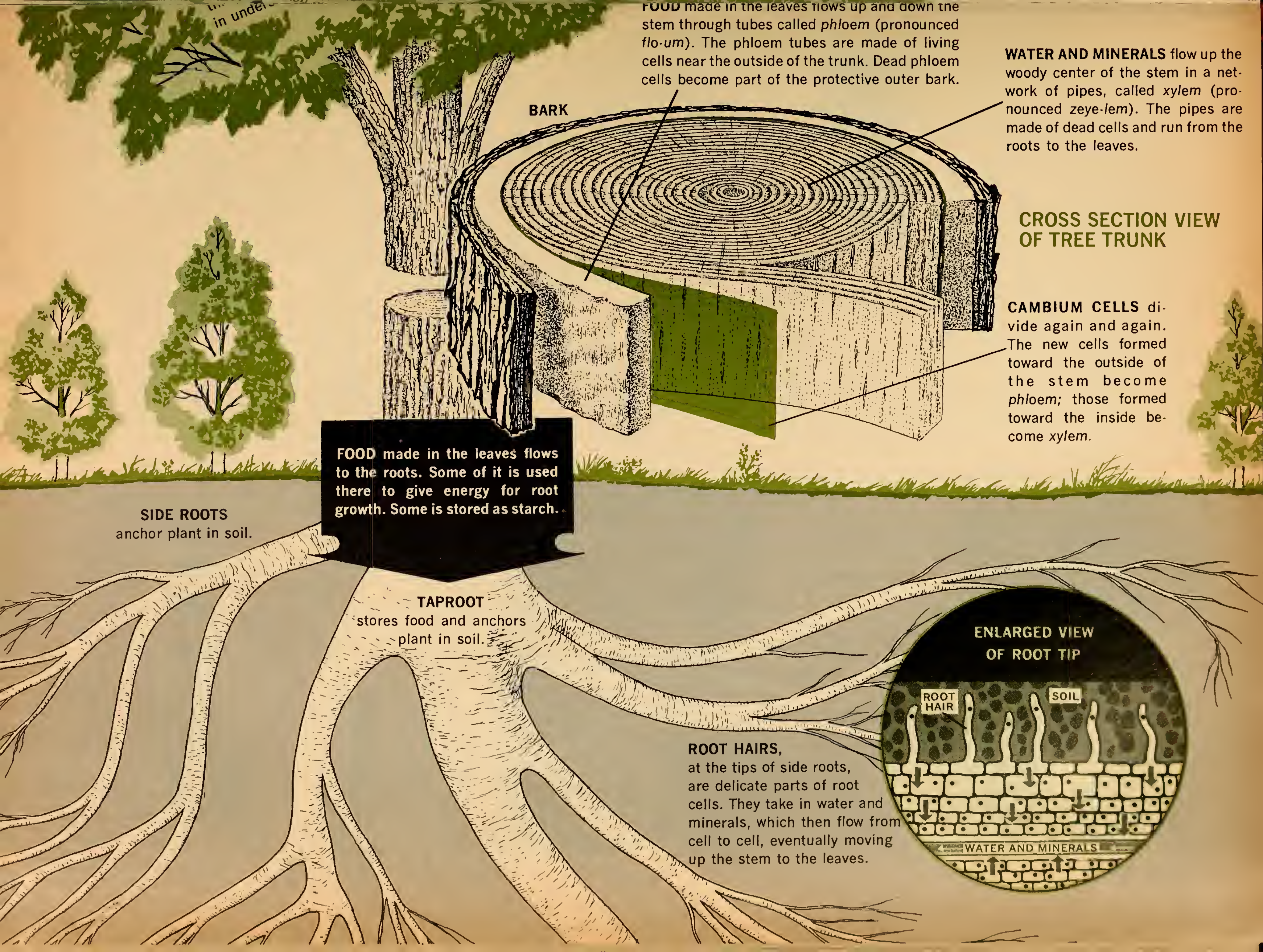
The stone-tipped spear-thrower also makes a well-balanced scraping tool for shaping and pointing a spear or digging stick. Its light weight and many uses made the spear-thrower a handy tool for people who travelled "light."

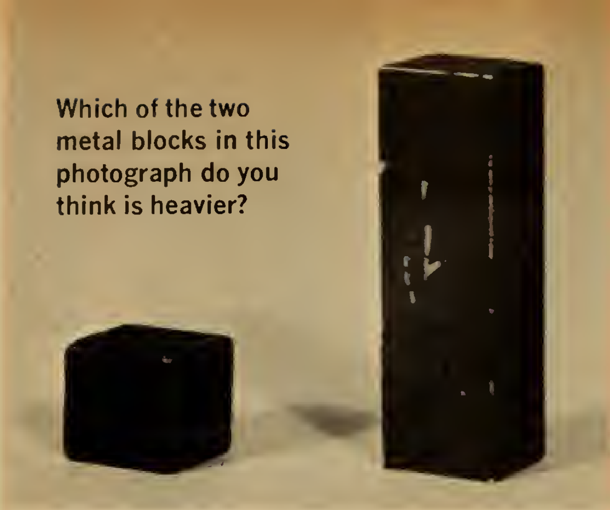
Using the spear-thrower as a lever, an Aboriginal hunter can throw a spear about 120 feet and hit a small animal. The hunter lets go of the spear as he swings the thrower forward, and a hook at the end of the thrower pushes the spear ahead with great force.

Visit to a PLANT FACTORY

A factory is a busy place, turning raw materials like iron and aluminum into complex products such as automobiles. A green plant is a sort of factory too. Take a tour of the plant on this chart and see how raw materials from the air and soil are changed into food, then used to give energy for growth of the plant's parts. The same process goes on in all green plants, and all life on earth depends on these plant "factories" for food.

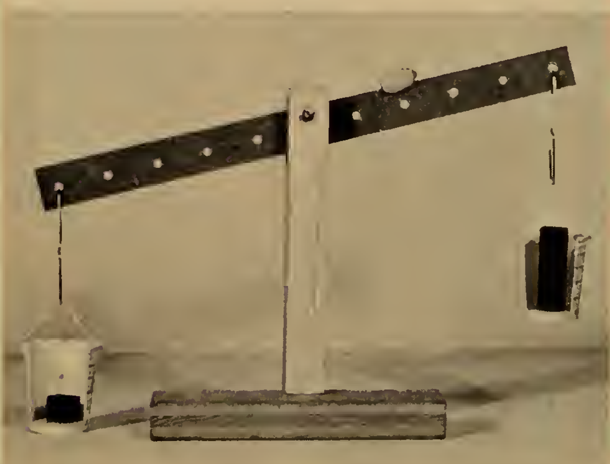



FOOD made in the leaves flows up and down the stem through tubes called phloem (pronounced flo-um). The phloem tubes are made of living cells near the outside of the trunk. Dead phloem cells become part of the protective outer bark.
BARK
WATER AND MINERALS flow up the woody center of the stem in a network of pipes, called xylem (pronounced zeye-lem). The pipes are made of dead cells and run from the roots to the leaves.
CROSS SECTION VIEW OF TREE TRUNK
CAMBIUM CELLS divide again and again. The new cells formed toward the outside of the stem become phloem; those formed toward the inside become xylem.
FOOD made in the leaves flows to the roots. Some of it is used there to give energy for root growth. Some is stored as starch.
SIDE ROOTS anchor plant in soil.
TAPROOT stores food and anchors plant in soil.
ENLARGED VIEW OF ROOT TIP
ROOT HAIR
SOIL
WATER AND MINERALS
ROOT HAIRS, at the tips of side roots, are delicate parts of root cells. They take in water and minerals, which then flow from cell to cell, eventually moving up the stem to the leaves.



Which of the two metal blocks in this photograph do you think is heavier?

You might guess that the bigger one weighs more. After all, a big rock weighs more than a small one, a gallon of milk is heavier than a glassful, and a fishing sinker weighs more than a BB. But does a ping-pong ball weigh as much as a golf ball? Does a baseball weigh the same as a tennis ball?



As you can see from this photograph, the little block is heavier than the big one. One of the blocks is made of lead; the other is aluminum. Can you guess which one is lead?

SCIENCE WORKSHOP

How Dense Are You?

■ A piece of lead weighs more than four times as much as a piece of aluminum of the same size. You might say that lead is much more *compact*—more closely packed together—than aluminum. Scientists say that lead is more *dense* than aluminum.

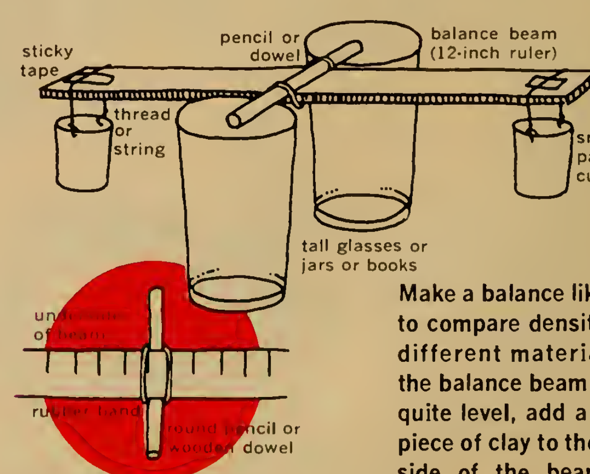
If you divide the weight of any piece of material by its *volume* (the space that it takes up), the figure you get is called the *weight density* of that material. For example, two cubic feet of water weigh 124.8 pounds, so the weight density of water is:

$$\frac{124.8 \text{ lbs.}}{2 \text{ cu. ft.}} = 62.4 \text{ pounds per cubic foot.}$$

Here are the weight densities of some materials you have probably seen. Which of these materials is the most dense? Which is least dense? Which substances seem to have about the same density?

MATERIAL	WEIGHT DENSITY (lbs. per cu. ft.)
Water	62.4
Gasoline	41.2
Aluminum	168.7
Lead	712
Gold	1,205
Iron	493
Glass	150-175
Wood (balsa)	7-8
Wood (oak)	37-56
Quartz	165
Air	0.08

You can find out which of two materials is more dense by hanging equal volumes of each material from the ends of a balance like the one shown below. Try it with a small block of wood and a clay block that you have molded to the same size and shape as the wooden block. Which block is more dense? (If you squeeze the clay block into a different shape, does its density change?)



Make a balance like this to compare densities of different materials. If the balance beam is not quite level, add a small piece of clay to the light side of the beam, as shown in the photo of a balance on this page.

PROJECT

Is a stone more dense than steel washers? To find out, you will have to figure out a way to get equal (or nearly equal) volumes of stone and washers. (Hint: An object that sinks in water displaces a volume of water equal to the object's volume.)

Is cooking oil more or less dense than water? To find out, use your balance to compare the weights of equal volumes of these liquids. (You might use a kitchen measuring cup to measure out 2 *liquid ounces* of each.) Is rubbing alcohol more dense than water? Than cooking oil?

Where Does the Drop Go?

There is another way to compare the densities of liquids. From the results of your weighings, what do you think will happen if you slowly squeeze a drop of cooking oil from the end of a medicine dropper into the middle of a container of water (*see diagram*)? Will the drop go up, down, or stay in the middle? What will happen if you squeeze a drop of water into some cooking oil? Into some alcohol?

Do you think the "drop test" for comparing densities is as useful as the "balance test"? You can find out by preparing some liquids that differ only a little bit in density. Line up four glasses about ¾ filled with water. Add one tablespoon of salt to one glass of water, two tablespoons to another, and three to another. Stir all three liquids until the salt has completely dissolved. Add a drop or two of food coloring to the liquids. You might color one liquid red, another blue, a third green, and leave the one without any salt in it clear.

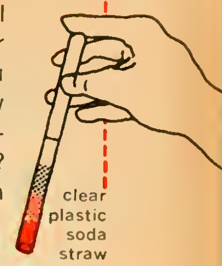
Try to work out the order of density of the four liquids from *1. Densest* to *4. Least dense* by the balance test. Now try to work out the order of densities by the drop test. You might put samples of each liquid into pill bottles or test tubes and add drops of one to the others. How many different combinations are there to try? Do you think the drop test or the balance test is better for comparing the densities of liquids?

SINK OR FLOAT

When you are in a fresh-water pool or lake and neither standing on the bottom nor swimming about, your body sinks. If you take a deep breath of air and hold it, your body floats at the surface. What does this tell you about your average weight density?

PROJECT

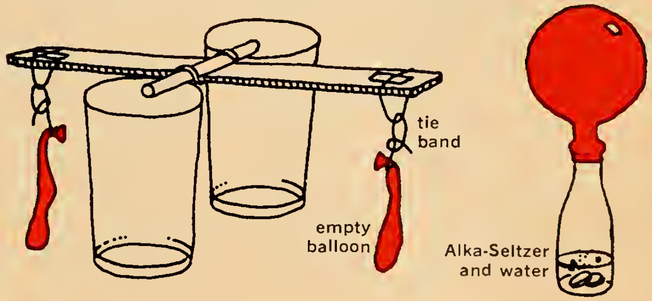
If you have some transparent soda straws or tall thin pill bottles, you might like to see whether you can layer your colored liquids. Can you make two, three, and four layers of liquids? How many *different* two, three, and four-layered liquids can you prepare from your four solutions? If you use other liquids, how many layers can you make?



You might try to find out where some other liquids would fit in your density order. Try alcohol, cooking oil, vinegar, sugar water, apple juice, milk, and so on.

Which Gas Is Denser?

As you can see in the table on page 10, air has a very low density. Do you think that all gases have the same density? Does carbon dioxide gas have the same density as air? To find out, get two balloons and tie-bands that have the same weight *(see diagram).* Then prepare some carbon dioxide gas by breaking in half three or four Alka-Seltzer tablets and dropping them into about an inch of water in a small pop bottle. Attach one of the balloons to the neck of the bottle to collect the gas. Close the balloon with the tie-band and remove it from the bottle. Then use a bicycle pump to put an equal volume of air into the second balloon. Use the balance test to find out whether one gas is denser than the other.



Suppose you replace the "pump air" in the second balloon with "lung air." How will the density of "lung air" compare with that of carbon dioxide? With that of "pump air"? Can you explain your findings? ■

MORE INVESTIGATIONS

- Using the drop test, can you find any difference in the density of hot and cold water?
- Are all solids more dense than all liquids? How about wood and water? Clay and water? Wood and alcohol? You can probably think of many other materials to compare for density.
- Is your bath soap more or less dense than water?

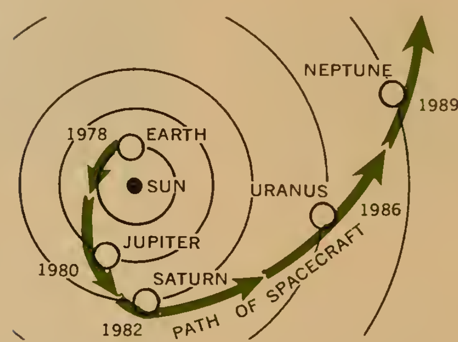
WHAT'S NEW

by
Roger George

A shot that misses can still kill a duck. When a hunter fires a shotgun at a duck, many lead pellets miss their mark and drop into the water. As ducks probe for food on the water's bottom, they often swallow these pellets by mistake. A pellet stays in the duck's gizzard until it is gradually absorbed into the digestive system. There the lead can cause poisoning and death. Scientists believe a single pellet can kill a duck in this way.

After 10 years of seeking a solution to this problem, the National Research Council of Canada reports progress. Their scientists are trying to make a pellet of lead powder held together by an adhesive that will "let go" when it gets wet. Thus the pellet would fall apart in water and be less dangerous to ducks.

A flight to four outer planets ought to be launched in 1978, say some American space scientists. At that time Jupiter, Saturn, Uranus, and Neptune will be lined up so that an unmanned spacecraft could pass close to each one *(see diagram)*. The gravitational pull of



each planet could then boost the spacecraft's speed enough to carry it to the next planet. The spacecraft would cover the 2.7 billion miles from the earth to Neptune in about 11 years. The planets won't be arranged like this again until the year 2157. Meanwhile, the only way to reach Neptune would be a direct flight lasting 30 years, and no existing spacecraft has the power to do it.

Spacecraft have flown by Mars and Venus, but no flight has yet reached the outer planets. One of the biggest obstacles in the way of such a flight would be its high cost.

Holding a fishy treat in one hand and a drugstore-window toothbrush in the other, Pedro Ponciano brushes some stains from the teeth of a killer whale at the New York Aquarium in New York City. Killer whales can be dangerous, so the keeper tries not to get too close. "I feel we have become friends," he says, "but I am not ready to get into the tank with her yet." The whale has other problems besides stained teeth. The white area on the whale's head is a treatment for sunburn.

Birds of a feather flock together, but why do they? Probably because each bird has gotten used to being with its own kind from the time it was hatched, according to Dr. E. A. Salzen and Dr. J. M. Cornell of the University of Waterloo, in Canada.

The two scientists dyed some newborn chicks red, others green, and left some yellow. When chicks of one color were raised together for eight days and then put with chicks of other colors, they stayed with chicks of only their own color. But when chicks of different colors were raised together, none of the chicks seemed to prefer chicks of its own color to chicks of the other two colors. Chicks raised alone didn't develop any color preference, unless they were able to see their own reflections in drinking water.

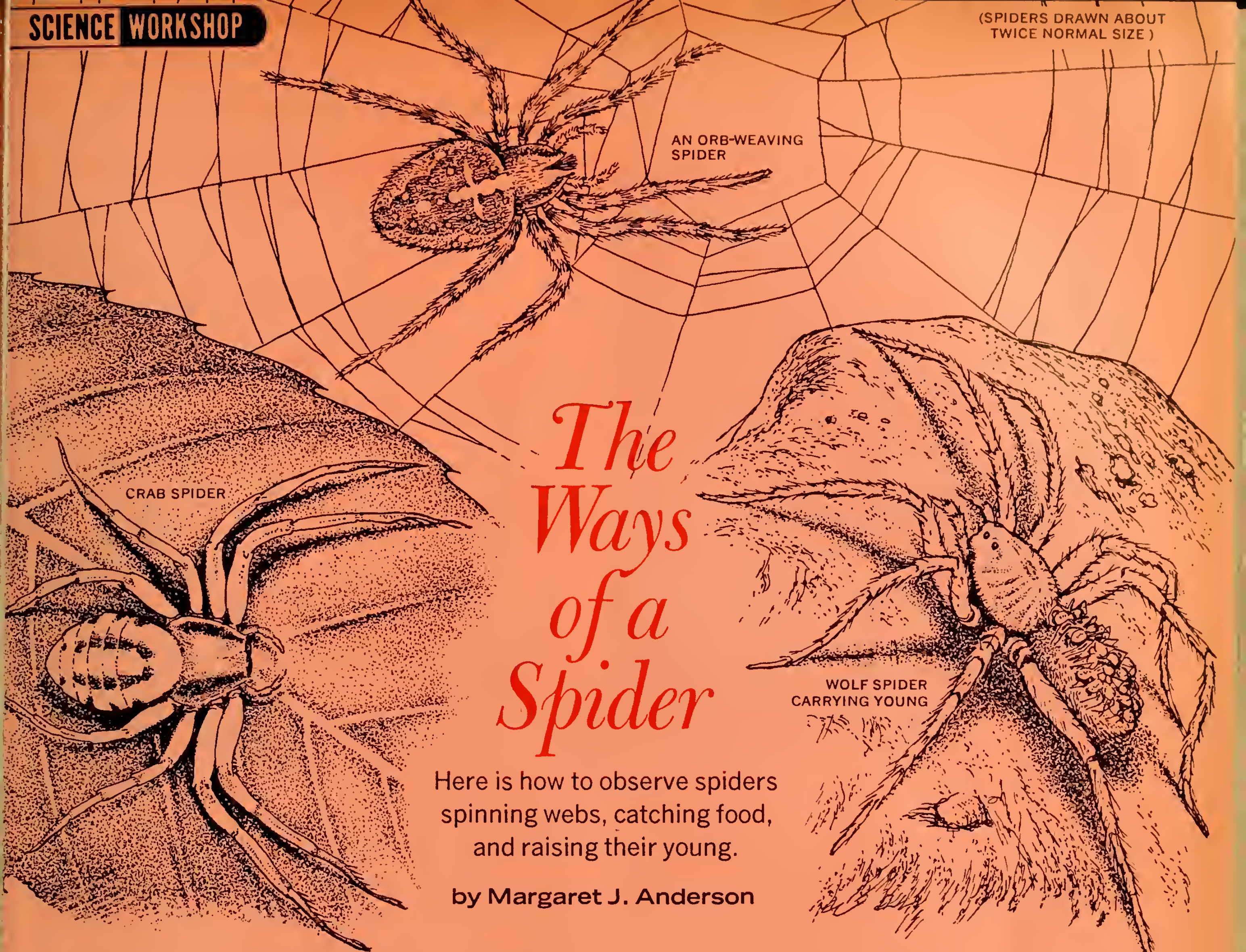
Cavemen liked flowers. At least, scientists investigating a grave deep in a cave in Iraq think they did. The scientists found the remains of a Neanderthal man who had apparently been buried on a bed of flowers.

A French scientist, Mrs. Arlette Leroi-Gourhan, found pollen of at least eight kinds of wildflowers in soil taken from the grave. The flowers were related to wildflowers now growing on the hillsides around the cave. This suggests that the flowers were gathered outside the cave and brought to the burial site.

Neanderthal men were the first prehistoric people to bury their dead, so their graves often yield valuable clues to the history of man.

Insects may hold the secret to better television reception. A TV antenna "picks up" waves of electromagnetic energy that the TV set changes into pictures and sounds. A pair of antennae on the head of an insect may detect sound waves, odors, or even light waves (also waves of electromagnetic energy).

P. S. Callahan, a scientist at the University of Georgia, in Athens, has found that spines on an insect's antennae are arranged much like the metal rods of a TV antenna and receive signals in much the same way. The insect antennae, however, appear to be far superior to any made by man. By studying the antennae of insects, scientists may learn how to build a better television antenna.



The Ways of a Spider

Here is how to observe spiders spinning webs, catching food, and raising their young.

by Margaret J. Anderson

■ Spiders live high on mountains and deep in caves, in the arctic and in tropical jungles, in dry deserts and even under water. Whether you live in a city or in the country, you can find live spiders to study.

Take a careful look at a spider. It belongs to a group of animals called *arachnids;* it is not an insect. You can see that it has eight legs and that its body is divided into two parts. An insect has six legs and its body is divided into three parts. Most adult insects have wings; spiders do not. (Some spiders seem to have 10 legs because their mouth feelers look like a small pair of legs.)

Glands in the body of the spider make special liquid which is spun out through little tubes (called *spinnerets*) and hardens into silk as it is pulled out of the body. Spider silk is used in many ways—for making webs to trap prey, for lining nests, for binding prey, and for protecting eggs. Perhaps you can discover other uses.

As a spider watcher you may see some fascinating things. You may see a wolf spider scuttling along with her egg sac attached to the underside of her body. Carefully pry off the egg sac and watch her dart about looking for it. Will she accept something roughly the same size and shape instead? After the eggs hatch, the female wolf spider carries the young around on her back until they are able to care for themselves.

Spiders get their food by trapping and hunting insects and other small animals. Crab spiders hide among flowers and catch insects that visit the flowers. Some crab spiders can even change color to match the flowers they are on. But if you find a white crab spider living in a white rose and move it to a yellow flower, you'll need patience to see the result. It takes the spider about a week to change color completely.

Life of the Garden Spider

A spider that makes a wheel-shaped web *(see above)* is the golden garden spider. It is a big, handsome spider, striped yellow and black, and up to an inch long *(see photo on next page)*. The spider usually rests clinging upside down to the middle of its web.

Wait for an insect to tangle in the web (or put one

(Continued on the next page)

The golden garden spider builds a strong wheel-shaped web in fields and gardens. When you find a web, try to find out which parts are sticky and which are not.

The Ways of a Spider (continued)

there yourself). Then watch the spider's actions. Spiders don't chew their food, although some squeeze and soften insects with their jaws. They flood their prey with digestive juices which turn parts of the insect into a liquid. Then the spider sucks in the liquid, leaving only the insect's hard outer skeleton. How long does a spider spend on a meal?

Damage the web and see how the spider repairs it. With luck you may be able to watch a spider spin its whole web. This is sometimes done in less than an hour.

In the early fall, the female garden spider makes an egg sac containing as many as 500 eggs, and then seals it with waterproof silk. Her work complete, she spends her last days guarding the egg sac, and then dies. Sometime during the winter the eggs hatch, but the tiny spiderlings stay safe inside the sac until the warm days of spring. If a spiderling gets hungry before spring, it simply makes a meal of a brother or sister!

When the spiderlings leave the egg sac they begin to explore their new world. Then, after a day or two, they crawl up a blade of grass and spin several lines of silk. The breeze tugs at the silken threads and the spiderling is lifted into the air and floats off to another area. This is called "ballooning." The scattering of the young spiders helps ensure that each one will have enough food.

If you find an egg sac in the fall or spring, put it into a jar. As the weather warms and the days get longer, watch for the spiderlings to hatch. Or you might catch a spider in the fall and put it into a jar with a few flower stems. Offer it a live fly now and then. If it is a female, and mated before you caught it, it will make an egg sac in the jar.

Once the young spiders emerge you can't keep them all together in the jar or they will eat each other. Release the spiders and watch them start on their "balloon" journey ■

■ For more information about spiders, see the book **Spiders and How They Live,** by Eugene David, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1964, $2.95.

Collecting Webs

On misty mornings in the fall you can see spider webs shining in trees and shrubs. You'll see wheel-shaped webs, funnel-shaped webs, tangled webs, and loose trailing threads. With a little practice you can collect the beautiful wheel-shaped webs.

You will need a spray can of white paint, a spray can of clear varnish, a sheet of construction paper (black or a dark color), and a fine brush. First spray paint on the web, holding the can at least two feet away. If you are too close the spray will damage the web. You may have to apply several coats in order to get paint on all the strands. While the paint is still "tacky," bring the construction paper against the web and make sure the whole web is touching it. Use the brush to gently break the foundation lines of the web at the edge of the paper. Then apply several light coats of varnish to seal the web onto the paper.

By collecting several webs, you can compare the ones made by different kinds of spiders. You might also try to collect several webs spun by a single spider. Collect a web every few days and mark the date on the back of the construction paper. What changes can you see in the webs of a single spider as the spider grows?

What gives leaves their brilliant fall colors? Why does the color vary from year to year? Plant scientists now have some answers to the question of . . .

How Leaves Change Color

by Richard M. Klein

■ Every year, as summer days shorten into fall, broad-leaved trees begin to change color. In Vermont, where I now live, the hillsides are aflame with red, orange, and yellow leaves. The colors are so beautiful that many people take tours through the New England countryside. Plant scientists *(botanists)* appreciate these colors too, but we also ask questions about the colors and about the reasons for them. We don't have all the answers, but we have learned something about how autumn colors form.

What Are the Colors?

Chemists know that there are many kinds of coloring matter *(pigments)* present in leaves. During most of the growing season, we see the *chlorophylls*—green pigments that help plants to make food. Chlorophyll is found inside roundish bodies called *chloroplasts (see diagram)* that are inside leaf cells.

Chloroplasts also contain several other pigments. Some are yellow. You can see their color in sunflowers, goldenrods, and buttercups. In tomato fruits and in carrot roots you can see red or orange pigments. All of these yellow, orange, and red pigments are called *carotenoids.*

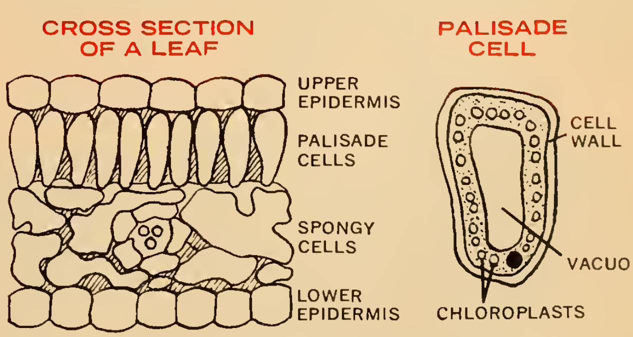
There are also small amounts of other pigments in plant cells. In the center of many cells is a bag of liquid (the *vacuole)* with red pigments inside. One of these is the deep red chemical in beet root cells. You can see other red pigments in red cabbage and radishes. These are called *cyanidins.* Finally, there are brown pigments called *tannins* in the walls of plant cells.

Because there is so much chlorophyll in leaf cells, we usually don't see the other pigments. They are hidden, or masked, by the green chlorophyll.

But in the Fall . . .

When the days begin to shorten in the autumn, the amount of chlorophyll in leaves begins to decrease. There

(Continued on the next page)



The green coloring of leaves is inside chloroplasts, which are most abundant in palisade cells. When the green chlorophyll disappears, other pigments in the chloroplasts, vacuoles, and cell walls can be seen.

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

How Leaves Change Color (continued)

are several reasons for this loss of chlorophyll, probably including some we don't even know about. Some chlorophyll disappears because of the natural aging of the leaves, and because of changes in the amount of water available in the soil. The shorter days and the cool nights slow down the formation of chlorophyll. When the chlorophyll begins to disappear, the yellow, orange, and reddish carotenoids can be seen.

This unmasking of the carotenoids causes the fall colors of many kinds of trees. The poplar trees in the western mountains of North America have leaves which become golden yellow. They lose their chlorophyll, and carotenoids show through. The fall colors of beech, elm, and sycamore trees are also caused by carotenoids.

When the chlorophyll of oak leaves disappears, carotenoids show through. There is also an increase in the amounts of tannins. There are already some tannins in the cell walls, and more are formed as the chlorophylls break down. In years when the autumn colors are dull, the browns of the tannins are about all that we see in oak leaves.

PROJECT

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

Some of the most spectacular fall colors are those in trees like the sumac and the maples. These bright reds are caused by cyanidin pigments in the vacuoles of the leaf cells. The most common red cyanidin is called *anthocyanin*. Botanists are trying to find out what causes the large amounts of anthocyanin to form.

There seems to be no one single cause. Warm sunny days and cool nights are needed. These conditions favor the build-up of sugar in the leaf cells *(see "Visit to a Plant Factory," page 8)*. Sugar is needed for anthocyanin to form. As the chlorophyll begins to disappear, sunlight penetrates deep into the cell. The sunlight apparently helps anthocyanin to form.

PROJECT

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

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

When Colors Are Best

The brightness of fall colors varies from year to year. For the brightest display, the chlorophylls must disappear quickly, the carotenoids must still be plentiful, and the anthocyanins must form rapidly. This usually happens at the end of a fairly dry period in late summer, followed by a crisp autumn with sunny days and cool nights. When the fall is cloudy and rainy, the colors are not so bright. Knowing this, you can probably predict how bright the colors will be in your area this year (if you live in a place where broad-leaved trees change color in the fall).

As the leaves continue to age, there is an increase in the brown tannins. Gradually, the yellow, orange, and reddish carotenoids begin to disappear, and anthocyanin stops forming. Just about this time, the leaves begin to fall from the trees and the winter buds harden. Finally, after a hard frost, the rest of the leaves die and the tree is prepared for its winter rest ■

INVESTIGATION

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

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

T TO A PLANT FACTORY

view of a tree shows how green plants make their own food from water, and carbon dioxide. The diagram shows the flow of nutrients e plant and explains the functions of the taproots, side roots, stems, leaves. The vital process of photosynthesis is diagrammed, step by This is an excellent teaching aid for introductory units on botany ife science.

VEL GUIDE TO THE SUN AND ITS PLANETS

is a fascinating chart on our solar system. Relative sizes of the ets are shown, and descriptive sketches of each planet tell the dis- e from the sun, the diameter, the number of satellites, the speed nd the sun, the period of revolution, the period of rotation, the sur- gravity, and the temperature as estimated by scientists on the earth. chart also includes a formula for students to use in determining what would weigh on the various planets.

"SPIRIT" THAT MOVES THINGS

chart illustrates and explains the concept of energy as a force that s many different forms—light, heat, mechanical, electrical, and chem- energy, to name a few—and can be stored or used but can never be royed. Through simple drawings and text, the chart helps children to rstand what energy is, where it comes from, and how it is changed one form to another. The chart can be used as a basis for classroom ussion and will stimulate students to look for the countless forms of gy in their personal lives as well as in the entire world around them.

ORY IN THE ROCKS

ematic drawing of the Grand Canyon in cross-section shows one of vorld's unique geologic timetables. The text explains how the canyon ormed and carved by the Colorado River, and simple descriptions tell each of the strata was formed. Another section of the chart illustrates representative fossils of each geologic period. By relating the fos- ogether with the type of rock in which they are found, students can much about the nature of the prehistoric world.

BIT ROLLERCOASTER

unusual chart deals with the annual population cycle of the cotton- It is useful in presenting the subjects of ecology, conservation, and ral life science. Few rabbits live as long as a year, and the illustra- show some of the reasons why—accidents, disease, parasites, preda- human hunters, and winter starvation. You can use this chart to many important concepts about the interdependence of all life and roblems faced by animals in their natural environment.

DISEASES GET AROUND

th and science classes gain rich new understanding from this excel- chart on disease transmission. Simple diagrams illustrate the ading of disease through unpasteurized milk, contaminated water and and airborne viruses. One panel of the chart contains a diagram h shows how vaccines protect us from disease by triggering the lopment of antibodies in the bloodstream. The chart shows that we ot get immunity to the common cold because there are 50 or more es that cause it.

EATS WHOM

ecology of the sea and its food cycle are clearly explained in this lsomely drawn chart. It explains how animal and plant plankton are eystone in the sea's food chain, and shows how minerals released by decay of dead animals and plants are returned to the food cycle as ents for the minute forms of life. The chart can also be used to the structure of various forms of sea life.

VAYS TO SUCCESS

nain ways in which plants and animals are adapted to insure the ervation of the species are shown in this striking wall chart. The ods include frequent reproduction, breeding at an age appropriate to development and life span of the individual, reproduction in vast bers, getting the sex cells together, protection of eggs, and protec- of the young. The chart is a useful stimulus for class discussion.

HORSE'S FIRST 55 MILLION YEARS

evolution of the horse is a dramatic story that quickly captures the ination of everyone. This chart uses museum reconstructions in a line presentation to tell that story, and paragraphs of text describes eet and teeth of the horse at each major stage in its development. chart has excellent applications for introducing units on evolution historical geology or for explaining the processes of adaptation and al selection.

EADING THE WORD

nunication is the subject of this chart, and it tells the story of man's of transferring knowledge from one place to another through the from the day of the cave man to the present. Fires, drums, smoke ls, trail markers, pictographs, writing, movable type, telegraphy, the hone, television, and satellite communications are among the many ods shown and discussed in this interesting and informative chart. eed for greater speed, volume, and accuracy is shown as the cause an's search to find new ways of communicating.

e Complete ection, Just $7.50

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

together in a substance or object. With simple equipment, they can compare the densities of different substances, and from the information given, they can make a good guess about the density of the human body.

Suggestions for Classroom Use

Have your pupils do their investigations at home or in the classroom, then compare their findings.

- To get steel washers nearly equal in volume to a stone (*Project, page 10*), measure the volume of water displaced from a full container when the stone is gently dropped into it; then drop washers into a full container until they displace about the same volume of water as the stone displaced.

- In "Sink or Float" (*page 10*), your pupils should be able to guess that the average density of their bodies is about the same as that of water, since the body sinks in fresh water but floats when its volume is slightly expanded by taking in air, which is not very dense.

The word "average" is important here, because different parts of the body—bone, blood, organs, etc.—have different densities. The same is true of other objects, though, because matter is never distributed with absolutely equal density through a substance. (An atom is mostly "empty space," with most of its matter packed into the nucleus. A molecule is made of atoms connected together with much empty space around them.)

- Your pupils may wonder if *density* is the same as *weight density*. *Density* is defined as the *mass*, or amount of matter, in an object or a sample of a substance divided by its volume. By comparing the masses of two samples of equal volume, the balance and drop tests show which sample is denser. To *measure* the density of a sample, we have to *weigh* it, or measure the downward pull of the earth's gravity on its mass in terms of the pull of gravity on a mass of "standard" weight—say 1 lb. or 1 gm. (For a more detailed comparison of *mass* and *weight*, see *N&S*, Nov. 13, 1967, page 2T.) Your pupils will see that knowing the weight densities of different substances is more useful than just knowing which of two substances is the denser.

A number called the *specific gravity* of a substance tells how many times denser (or less dense) than water (sp. gr. 1) the substance is. Your pupils can figure out the specific gravities of substances in the table on page 10 by dividing their weight densities by the weight density of water (aluminum, 2.7; gasoline, 0.66; and so on).

Brain-Boosters

Mystery Photo. The bright marks in the photograph of the sun may have been made by sunlight that was reflected from a metal surface inside the camera to the backs of the eight blades of the camera's diaphragm, and from there back to the film. The photographer doesn't know for sure.

If you can obtain an unloaded camera with an adjustable lens opening, you can show your pupils what the diaphragm looks like and how it works. Open the back and look through the lens while the shutter is open. Move the diaphragm control dial to various positions (or *f-stops*) to show how the diaphragm adjusts to let more or less light through to the film.

Let the pupils decide whether they think reflections from the diaphragm could have made the bright marks in the photo, or whether there could be some other way in which the marks were made.

What will happen if? If your pupils try this in their bathtubs at home, they will see that at first the water squirts increasingly farther from the pinhole as the balloon gets larger. But as the rubber stretches some more, the pinhole gets larger and the stream of water smaller.

If water is released through the neck of the balloon, the stream from the pinhole will decrease further. This is because the skin of the balloon exerts less and less pressure on the water as the balloon collapses, and also because the rubber around the pinhole has become permanently stretched, so that the hole will not return to its original size. If you try the demonstration again with the same balloon, the stream from the pinhole will never squirt as far as it did the first time.

Can you do it? Give each pupil a small amount of a salt-and-pepper mixture in a plastic bag, and see who can bring in the separated salt and pepper the next morning. One way to do this is to dump the mixture into a glass of water. The salt will dissolve, while the pepper floats to the top. Another way is to run a comb through your hair several times, then hold it above the mixture. Static electricity will draw the pepper to the comb, leaving the salt on the table.

Ask your pupils whether they think the mixture can be separated by twirling the mixture around in a container at the end of a string. (The *centrifugal effect* should force the heavier component of the mixture to the "outer" end (or bottom) of the container.) Which do they think may be forced to the bottom—the salt or the pepper?

Fun with numbers and shapes. I had seven pennies, and you had five. Problems like this are easy to make up, and your pupils may have some fun "stumping" each other with their own.

For science experts only. The letters in the secret message are in the correct order to give a normal sentence, but are split up into meaningless groups. Regrouping the letters in the same order gives: IF YOU LOOK CAREFULLY YOU SHOULD BE ABLE TO FIGURE OUT THIS MESSAGE. The children might enjoy challenging their classmates to read messages written in their own "secret codes."

Just for fun. Leave an uncooked egg on a table in your classroom to give everyone an opportunity to see how it resumes spinning after a momentary stop. After everyone is satisfied that it does, you might place a hard-boiled egg on the table, without explanation, and see whether anyone can guess what happened to this egg to make it behave differently from the other. Since the contents of the boiled egg are solidified, they will stop spinning when the shell does.

(continued from page 1T)

series of adventures. His interest ranged from whales to dinosaurs. He was for a time the Director of The American Museum of Natural History; he was the author of a dozen books, and he organized the first motorized scientific expedition into the Gobi Desert in 1922. This expedition is probably best remembered for the discovery of dinosaur eggs, but the scientists made many other remarkable discoveries. This biography, with its lively writing and careful research, will appeal to many boys and girls 12 or older.

Animal Vision, by George F. Mason (Wm. Morrow, 95 pp., $2.95). The subject of vision is not a simple one; the adaptations of animal eyes seem endless. Some mammals (such as rabbits and horses) can see behind them while facing forward, many animals can see well at night, and there is a South American fish called Anableps that has two eyes with two pupils each—one set of pupils for aquatic vision, one for aerial vision. Before any of these variations can be understood the human eye must be understood, so the book first explains the anatomy and functioning of the human eye. Though the vocabulary is often difficult, this should be a useful reference book at the junior high level.

Blood, by Herbert S. Zim (Wm. Morrow, 63 pp., $2.95). This book for 8- to 12-year-olds is a short one, with large type and pictures on every page; yet it is remarkable how much information is packed into it. The introduction is especially good, including explanations of how life in the ocean utilizes the sea water and of how land animals have had to become adapted in order to live without it. Children will learn not only the composition of blood, but also the various functions of blood, what makes blood types different, what happens when disease strikes, and how vaccines work. The text is clearly written and holds the reader's interest to the end.

Ferns: Plants without Flowers, by Bernice Kohn (Hawthorn Books, 78 pp., $3.75). Many species of ferns are difficult to tell apart, and others do not even look like ferns. In this book for 9- to 12-year-olds, children will learn to know these species, about a dozen other commonly found ferns, and closely related plants. The life story of ferns is told, and there is information on growing ferns, both indoors and out. Surprisingly, there is no mention of growing ferns from spores, an interesting project for children. The drawings are mostly adequate, but do not always show the care and accuracy needed to complement the text.

The Remarkable Chameleon, by Lilo Hess (Chas. Scribner's Sons, 45 pp., $3.25). With its prehensile tail, grasping toes, and fantastic turret eyes (swiveling independently), the chameleon is a natural for a photographer; the photos in this book bring out all its oddities. The author rightly distinguishes between the true chameleon and the little native lizard or anole sold as a pet and misnamed "chameleon." The main drawback, as far as parents or teachers are concerned, is the very attractiveness of the photos; children may want a chameleon for a pet. Fortunately, it is pointed out that they are delicate and not easy to keep. Directions are given, though, for those who still wish to try it. The text is accurate, and suitable for 8- to 10-year-olds.

Animals Are Like This and **Plants Are Like That,** both by Irving Leskowitz and A. Harris Stone (Prentice-Hall, 64 pp., $3.95). These books contain suggestions for experiments. Each chapter asks a number of related questions on a subject and gives the reader considerable information. In the book on animals, most ideas involve invertebrates. (How do ants find their way from place to place? Can a butterfly tell the difference between a sugar and a salt solution?) In the book on plants there are questions involving such things as enzymes, pigments, and photosynthesis. The books give no answers or solutions to the questions. Although there are directions for performing experiments, they are vague or incomplete, assuming considerable prior knowledge and experience on the part of the reader. The language, too, is sometimes difficult. These are books for the exceptional child, to be used, in most cases, with the help of a science-oriented adult.

The Moon of the Owls, The Moon of the Bears, The Moon of the Salamanders, all by Jean Craighead George (Thomas Y. Crowell, 40 pp. each, $3.25). These three slim books are the first in a series entitled, "The Thirteen Moons." Each follows a seasonal event in an animal's life for the space of one month. At times there is over-simplification, but the natural history is basically sound and the writing is excellent. The book on owls contains lovely, detailed drawings by Jean Zallinger. The illustrations in the bear book are decorative, but vague, especially those of plant life and insects. John Kaufmann's illustrations in the salamander book are imbued with life and capture the feeling of the text. Children from the fourth grade up should enjoy these books.

The World of the Ocean Depths, by Robert Silverberg (Meredith Press, 156 pp., $4.95). The hidden land beneath the sea is fully as rugged and complex as the familiar land above it. There are drowned mountains taller than Everest and depths reaching down more than seven miles. The ocean contains life at all depths, in some places in incredible numbers. The author presents a comprehensive view of the subject, from basic facts to the latest theories and ideas for possible future uses of the sea. Ably researched and well written, this timely book should interest a wide audience of children from the sixth grade up.

Karl Patterson Schmidt, by A. Gilbert Wright (pub. by M. Evans and distributed by J. B. Lippincott, 127 pp., $3.25). As a renowned herpetologist, a trained geologist, and an outstanding field naturalist, Karl Schmidt lived an exceptionally full life. From the time he was a young student on a Wisconsin farm, keeping notes on a captured pine snake, to many years later when he sailed as a scientist on an important expedition into the South Pacific, his life is a fascinating story. It makes easy reading for children in the fifth grade and above. But it seems too bad that a book about a herpetologist should contain misleading statements and errors concerning reptiles and amphibians, mostly occurring in a 21-page appendix on nature projects.

nature and science

TEACHER'S EDITION

VOL. 6 NO. 3 / OCTOBER 14, 1968 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Living with the Aborigines

Mrs. Gould's delightful account of a day with the women of a group of Australian desert Aborigines will give your pupils some idea of the importance of food-getting activities in a "hunting and gathering" society. You might point out that our ancestors lived this way—by hunting, fishing, and gathering edible parts of wild plants—for thousands of years before they began to raise plants and animals for food.

Through class discussion of Mrs. Gould's articles and the topics suggested below, you can help your pupils understand how the way in which we get our food tends to shape our other ways of living.

Topics for Class Discussion

• *Can you guess why the Bushmen of the Kalahari Desert in Africa and the desert Aborigines of Australia still make their living by hunting and gathering, instead of by farming and herding?* So little rain falls in these deserts (less than 8 inches per year on the average in the Gibson Desert of Western Australia) that these people are hard put to find enough water for personal use, much less for farming or raising food animals.

• *Why do the desert Aborigines live in such small groups and build only shade shelters made of bushes?* The supply of food and water within an area that they can cover on foot in a day will support only a few people for a short time; then they have to move to a new area to find more food and water. Brush shelters provide some protection from the desert sunlight, and fires help warm them in the cold desert nights; building a more permanent shelter would be a waste of valuable time. A tent would be just one more thing to carry, along with weapons, tools, and bowls, when they walk to a new area.

• *Do you think the desert Aborigines are "primitive," or "inferior" to other peoples, as they are often called?* It depends on what you mean by these terms. The Aborigines don't have many material possessions, but they couldn't carry many around with them anyway. And finding enough food and water to survive doesn't leave them much time to make or do other things. Still, as Mrs. Gould points out, they have developed great skills in finding their way around the desert; in making simple, easy-to-carry tools that serve many different food-collecting purposes; and in finding food and water in places and ways that other people would never think of. Mrs. Gould's lack of these vital skills probably made her seem "primitive" and "inferior" to her Aboriginal friends.

The Aborigines also decorate their weapons with artistic skill and hold

(Continued on page 2T)

MYSTERY OBJECT CONTEST

Can any of your pupils stump Mr. Brain-Booster by sending him an object, or photo of an object, that he can't identify? See page 12.

IN THIS ISSUE

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

• **Living with the Aborigines**
This delightful account of their food-getting activities raises some important questions for your pupils to consider (*see column 1*).

Not All Boomerangs Boomerang
A look at the aerodynamics of the boomerang—why some fly straight and others return.

The Traveling Seeds
• **How Seeds Get Around**
A SCIENCE WORKSHOP investigation into seed dispersal and a WALL CHART showing some of the forms this survival mechanism takes in different plants.

• **Brain-Boosters**

• **What Makes a Drop?**
Your pupils can explore the shape and size of liquid drops and find out how surface tension holds drops together.

• **"Surfing" to Safety**
How the Stenus beetle uses the force of surface tension to escape a predator that walks on water.

IN THE NEXT ISSUE

A special-topic issue explores the efforts of scientists to explain the activities inside the earth that cause earthquakes, volcanoes, mountain formation, and perhaps continental drift.

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

fairly elaborate ceremonies honoring or appeasing the "spirits" of the animals and plants that they depend on for survival. Their rules for such ceremonies, for deciding who can marry whom, for getting along with other groups of Aborigines, and so on, are just about as complicated as our own rules about such things.

• *You can see that the desert Aborigines' life is shaped almost completely by their way of getting food. How does our way of getting food affect our lives?* The "invention" of farming and herding about 10,000 years ago gave men a more reliable source of food; made them settle in one place instead of roaming around in search of food; and freed some people from food-getting work. This led to the beginnings of what we call "civilization" *(see "When Men First Learned To Farm,"* N&S, *Nov. 14, 1966).*

In the United States, modern farming machinery and methods enable less than 10 per cent of the people to produce enough food for the entire population, freeing the others for activities such as manufacturing, building, education, the arts and professions, entertainment, and so on. Rapid transportation of food over long distances; preserving foods by canning, freezing, and other processes; and distributing foods in packages through stores all over the nation—these things make it possible for people to live just about anyplace they wish, instead of in or near a place where food is raised.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

(You might point out that while nearly all peoples get their food by farming and herding today, the lack of good soil, fertilizers, and modern machines and farming methods keeps people in many countries from being able to feed themselves adequately. Also, no one knows whether farming and herding—on the land and even in the oceans—can supply enough food for all of the earth's rapidly increasing human population.)

• *How does the desert Aborigines' way of getting food affect their* natural environment—*the soil, water, air, plants, and animals where they live?* When the Aborigines leave an area (to search elsewhere for food), the soil and air have not been changed at all; in time, the living things grow back, and the water is replenished. By living *with* their natural environment, the Aborigines have survived for thousands of years.

• *How does our way of getting food affect our natural environment?* Farming *changes* the natural environment irreversibly. The *natural cover* (grass, forests, rocks, etc.) must be removed from land to raise crops on it. (Overgrazing by herds of animals often destroys the cover in dry areas.) Rainwater that would be held in the soil by the natural cover tends to run off the "uncovered" land swiftly, carrying part of the topsoil along with it (and sometimes producing floods). In dry seasons, strong winds also carry away dry topsoil. (The topsoil, formed over millions of years, is only 2 to 5 feet deep in farming areas of the U.S.)

Building dams and canals to irrigate dry farmlands slows up the flow of water in streams, making them drop silt that eventually chokes up the dams and canals. Pumping water from wells uses up the ground water faster than it is replenished, and often lets salty water seep into the ground water supply.

Fertilizers washed from farmlands into lakes increase the growth of water plants that choke off life in the lakes *(see "How To Kill a Lake,"* N&S, *Apr. 1, 1968).* Raising one kind of plant on acres of land encourages insects that feed on that plant to grow in numbers, sometimes to "plague" proportions. *Biocides*—chemicals used to kill weeds and insects—drift in the air and wash into the soil and water, poisoning many fish, birds, and other animals.

Even the highways, railroads, warehouses, factories, and stores we build to carry, process, and sell foods often destroy natural cover and expose topsoil to erosion (wearing away by wind and water). Trucks, trains, and ships that carry our food supplies help pollute the air and oceans with fumes and oil wastes.

We are just beginning to understand that in changing our natural environment to produce more and more food for more and more people, we may be endangering the food supplies, the health, and perhaps even the survival of future generations.

• *Do you know of any edible plants and animals that grow wild in your environment?* This will be a hard question to answer, for reasons that merit discussion: 1) Where many humans live, there is usually very little wildlife left. 2) Our food habits make some things seem inedible that would be considered delicacies by people who live by hunting and gathering. 3) Lacking the *need* to recognize and find wild foods, few people today learn how to do it.

Your pupils may think of a few things, such as nuts, berries, and dandelion greens, but they will probably realize that the amount of such foods in their area would not feed many people for very long.

One of your pupils might read and report to the class how a man and his wife managed to survive for two weeks on an uninhabited island in Lake Superior by hunting and gathering food. This fascinating and revealing adventure is related in a two-part illustrated article, "Desperate Vacation," by Patrick K. Snook, in *National Wildlife* magazine for February-March and April-May, 1968 (available at some libraries or possibly from a member of the National Wildlife Federation, which publishes the magazine).

How Seeds Get Around

The dispersal of plants and animals is often essential to their continued existence. Point out to your pupils that

(Continued on page 3T)

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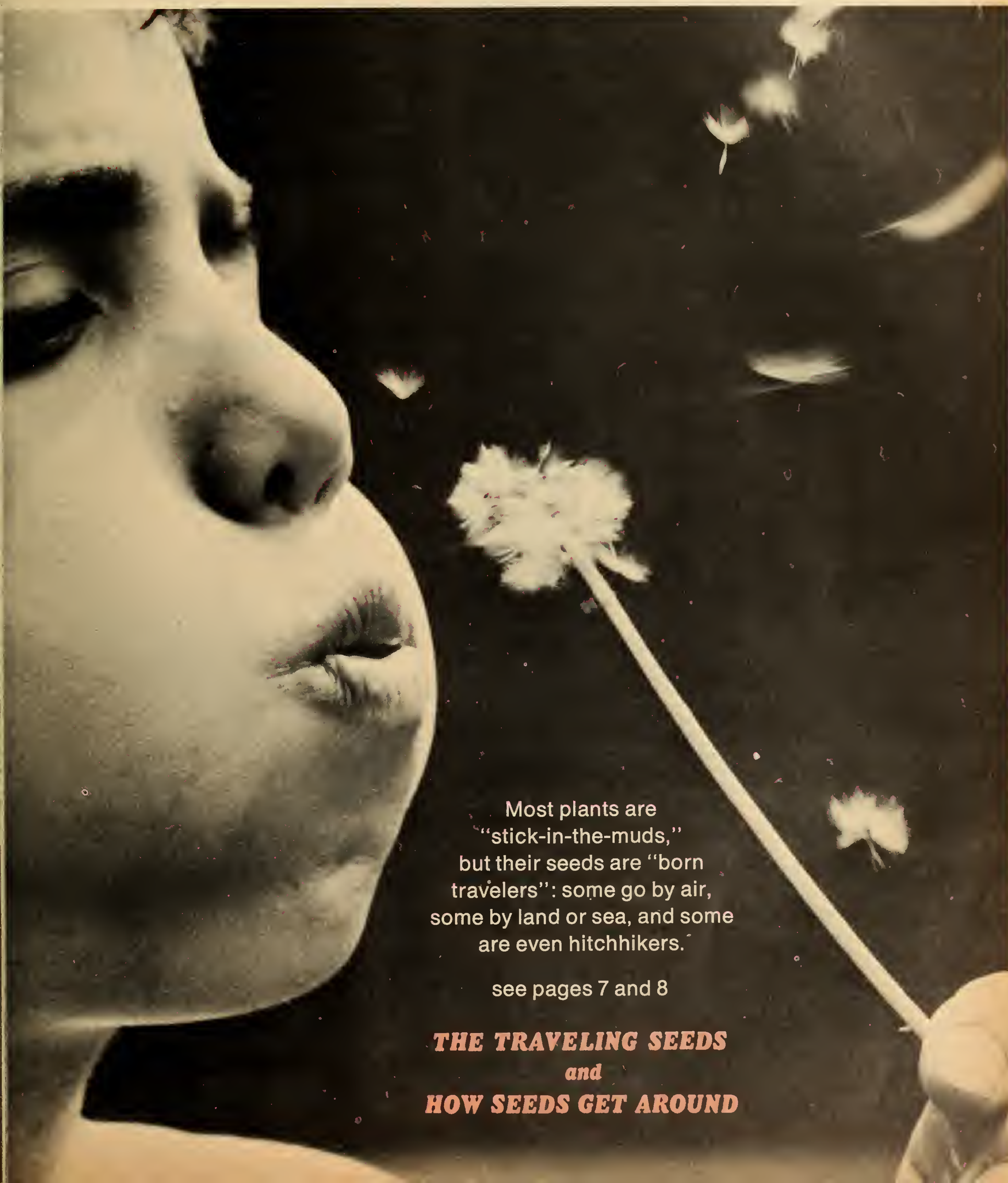
Are all drops of water the same shape and size? You can find out what holds them together.

see page 13

WHAT MAKES A DROP?



Most plants are "stick-in-the-muds," but their seeds are "born travelers": some go by air, some by land or sea, and some are even hitchhikers.

see pages 7 and 8

THE TRAVELING SEEDS
and
HOW SEEDS GET AROUND

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 EDITOR** R. J. Lefkowitz; **ASSISTANT EDITOR** Margaret E. Bailey; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen **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 September, October, December through March; monthly November, April, May, 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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Living with the Aborigines

Part 2

by Elizabeth B. Gould

■ When we got to Warburton Ranges, we found only a small church mission where Aborigines often camp and get some food supplied by the Australian government. Sometimes, though, they go off in groups of a dozen or so to live in the Gibson Desert as their ancestors did.

We spent about seven months, altogether, living with the Aborigines out in the desert. We found that the most important things in these people's lives are food and water —especially when they are trying to survive in the desert.

We tasted the food that our friends offered us *(see photo)* but mostly we lived on the food we brought in cans. It wouldn't have been fair to expect them to feed us, because finding enough food and water to keep themselves alive takes most of their time and energy.

The Daily Search for Food

When morning comes, an Aboriginal woman of the desert knows she will have to spend much of the day gathering food for her family. She cannot reheat yesterday's "leftovers," because there is probably no more than a crust of seed cake or a kangaroo's head with a few shreds of meat clinging to it left from yesterday's meal. And she cannot depend on her husband to bring home a freshly-killed kangaroo or emu bird; such a large animal is a rare treat.

The women leave camp in small groups while the morning coolness is still in the air. Often I would go along with them while they gathered food. One night some of the women told their friends that they had found large areas of a ripening seed called *wangunu*. They had filled their bowls with it, but there was plenty left for several more n the last issue, Mrs. Gould told ow she and her husband, an nthropologist at The American Museum of Natural History in New ork City, made friends with a roup of native Australians who ere living on a government eservation. The Goulds began to earn the language of these eople and something about their ay of life. Then they drove eeper into the desert to find ut how some Aborigines live n the way their ancestors ved for centuries.

Mrs. Gould samples *yawalyuru* berries picked by an Aborigine in the Gibson Desert. These people roam the desert in small groups, getting most of their food by collecting small animals and the edible parts of wild plants.

ays' collecting. So the women started off early the next orning, each with her digging stick and a wooden bowl, she had one. The small children tagged along; some were icky enough to get a ride on their mothers' backs.

On the way to the wangunu seed, everyone kept a sharp ookout for other food. Sometimes they saw a tree bearing few hard, round, green fruits called *kalkurla*. Often they opped berries or fruits into their mouths as a "snack" as they walked along. One of the women saw some fresh *goanna* (lizard) tracks, and she went off to follow the goanna to its burrow and dig it out.

An Aboriginal woman spends her mornings gathering food, the afternoons preparing it. The top photo shows a woman collecting seeds from wild *wangunu* plants. At the left, she is shown making cakes of *kampurarpa* seeds.

When they reached the wangunu plants, each woman stooped and put her wooden bowl at the base of a clump of plants, which stand about two feet high. Then she shook the stalks so the heavy heads of grain fell into her bowl *(see photo)*. She walked back and forth, looking for good stalks of ripe wangunu. When her bowl was filled, she sat down in a clear spot and tossed handfuls of seed into the air to let the breeze blow away the chaff.

Trailing Tasty Treats

The women look for many kinds *(species)* of small *marsupials*, or mammals with pouches to hold their young, that are native to Australia. They also look for other animals such as rabbits, mice, and cats that have spread in the wild since the Europeans brought them to Australia. All of these are considered tasty treats by the Aborigines.

Women who are out gathering food don't simply wander from place to place hoping that there might be something across the next sand ridge. They know where they are going and what they expect to find. I was often amazed at how easily these women read the tiny signals that pointed

(Continued on the next page)

Seated at her desert "oven," an Aborigine removes the meat course for the afternoon meal—roast lizard—from a bed of hot coals.

to food. Tracks in the sand that were almost invisible to me told them a whole story about the animal that had passed that way: how big it was; when it had been there; which way it was going. And this might tell them which waterhole the animal would visit next.

It wasn't that I couldn't see these clues; I just didn't know what to look for. I had been brought up to use such things as clocks and traffic lights to get along in my world; these people had learned from early childhood to read messages in the landscape with astonishing accuracy. As time went on, I understood more, but it was always a great joke to the Aborigines that, if left alone, I would probably die in the desert, even though I was surrounded by clues to food and water.

These women know the location of every nearby water hole, and they take care not to go too far away from one. They know their country so well that they can distinguish between different sand-hills and groves of trees that all looked the same to me. (Sometimes it seemed as if each tree had its own personal name!)

Once when I was out with several women, one of them saw a *mulga* tree that was shaped just right for a spear-thrower to be cut out of its bark. Women never use or make spears and spearthrowers, but their husbands are always looking for good raw materials. When we got back to camp, this woman told her husband about the spear-thrower tree in such great detail that he was able to go straight to that tree. Women also tell their husbands about any fresh kangaroo tracks they may see, for kangaroo hunting, too, is men's work.

By mid-afternoon most of the women are back at camp. It is too hot to walk around in the sun, and they have work to do in camp. They cook the small animals by roasting them in hot coals. They grind up the seeds into flour and make cakes which are also cooked in hot coals. Sometimes one of the men may bring home a kangaroo or emu bird, and then they will all share in the feast. But this is unusual, for most of the time the hunters return empty-handed or with only a few lizards tucked into their hair-string belts.

Food and a Woman's Pride

Since food is not always plentiful in the desert country, the Aborigines' diet is pieced together from many different kinds of plants and animals. This variety is helpful, because the Aborigines do not have to depend on any one species of plant or animal for food to survive.

Because it is so scarce, however, food is one of the major topics of conversation around the Aborigines' camp. A woman knows she is providing most of her family's food, and she is proud of it. If she comes back at the end of the day with several rabbits dangling by their ears from a stick, her skill will be the talk of the camp.

She hates to go home empty-handed, though. I can remember waiting impatiently when it was time to return to camp and the women would not give up looking. They dig in the sun for hours, perspiration dripping from their heads and their damp hair hanging in strings. They move enormous quantities of soil, sometimes digging down until they are almost out of sight. If the burrow is empty when they reach its end, they are very disappointed.

But if a woman has a bad day, only her pride will suffer. She knows that her relatives will not let her children starve ■

Kangaroo meat is a rare treat for the desert Aborigines. The carcass is buried in hot coals, and roasts until they cool, leaving the meat very uncooked, by our standards.

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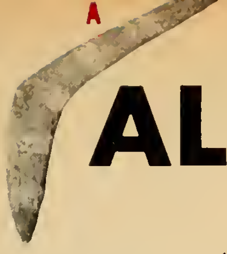
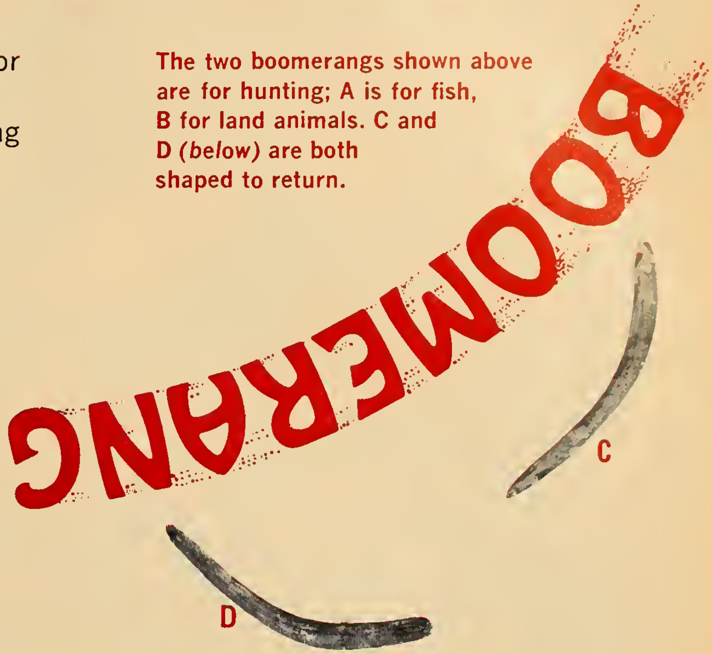

B


NOT ALL BOOMERANGS

Different kinds of boomerangs were important tools for Aborigines living in the wilds of Australia. Here is how some boomerangs, including the famous returning kind, were used by the Aborigines.

The two boomerangs shown above are for hunting; A is for fish, B for land animals. C and D *(below)* are both shaped to return.



■ We use the word "boomerang" to describe something that returns to its sender. An object (or a remark) that returns is said to "boomerang." But oddly enough, very few real boomerangs ever come back. There are many kinds of boomerangs and only one kind is designed to return when you throw it.

Boomerangs were invented by the Aborigines of Australia *(see page 2)*. They were first used as throwing weapons for killing small animals and perhaps for fighting. The Aborigines had few tools. They wore little or no clothing, and had no pockets, so every object they carried had to be useful in many ways. A boomerang could be used for hunting, fighting, digging, cutting, starting a fire, and for making music. Only one kind of boomerang, made and thrown in a special way, would circle and come back *(see "Why a Boomerang Returns," on the next page)*.

Boomerangs for Hunting

The Aborigines used three kinds of boomerangs for hunting. One was a club that was used mainly for hunting emu, bustard, and other long-legged birds. It was thrown overarm, straight at the animal. It would spin in flight but didn't return.

Another hunting boomerang that didn't return was much lighter and a little smaller, and was used for killing fish in shallow water, and birds such as parrots, pigeons, and ducks. It was normally used with the third type of hunting boomerang—the famous returning kind.

To hunt ducks, a group of Aborigines would surround a pond, and on a given signal, most would stand and throw a non-returning boomerang into the flocks of ducks sitting on the water. The boomerangs would slice across the surface and kill or injure many birds. Of course, the other ducks would start to fly away. At this moment a few men would throw their returning boomerangs above the rising ducks. At the same time the men would imitate the call of the duck hawk. The flock, seeing the circling forms above them and hearing the call, would dive low to the water or earth to escape the expected attack of a hawk. Then the hunters would throw more "killer" boomerangs.

Sometimes the hunters spread their nets between tall trees, then threw returning boomerangs high into the air. This frightened flocks of birds into the nets, where they were caught and clubbed.

Even today young people in Australia use a kind of boomerang for killing mullet, salmon, herring, and other fish. They use a "kylie"—a piece of iron about 18 inches long that is folded and flattened until it forms a V with an angle of about 40 degrees. In the summer, people hurl kylies at schools of mullet in the shallow water of the Indian Ocean. The mullet flee from the splash, but then they immediately return to examine the spot where the splash took place. At that moment the fishermen throw another kylie at the same spot. The word "kylie" is the name given to a hunting boomerang used by Aborigine tribes of Southwestern Australia.

Although Aborigines sometimes had fierce battles, they were not fighting men in the way many of the American Indian tribes were. The club-like hunting boomerang was used in fights. Some of the men threw their boomerangs flat so that they spun sideways through the air. Others threw the boomerangs at the ground so that they bounced up and struck the enemy. In close fighting, boomerangs were held by their handles with the sharp edge facing the enemy and were used like an axe. The fire-hardened edge could be very dangerous.

In peaceful day-to-day living, a boomerang might be used to dig a lizard from its hole in the ground, or to start

(Continued on the next page)

a fire. The Aborigines sometimes made fire by rubbing the hard edge of the boomerang across a groove in the center of a soft wood shield. I have seen fire made within 30 seconds in this way.

Aborigines also used boomerangs as picks and shovels. To build a new home, a man would first break off branches from a mulga tree. Then he would drive the end of his boomerang into the sand, wiggling and twisting it to make a hole in which to put a tree branch. One by one, more branches were stuck in the ground in this way until they formed a seven-foot-wide circle, with the tops of the branches touching. More branches were then woven into this framework. The earth inside the circle was loosened and shoveled with the boomerang, forming a pit below ground level, out of the wind.

Some Boomerangs Return

Since Australia was settled by people from Europe, the old tribal systems of the Aborigines have been broken up.

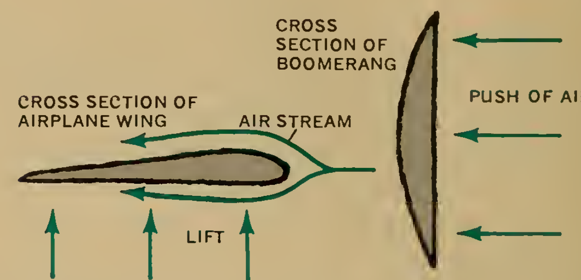
This desert Aborigine showed Dr. Gould (*see page 2*) how to make a boomerang from a curved tree limb, though his own people do not usually use these hunting weapons.

Nearly all of the Aborigines now live in reserves or at missions. The children go to school and eventually become Australian citizens. But the parents cannot or will not change, and live their old life as much as possible.

One of the sports that they play is boomerang throwing—the art of hurling a returning boomerang and watching as it whizzes in a great circle and then returns to the thrower's hands. Recently at a mission I watched an Aborigine throw seven boomerangs, one after another. The seventh had left his hand by the time the first one was returning. He was able to catch six out of seven, and I think he would have caught the seventh if his attention hadn't been distracted.—HARRY BUTLER

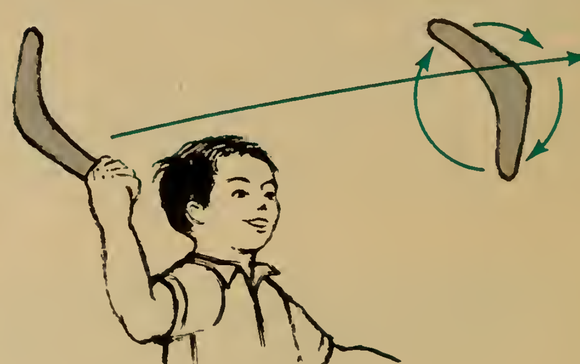
Why a Boomerang Returns

A returning boomerang travels in a circle, back to its thrower, for the same reason that an airplane flies. As an airplane is pushed forward by its engines, air flows over the surfaces of its wing. The upper surface of each wing is curved, so the air rushes over this surface faster than it does over the flat lower surface (see *diagram*). Because the air moves faster, it



presses down less on the upper surface than it does on the flat lower surface. The greater pressure on the lower surface of the wing tends to push the wing upward.

A returning boomerang also has a flat surface and a rounded surface. If you threw a boomerang horizontally, like an airplane wing, it would go straight and would rise in the air as an airplane does. But when it is held and thrown vertically (see *diagram*),



the air pushing on the flat surface makes the boomerang turn in the direction of its curved surface. The stronger the throw, the farther the boomerang will circle.

You can buy boomerangs in some toy shops and department stores. Some of these are poorly made and won't return no matter how you throw them. If you do try to throw a returning boomerang, be sure to practice in a big open field and keep a good distance from other people. If you succeed in having a boomerang return, you have one more problem: stopping it. Even Aborigines sometimes hurt themselves when they try to catch a fast-moving, spinning boomerang. Just let the boomerang fall to the ground.

Autumn is a good time to investigate the ways in which different plants scatter their seeds. Here is how you can go about studying . . .

The Traveling Seeds

by Nancy M. Thornton

A head of dandelion seeds, each with its own wind-catching "umbrella," is fascinating to look at and fun to blow (see cover).

■ More weeds in the garden! No one planted dandelions and burdocks among the roses, yet there they are. How did they get there?

Dandelions and burdocks are just two kinds *(species)* of plants that have evolved special ways of scattering their seeds. Plant scientists *(botanists)* call this *seed dispersal.*

The scattering of seeds is one way that a species of plant has of ensuring that it will survive. If all of the seeds dropped directly below a parent plant, many might not sprout. Those that did sprout would compete with each other, and with the parent plant, for sunlight and moisture. When the seeds scatter away from the parent plant, however, they have a better chance to sprout, grow, and produce seeds of their own. *(For illustrations of the ways some common plants scatter their seeds, see pages 8 and 9.)*

Flying and Floating

You can probably find many examples of seed dispersal in your neighborhood. You might want to make a collection or display of the seeds you find. Collect a twig of the plant with some leaves on it along with the seeds. Dry the twig and leaves between sheets of newspaper with a weight to press them flat, and put them in a cellophane envelope with the dried seeds. Make a label with the plant's name and the seed dispersal method. If you don't know the name of the plant, take notes on its height, appearance, and other characteristics. This information, with the leaves and seeds you collected, will help you identify the plant.

Look for mature seeds on the plant. They should be firm on the outside, and the inside should not be green or milky. Sometimes, of course, the seed will be part of a fruit, such as a berry.

Seeds are scattered by wind and water, and by animals such as birds, insects, and mammals, including humans. When you look at mature seeds you may find special parts that help them travel. If a seed is to be carried by the wind, it usually has some structure that enables it to float or spin in the air. Look for fluffy "parachutes" or some sort of "wings." Some seeds are carried by the wind because they are as tiny and lightweight as a speck of dust.

The seeds of many plants that grow near oceans are spread by water. A cocoanut seed, enclosed in a lightweight, water-tight husk, may float for hundreds of miles.

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Seeds with "wings" spin or sail away from their parent plants.

When the tough seed pods of milkweed split open, about 100 seeds with silky "parachutes" begin to drift away through the air.

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Squirrels and chipmunks often forget where they hid nuts and acorns. Later these seeds may sprout and grow.

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Rain drops splash seeds out of the seed containers of the pearlwort plant.

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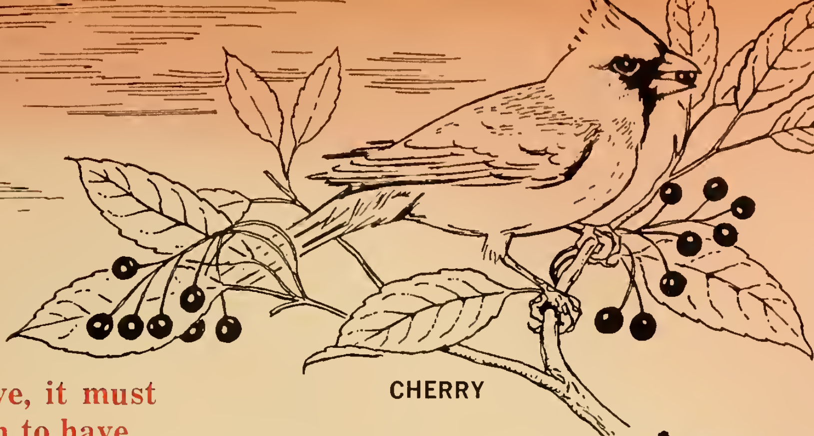
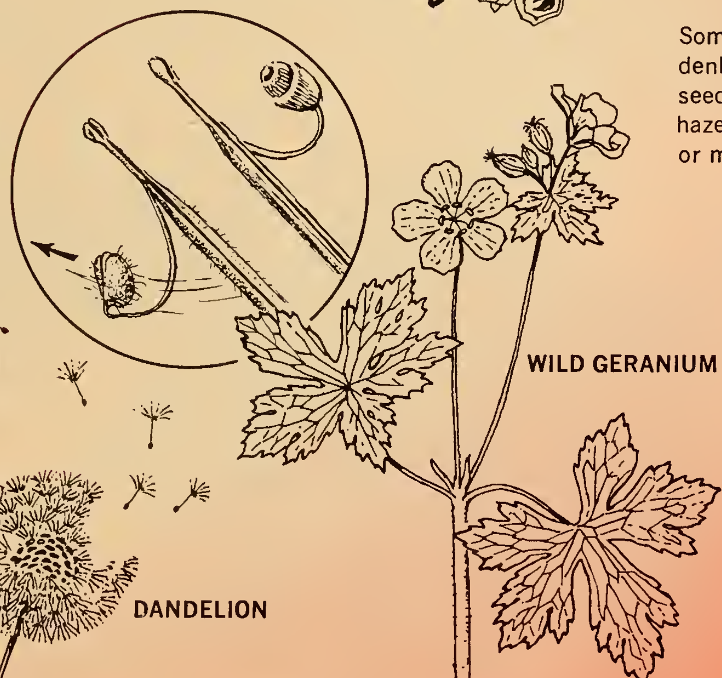


CHERRY

The seeds of many fruits are protected by tough coatings. When birds and mammals eat the fruits, the seeds are not digested. They pass out of the animals' bodies as waste, perhaps miles from where the fruit was first eaten.

WITCH HAZEL

Some seed containers suddenly pop open and shoot seeds in all directions. Witch hazel seeds may travel 10 feet or more.

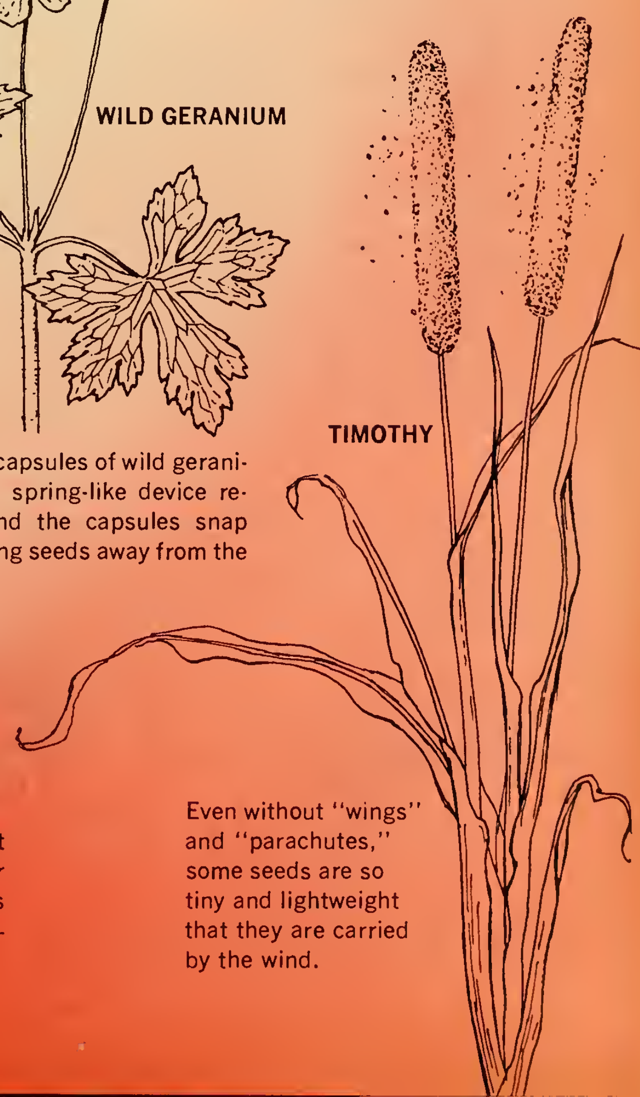


WILD GERANIUM

When the seed capsules of wild geraniums dry out, a spring-like device releases them and the capsules snap outward, throwing seeds away from the plant.

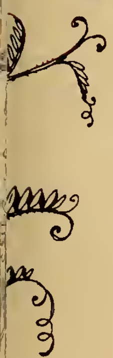
DANDELION

The umbrella-like tops of dandelion seeds have helped spread this plant around the world.



TIMOTHY

Even without "wings" and "parachutes," some seeds are so tiny and lightweight that they are carried by the wind.



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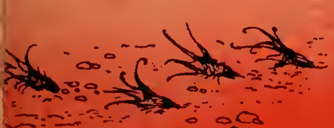
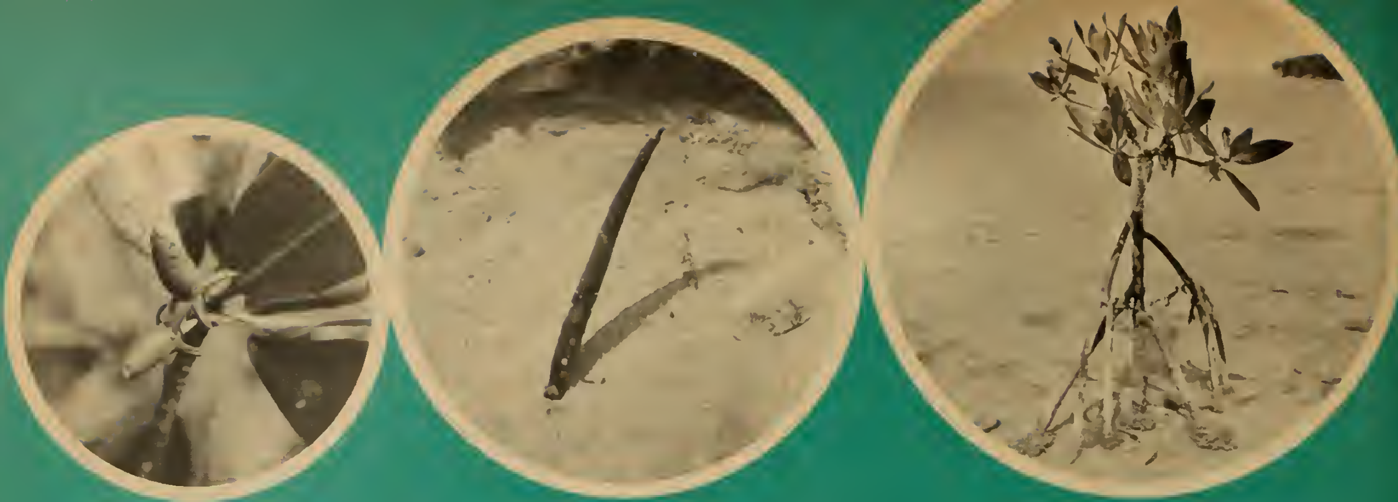


Some seeds have bristles that spread apart and then close as the amount of water vapor in the air varies. This movement of the bristles makes the seeds creep slowly along the surface of the ground.

CRIMSON CLOVER



A seed grows from the tip of the red mangrove plant's fruit (left). When it is about a foot long, it drops and takes root there (center) or floats in the water until it takes root and grows into a tree (right).

The Traveling Seeds (continued)

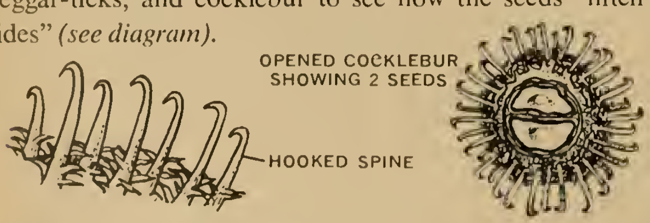
Raindrops sometimes help seeds of land plants to scatter; the drops splash seeds of a plant called pearlwort out of their containers in the plant.

Taken for a Ride

Many seeds that are inside fruits are spread by animals. A bird may eat the fruit and then drop the seed to the ground. Or the whole fruit may be swallowed. Then the seed may travel unharmed through the bird's digestive tract and pass out of its body miles from where it was first eaten.

Recently a Texas biologist, Dr. Vernon Proctor, decided to find out how long seeds can stay within the bodies of some caged birds and still be able to sprout. He found that the seeds of some water plants would still sprout after being inside ducks and shorebirds for as long as 100 hours. One bird, a killdeer, carried a sumac seed in its body for 340 hours. If the birds had been free to fly, they might have carried the seeds thousands of miles.

Even as you walk in a field looking for different examples of seed dispersal, you may be helping plants scatter their seeds. Check your clothes to see if any seeds have become "hitchhikers." Many seeds have hooks, barbs, or spines that catch on clothing, fur, or feathers. Take a magnifying glass along and look at the seeds of burdock, beggar-ticks, and cocklebur to see how the seeds "hitch rides" *(see diagram).*



When you look at some plants you'll be able to tell at a glance their ways of seed dispersal. Others will be more difficult to guess at. Some plants, for example, have seed capsules that help scatter the seeds. When the capsule dries, it suddenly splits open and the seeds are tossed out. In other plants, water pressure or spring-like devices send the seeds zooming through the air to land several feet from the parent plant.

Look for these kinds of seed capsules on such plants as witch hazel, jewelweed, and violet. If you find a plant that is scattering its seeds, measure the distance a seed travels from the plant. Do this for several seeds (including some from different seed capsules). How far is the average seed thrown from the plant?

This is just one question about seed dispersal that you can investigate. Some other investigations are listed on this page, along with some helpful books ■

For more information about seed dispersal, see these well-illustrated books: **The Amazing Seeds,** by Ross Hutchins, Dodd, Mead & Company, New York, 1965, $3.50; **Play with Seeds,** by Millicent Selsam, Wm. Morrow and Company, New York, 1957, $3.14.

INVESTIGATIONS

- Plants that die after one growing season are called *annuals;* those that live for several growing seasons are called *perennials.* Compare the ways of seed dispersal of several annuals and perennials. Does one group have a greater ability to scatter its seeds? Why?
- Observe some wind-carried seeds to see how far they travel from a plant before settling to earth. Is this the end of their journey?
- Compare the ways of seed dispersal of wild plants with those of domestic plants, such as garden vegetables and flowers. Are there any garden plants whose seeds seem to be spread only by humans? What problems might seed dispersal present to growers who produce seeds for use on farms?

Mystery Photo
What is it? *Submitted by Betsy Harding, Ithaca, New York*

brain boosters

prepared by **DAVID WEBSTER**

Can you do it?

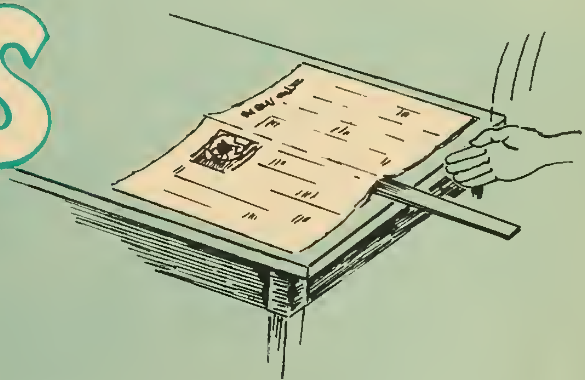
Can you swallow some water while you are upside down?

Fun with numbers and shapes

How many times in 12 hours does the minute hand of a clock pass the hour hand?

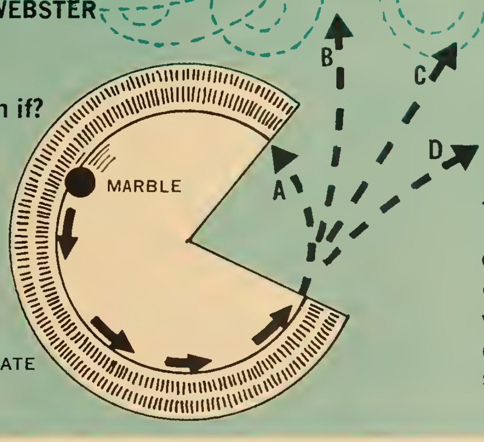
For science experts only

If you placed a yardstick on a table so that half of it extended past the edge of the table, and then you hit the unsupported end of the yardstick sharply with the edge of your hand, the yardstick would fly across the room. But if you placed a sheet of newspaper over the part of the yardstick that is on the table *(see diagram)*, the yardstick would probably break when you hit it. Can you figure out why?



What would happen if?

Which path would the marble follow after it left the plate?



Just for fun

Drop some pepper or tiny pieces of paper towel into a glass of hot water. Then put in an ice cube and watch the pepper or paper bits move around through the water. The cold water from the melting ice cube is denser than the hot water *(see "How Dense Are You?," N&S, September 30, 1968)*, so it sinks to the bottom, making a current as it moves.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The photographer thinks that the bright marks in the photograph of the sun may have been made by sunlight that was reflected from a metal surface inside the camera to the backs of the eight metal blades of the camera's diaphragm, then back to the film. Can you figure out any other way that the bright marks may have been made?

What will happen if? The water from the hole in the balloon at first squirts farther as the balloon gets larger. When the rubber stretches more, however, the pinhole becomes larger and the stream of water decreases. What will happen to the stream from the pinhole as water is released from the balloon through its "mouth"?

Can you do it? One way to separate the pepper from the salt is to dump the mixture into a glass of water. The salt will dissolve, while the pepper floats on top. Another way is to use static electricity. Run a comb through your hair several times, and then hold it close to the mixture. The pepper should fly up and stick to the comb.

Fun with numbers and shapes: I had 7 pennies and you had 5. Suppose we had 12 pennies altogether and you had twice as many as I had. How many would you have?

For science experts only: The secret message was: IF YOU LOOK CAREFULLY YOU SHOULD BE ABLE TO FIGURE OUT THIS MESSAGE.

Do you know what any of these things are used for?

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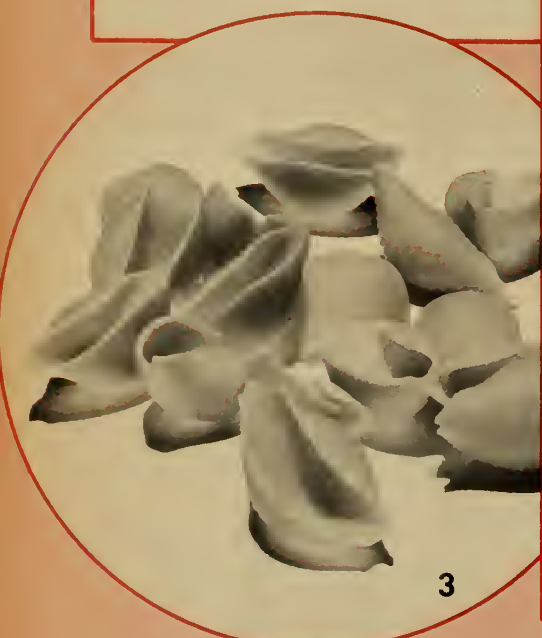

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MYSTERY OBJECT CONTEST

This year, instead of a Brain-Booster Contest, we are having a Mystery Object Contest. Can you find something that I am unable to identify? You can either mail the thing to me or send me a photograph of it. Your Mystery Object can be something that you buy in a store or something you find outdoors.

I will write to everyone who enters the contest. If I know what your Mystery Object is, I'll give you the answer. If I don't know, I'll have to write and ask you to tell me. A $10 award will be made to each of the 10 readers who submit the *best* Mystery Objects.

To enter the contest, send your object or photograph to:

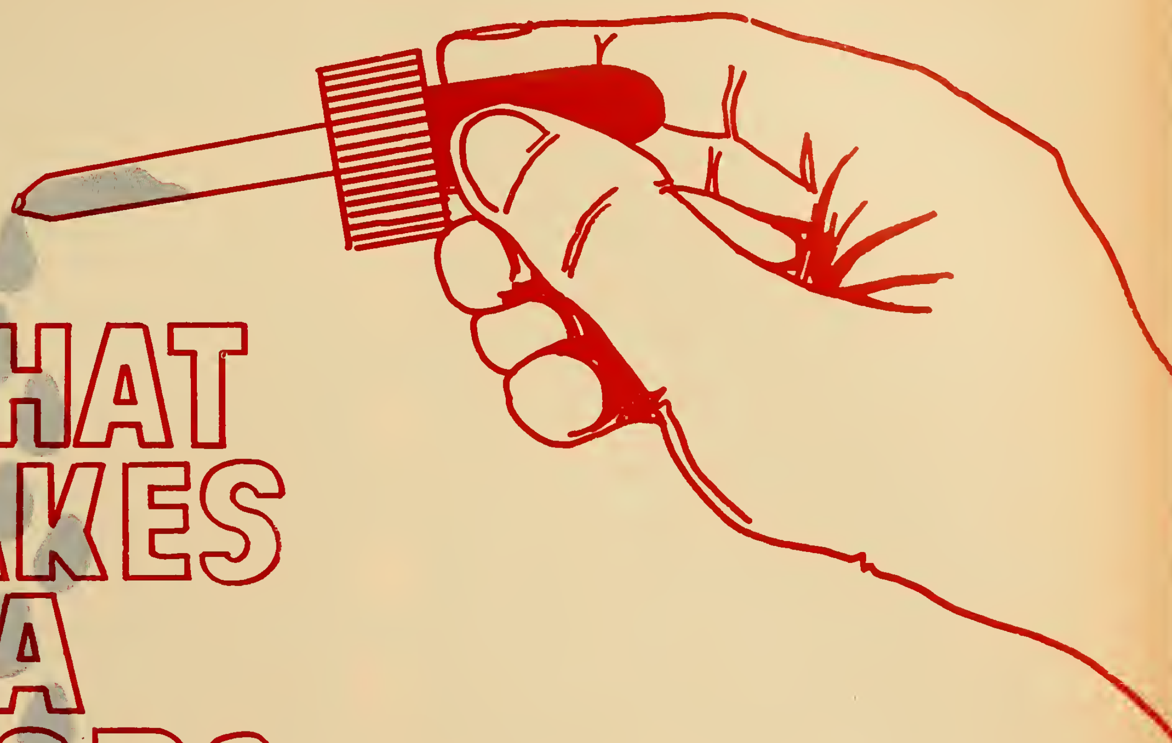
Mr. Brain-Booster
Bedford Lane
Lincoln, Mass. 01773

Entries must be mailed by November 15, 1968. Be sure to give your address, age, and grade in school, or tell me if you are an adult. We will publish the names of the winners and some of their entries in the February 17, 1969 issue of *Nature and Science.*

I'll bet you can't stump me!

Mr. Brain-Booster

P.S. The Mystery Objects shown in photos on this page are: 1. A hook used for tightening boot laces. 2. A screen that is placed in the top of a rainspout to keep leaves out. 3. Shell macaroni for cooking and eating. 4. An archery finger guard, for protecting the fingers when shooting a bow. 5. A holder for toasting four pieces of bread on a gas stove.



WHAT MAKES A DROP?

Drops of liquid do strange things. With a medicine dropper, some water and cooking oil, and a piece of aluminum foil, you can find out a lot about them.

BY DAVID WEBSTER

■ Drops come in many shapes and sizes, and they do things that may surprise you. Take a glass of water outdoors and throw the water up into the air. You will see that some of the water forms drops. Are all the drops the same size? Now try to throw the water higher to see if more drops are formed.

Have you ever wondered why water makes drops? Why not do some experiments to find out more about them? All you need is a piece of aluminum foil or wax paper, and water. Wet your hand and sprinkle some water onto the aluminum foil. Now you have drops which you can study. Bend over so you can look at the drops from the side. Which ones are rounder, the small ones or the larger ones? Can you figure out why some water drops are rounder than others?

You can move your drops around with a pin or paper clip. Push two or three small drops together to make a bigger drop. Then take two pins and try to pull the bigger drop apart to make two smaller ones. Does the drop seem to stick together?

Drops Have Elastic Skins

Do water drops remind you of small balloons filled with water? Get a round balloon and put a little bit of water in it. Hold the opening closed and see what shape the balloon has when it rests on a table. Fill it with more water from the faucet and set it down again to check its shape. Keep on forcing water into the balloon until it gets quite big. (The safest place to do this is in the bathtub.) Now what shape is the balloon? Does a large water balloon look like a large water drop on the aluminum foil?

A water drop seems to have a rubber-like skin on it too. But the skin of the drop is made only of water. This elastic coating of water is caused by something called *surface tension.* The stretchy skin of a water drop is so strong it can hold up a pin. Lay a pin across a drop on your

(Continued on the next page)

aluminum foil to see if it holds the pin up.

Water in a glass also has an elastic skin. If you carefully lower a needle into some water, you might be able to float the needle on this strange skin. Have you ever seen insects walking on the water in a quiet stream or lake? Now you probably know why they can walk on top of the water. *(See page 15.)*

You can watch a water drop as it falls and see what happens to it. When water drops fall through oil, they fall more slowly, so you can watch them all the way down. Fill a small jar with cooking oil. Now put a drop of water on the oil with a medicine dropper or a paper straw. The drop will probably float on top. Do you think this means that oil is denser than water? (Did you compare the densities of oil and water as suggested in "How Dense Are You?", *N&S*, September 30, 1968?)

Push the drop down into the oil with your fingers. Now what do you think? What held the water drop up on top of the oil? Has oil an elastic skin too? If it does, is its skin tougher than the skin of water?

Watch a drop as it falls to the bottom of the oil. What shape is it? Try to make a larger water drop. Keep dropping water on top of the oil until the drop gets so big that it falls by itself. Make some drops go down through the oil to see what happens when they hit the bottom.

Drops of Air and Solid Drops

Have you ever seen air drops? Of course you have; that's what bubbles are. You can watch air bubbles in a jar of thick liquid like cooking oil or Karo syrup. Shake the bottle hard to mix the air with the syrup. What shape are the bubbles? Which ones rise faster, the big ones or the small ones? Can you think why this might be?

If water drops freeze, they become solid balls. This is how sleet is formed. If you drip melted sealing wax into some water it will harden into round little balls. BBs (shot) are made by dropping melted lead through a screen into a tank of water. When the drops of lead hit the water they get hard.

What is the biggest hardened drop you have seen? There is one which everyone knows about. Some scientists think that in the beginning this drop was just a huge piece of hot liquid rock. As it floated through space it took the shape of a giant drop. As the drop cooled it became solid on the outside. If you haven't already guessed, this big drop is the earth ■

INVESTIGATION

MEASURING THE SIZE OF DROPS

The elastic skin of water causes drops to form. Do all liquids have an elastic skin like water? Other liquids do form drops, so they probably have an elastic skin too. But is the strength of the skin always the same? You can find out by measuring the drop size of different liquids.

Gather three or four liquids that you want to test. You could try some of these: water, milk, cream, liquid detergent, salty water, rubbing alcohol, soapy water, kerosene, vinegar, cooking oil.

With an eyedropper, make drops with one of your liquids. Notice how the drops form. Are all the drops of this liquid the same size? Now make drops with some of the other liquids. Do all liquids seem to have the same-sized drops?

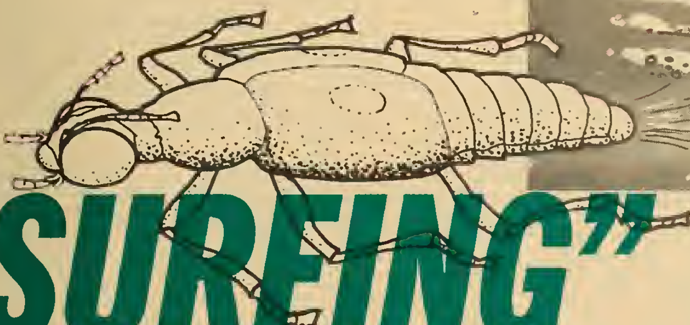
One drop is so small that it is hard to measure alone. But by putting many drops together, you should have enough liquid to measure. Squeeze out several hundred drops of one liquid into a small, narrow bottle like a pill bottle. Before emptying it, mark how high the liquid is. You can stick a piece of tape to the side of the bottle and mark the level of the liquid with a pencil. You can then count out the same number of drops with the second liquid. How high up did this one come? Are these drops larger or smaller than the first drops?

Measure the drop size of all the liquids you have in this way. You will be able to keep a record of your investigation if you fill in the chart.

	NAME OF LIQUID
LARGEST DROP	
2ND LARGEST	
3RD LARGEST	
4TH LARGEST	
5TH LARGEST	
SMALLEST	

Do you think the liquids with the biggest drops have the strongest skins?

Attacked from the rear by a water strider, which walks on the surface of a pond, a slowly paddling Stenus beetle suddenly skims forward, leaving the strider foundering in its wake. Scientists discovered how Stenus does it by—



"SURFING" TO SAFETY

by Anthony Joseph

■ The little beetle called Stenus lives near a pond or a stream, where it can often be seen paddling slowly at the surface of the water. Every now and then, this beetle skims across the water like a jet-propelled surfboard. Scientists have long known how Stenus achieves this skimming motion, but only recently did they find out how it helps the beetle escape from one of its predators.

The discovery was made almost accidentally by two biologists, Karl Linsenmair and Dr. Rudolf Jander, of the Zoological Institute in Frieburg, Germany. They were trying to find out how Stenus turns in different directions as it swims or skims along. The more they watched this little insect, the more they were struck by the way it could change in an instant from a slow, paddling motion to a rapid, speedboat-like motion. Sometimes it skimmed as fast as 2½ feet per second, and as far as 45 feet.

Sinking the Enemy

The scientists noticed that this happened whenever a Stenus was attacked from the rear by a water strider—an insect that walks around on the surface "skin" of the water *(see "What Makes a Drop," page 13)*. A Stenus would sense a water strider sneaking up on it from the rear. In a flash the Stenus would skim away, leaving the strider foundering in its wake. By observing the Stenus closely, the scientists found that it escapes attack from the rear by making a fast-moving wave and "surfing" to safety on its crest.

PROJECT

Rinse a dish thoroughly, then fill it with water. Lay a needle on a small piece of tissue paper and put it on the surface of the water. Can you "float" the needle on the water this way? Can you guess why? Now remove the needle and sprinkle some talcum powder over the surface of the water. Touch the water at the center of the dish with a sliver of soap. Can you explain what happens? Will the surface of the water in the center support the needle now?

The Stenus beetle has two tube-like glands near its back legs. From these tubes, it squirts a soap-like liquid whenever it is attacked. The liquid weakens the surface tension of the water at that point, and the "skin" of the water pulls apart in all directions—like the skin of a balloon when air breaks through a weak spot in the rubber. The edge of the rapidly widening "hole" in the water's skin acts like a swift wave that carries the beetle forward. When the "hole" reaches the water strider, the insect sinks.

The scientists found that the Stenus usually escapes in a series of short spurts. Going 45 feet at top speed uses up all of its soap-like fluid, and it takes a week or so to build up a new supply.

While the water strider has become adapted over millions of years so that it can walk on water, the Stenus beetle has become adapted so that it can escape from, and sink, a strider that attacks it from the rear. The beetle's defense is not complete, though—a water strider that attacks it from the front gets its prey nearly every time ■

WHAT'S NEW

by
Roger George

Egg-stealing scientists may be helping the whooping crane win its battle for survival. The scientists began their fight to save the whoopers from extinction in 1938, when there were only 14 of the giant white birds left in the world.

The number of birds increased over the years, but only very slowly. The problem was that few young birds were able to survive their first year in the wild. That's why scientists started stealing eggs. In the last two years they've taken a dozen eggs from the nests of whoopers in remote northern Canada, hatched them at a wildlife research center in Maryland, and raised the young birds in captivity *(see photo)*. Almost all have survived. As a result, the total population of whooping cranes is now nearly 70.

Red, orange, and yellow mud fell on England recently. It all began with dust from the Sahara Desert, over 1,000 miles away. Strong winds had lifted dust from the African desert high into the air and carried it over England. There the dust mixed with rain and fell as mud. Once before, in 1902, dust clouds were blown from Africa to England.

Other severe dust storms are on record. In 1912, for example, dust from the eruption of an Alaskan volcano settled on Seattle, Washington, 1,600 miles away. During the 1930s, disastrous dust storms over the southwestern United States picked up fertile topsoil and deposited it as far away as the Atlantic Coast, leaving behind the barren dust bowl of the Great Plains.

Objects falling from space are a threat to high-flying aircraft. In the past five years, airline crews have reported seeing at least 1,230 falling objects. Of these, 1,077 were classified as meteors, 100 were man-made satellites and other known objects, and 23 were pieces of unknown debris. Thirty were classified as UFOs (unidentified flying objects).

Pilots are now being warned when spacecraft debris will re-enter the atmosphere. But today's jets, which travel at altitudes of about 35,000 feet, are not likely to be damaged by falling objects. Before most objects fall to this altitude, they are burned up through friction with the air. Others are broken up and slowed down. Supersonic jets of the future, however, will fly at about 70,000 feet. At this altitude there is more debris, and it is falling at the rate of 2,000 miles an hour. So even a tiny piece could cause serious damage.

"It's too quiet," grumbled employees in a new $10 million office building in Cologne, Germany. The modern soundproofing system worked so well that workers couldn't stand the silence. Engineers are now planning to record background sounds of traffic, telephones, and typewriters, and pipe them throughout the building.

Apparently silence is *not* golden when there is too much of it. The ideal sound level seems to lie somewhere between a whisper and a roar.

There may be life on Venus, Mars, and Jupiter. At least, recent U.S. and Soviet space probes suggest this possibility. Oxygen has been detected on Venus, for example. The oxygen could be the product of living plants, says Dr. Willard F. Libby, a chemistry professor at the University of California. Most of Venus is too hot for plants, but there seem to be huge ice caps at its poles. Plants might be able to grow near the ice.

Unlike Venus, Mars is frigid. But some simple forms of life can survive in extreme cold. Besides, Mars probably once had a milder climate. Living things could have developed in the milder climate, and then adapted to the slowly cooling conditions, says Cyril Ponnamperuma, a chemist for the National Aeronautics and Space Administration (NASA).

As for Jupiter, life may be developing there right now, according to Harold P. Klein, another NASA scientist. Conditions on Jupiter may be something like those on the earth billions of years ago, at the dawn of life.

Is the steam car the dream car of the future? Some scientists think so. They say that steam-driven cars won't pollute the air nearly as much as gasoline-powered cars. A steam engine burns fuel much more completely than a gasoline engine does, so far fewer particles and fumes are left to escape into the air. The steam car should also be cheaper to buy and maintain than a gasoline-engine car. And it is expected to travel up to 100 miles an hour and average about 30 miles per gallon on inexpensive fuel.

Why, then, aren't steam cars in the showrooms? One reason is that setting up production lines will take a lot of money. Perhaps the government may have to help out if steam cars are to be mass-produced.

The baby whooping crane, shown standing in its dish of drinking water, was hatched recently at a wildlife research center in Maryland. When it is grown, it will look like the adult whooping cranes at right, on display at The American Museum of Natural History in New York City.

dispersal among animals is generally *active*, while in plants it is most often *passive*. That is, it is usually effected by external agents such as wind, water, animals, and man. Exceptions are those plants that actually shoot their seeds from pods (the range of spread in these cases, however, is never very great). The great seed-spreaders are birds and man.

Topics for Class Discussion

• *Have your pupils consider the many seeds produced by a single plant.* Do they see a relationship between the number of young that a species of living thing produces and the chances that the species will survive? Mice and rabbits are good examples of animals that produce many young and have a high rate of mortality.

• *Of the seeds that are spread by man, what kinds are apt to be carried on purpose and what kinds by accident?* Food plants are spread deliberately, weeds accidentally. The Russian thistle entered this country in a bag of flax seed and quickly became a pest to farmers. Many other common weeds in the United States were brought accidentally from Europe.

• *Will seeds collected in the fall sprout if planted indoors?* Some will, but many seeds need a period of cold temperatures (such as they would be exposed to outdoors) before they will sprout. Florists often keep seeds refrigerated for a time to simulate cold winter temperatures.

Activities

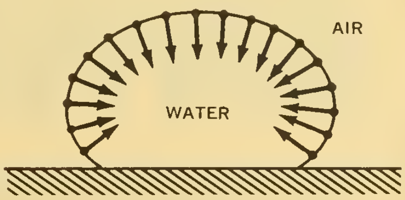
• Fall is an excellent time to gather seeds. Let the class arrive at a way of sorting and arranging them for display. Very likely they will choose to organize seeds by the way they travel. Seeds may be glued onto construction paper, or dried (to prevent mold) and displayed in clear plastic envelopes.

Keep mystery seeds to one side and encourage identification by letting the pupil who solves the mystery add the seed in question to the regular display.

• Someone might read and report on John Chapman, better known as "Johnny Appleseed."

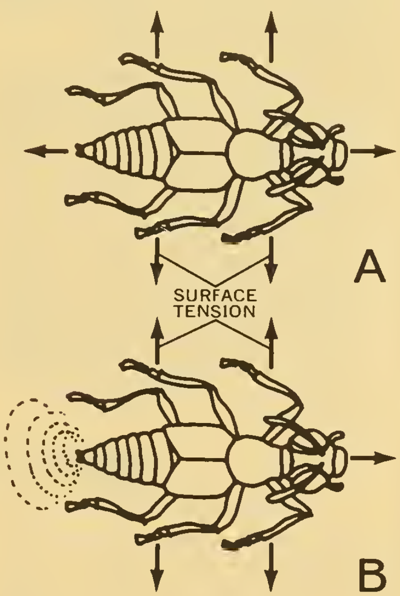
What Makes a Drop?

• After completing the suggested investigations, your pupils might—with a little help—be able to guess what causes the surface of a liquid to act like an elastic skin (the *surface tension* effect). Remind them of the forces of *cohesion* and *adhesion* mentioned at the end of "Climbing Water" (N&S, *Sept. 16, 1968)*, and ask if they think water attracts water more strongly than it attracts air. It does *(see diagram below)*.



The *molecules*, or smallest particles, of water at the surface of a drop are attracted to the water within the drop more strongly than to the gas molecules in the adjoining air. This makes the surface water molecules act like a "skin."

• A swimming Stenus beetle (*see page 15)* is pulled in all directions with equal force by this elastic skin at the surface of the water *(Diagram A)*.



When the beetle secretes a soap-like liquid from the rear, the surface tension there is weakened, allowing the beetle to be pulled forward *(Diagram B)*.

• *How do soap and other detergent chemicals help us wash greasy dishes and dirty clothes?* They weaken the "skin" of water, allowing it to mix more freely with the dirt and grease so they can be rinsed away.

Brain-Boosters

Mystery Photo. The photo shows a small waterfall, only a few inches high.

What would happen if? Cut a wedge from a paper plate and let your pupils observe the motion of the rolling marble. If the table is level, the marble will leave the plate in path C, a straight line tangent to the marble's previous circular path.

The motion of the marble is explained by Newton's law of inertia: An object in motion will tend to keep moving in a straight line at constant speed unless acted upon by an outside force. The marble's motion around the plate actually consists of an infinite number of tiny, straight-line motions in directions tangent to the marble's circular "track." The rim of the plate provides the outside force that keeps changing the marble's direction, forcing it into a circular path. When the marble reaches the break in the plate, there is no longer any force acting on it to change its direction, so it continues to move in the straight line it was following at the instant that it left the plate. Frictional force between the marble and the tabletop slows the marble down, however.

If the tabletop were slanted. then another force, gravity, would act on the marble, causing it to curve in its path.

Can you do it? It is possible, though inconvenient, to swallow while you are upside down. Muscles of the esophagus contract in sequence to force the water (or food) toward the stomach, whether you are in a normal or inverted position. This action, known as *peristalsis*, can be easily seen when a person is swallowing.

Ask the class whether they think that all animals have muscles that force food to their stomach. Perhaps someone will have noticed that birds (which lack such muscles) drink by first dipping their beak into the water. then throwing their head back. This action enables gravity to make the water (or food) fall into their stomach.

Fun with numbers and shapes. The

(Continued on page 4T)

(continued from page 3T)

minute hand of a clock passes the hour hand only 11 times in 12 hours. If the children have difficulty visualizing this, let them turn the hands on a clock or on their own wristwatches through 12 hours and see.

For science experts only. If you can afford the probable loss of a yardstick (or can get a similar stick from a woodworking class), you can use it to demonstrate dramatically that the earth's atmosphere exerts a pressure. (We are not usually aware of air pressure, because—except when the wind is blowing—the pressure is the same on all exposed parts of the body.)

When you strike the free end of the yardstick, the covered end begins to move up, carrying the sheet of newspaper with it, and causing a partial and momentary vacuum beneath the paper. Normal atmospheric pressure against the paper will hold the paper and yardstick down long enough for the stick to break, if it was hit hard enough.

Just for fun. After your pupils try this, you might ask them why cold water is *denser* than hot water. (The concept of density is explained in "How Dense Are You?", *N&S*, Sept. 30, 1968, pages 10 and 2T.) When water or any other substance is heated, the tiny particles of matter that make up the substance *(molecules)* move around faster than before and bounce farther apart when they collide with each other. The substance therefore *expands*, or fills a larger volume of space, and so becomes less dense than before.

As the colder, denser water sinks through the warm water, it is warmed up a bit, and is pushed upward by the colder water sinking from the ice cube. This produces a flow of water (and pepper) down and up in the glass. Such a flow is called a *convection current*, and it occurs whenever two masses of fluid (liquid or gas) at different temperatures come together. Can your pupils think of some examples of convection currents in nature? Ocean currents and the winds (convection currents in the atmosphere) are two such examples.

nature and science

TEACHER'S EDITION

VOL. 6 NO. 4 / OCTOBER 28, 1968 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Has earth science always seemed a rather static and dull subject to your pupils—and perhaps to you?

This special-topic issue should change your opinions, for it presents a fascinating, up-to-the-minute picture of scientists working in ingenious—and sometimes dangerous—ways to investigate the mysterious forces that are constantly changing the unstable "platform" we live on.

Faults of Earthquakes

• A *fault* in the earth, where earthquakes begin, is something like a break in the pavement or sidewalk where the concrete block on one side of the break has been pushed down or sideways past the block on the other side, perhaps by a heavy truck. Like such a break, a fault may disappear at each end, where the material on each side joins together, or the fault may join other faults at one or both ends.

If the block on one side of a "sidewalk fault" is loosely supported, or is free to move along the ground, a person stepping on it may get shaken up as the block drops, rocks, or slides under him. This is what happens to the earth when a rock mass inside it suddenly moves along a fault.

• The idea of a rock mass "bending" may be hard for your pupils to believe. Point out that heat and great pressure within the earth make the rock there more "elastic" than surface rock.

Activity. Here is a way to show your pupils how a rock mass that has been kept from moving along a fault stores up enough energy to overcome the friction that held it back, and releases this energy in a sudden movement that causes an earthquake:

Place some old dishes on a heavy table or chest (the "rock mass" on one side of a fault). Have a pupil try to push the table along the floor (the "rock mass" on the other side of the fault). If the table slides over the floor easily, it may move without shaking the dishes (which represent the surface of the earth). But if it has to be pushed awhile to get it moving at all, the table stores up the pushing as *potential energy*—until it has enough energy to overcome the friction with the floor. Then the table springs forward suddenly, shaking the dishes on top. (A molded gelatin dessert on one of the dishes will heighten the effect.) If the table slides easily, you might block it from the other end, then release it suddenly as the child is pushing.

• To help your pupils understand how the Rouse belts were discovered, have them compare the diagram at the top of page 4 with the sliced-open globe in the center background of the photo on page 3. The diagram shows how deep faults in a particular earthquake zone are arranged in a "flat" pattern, or *plane*. When this plane is projected ("stretched out") in all directions, it meets the surface of the earth at an angle of about 60° along a large circle on the globe.

Activity. You can make a cardboard "plane" like the one shown on

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 1T, 2T, 3T.)

● The Faults of Earthquakes
Your pupils will find out how an earthquake starts at a "break" in the earth, and how a graduate student discovered a new way to investigate these mysterious breaks.

● Inside the Earth
Earthquake waves tell scientists where a quake occurs and what the inside of the earth may be like.

Earthquake Lab
How scientists at a new research center in California study large and small earthquakes.

● Shaping the Earth's Crust
This WALL CHART shows some of the ways that mountains, plateaus, and valleys are formed by forces working inside the earth.

Kilauea Blows Its Cool
Scientists braved fiery lava fountains to study this volcanic eruption—a fascinating SCIENCE ADVENTURE

● World's Biggest Jigsaw Puzzle
The mystery of whether the continents were once joined together may be nearing a solution.

● Brain-Boosters

IN THE NEXT ISSUE

How a zoo doctor keeps thousands of exotic animals healthy... Exploring the structure of wood... A WALL CHART showing how scientists find the ages of animals... The birth and use of the barometer... Making the most of yeast.

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

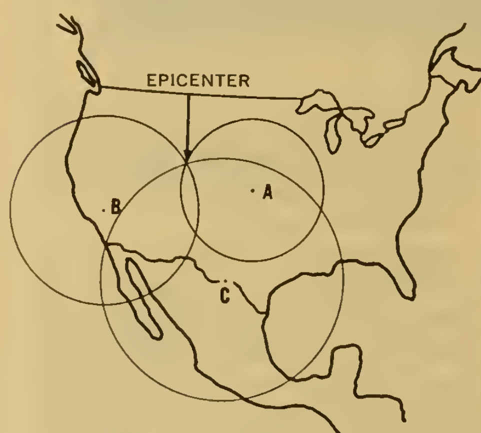
page 3 that will meet the surface of your classroom globe at a 60° angle. Multiply the diameter of your globe by 0.87 to find the diameter for the hole in the cardboard ($10\frac{7}{16}$ inches for a 12-inch globe). Use a compass to draw the circle, and scissors or a knife to cut the circular hole. If your globe has a vertical support reaching to the "North Pole," cut a slit in the cardboard so it can be slipped over the support to fit over the globe.

Have your pupils fit the plane over the top of the globe so that the edge of the hole lines up with Mexico City (where an earthquake killed three persons on August 2, 1968) and with Costa Rica, in Central America (where a volcano—Mt. Arenal—erupted July 29, 1968). If the plane was fitted properly, your pupils will find that the circle it makes with the surface of the globe also runs through Iran, in the Middle East, where some 12,000 people died in an earthquake on August 31, 1968.

Inside the Earth

• Your pupils may wonder why a weighted pen hanging by a wire from the frame of a seismograph doesn't vibrate when an earthquake wave shakes the frame and recording drum. Too little of the wave's energy is transmitted through the wire to overcome the weighted pen's *inertia*, or tendency to remain at rest. (Inertia is what makes a bicycle rider use more energy to start the bike from a dead stop than he uses to keep it moving once it is started.)

• Seismologists use a table based on the travel speeds of P-waves and S-waves along different paths through the earth to find the distance of a quake's epicenter from the seismograph. For example, if the first S-wave arrives 2 minutes and 41 seconds after the first P-wave, they can tell from the table that the epicenter is 1,000 miles away from the seismograph. The diagram shows how the distances of the



The circle drawn on a map around each of these seismograph stations has a radius equal to the distance the earthquake waves traveled to reach the station, so the epicenter of the earthquake must lie where the circles intersect. Can your pupils guess why the distances from *at least* three *widely* separated stations must be known to locate an earthquake?

epicenter from three (or more) widely separated stations are used to locate it.

Activity. Have your pupils make *compression waves* (P-waves) and *shear waves* (S-waves) as shown at the right to help them understand why P-waves can travel through a solid, liquid, or gas, while S-waves can only travel through a solid material, whose particles (molecules) keep their arrangement when the material is shaken up and down or sideways.

Shaping the Earth's Crust

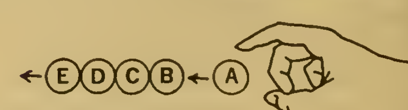
Since this issue concentrates on changes caused by forces working *within* the earth, the role of *erosion* in shaping the earth's crust is not discussed in detail in this WALL CHART. For further references on erosion, see "Is the 'Great Ice Age' Over?", *N&S*, Sept. 16, 1968; "Grandest of All Canyons," *N&S*, Nov. 13, 1967; and "How Ice Changed the Land," *N&S*, Dec. 19, 1966.

Biggest Jigsaw Puzzle

The theory of continental drift—that the continents were once joined in a single land mass but have split off and "drifted" apart during the past several hundred million years—is not yet completely accepted by all scientists. However, more and more evidence that seems to support the theory is being discovered. This fascinating new article by Mrs. Sherman (who wrote an article with the same title in *N&S*, March 7, 1966) brings the subject up to date, including news about an ocean-drilling project now in progress that may turn up evidence that could solve this mystery.

Activity. To help your pupils understand what happens when the earth's magnetic field reverses polarity *(see page 15)*, hold a toy compass over a bar magnet and turn the compass until the "north-seeking" end of its needle (usually colored) points to "N" on the compass face. Then turn the bar magnet in the opposite direction so they can see the needle's north-seeking end pointing to "S" on the compass face. Explain, though, that the "magnet" in the earth does *not* turn around like the bar magnet; instead, the earth's magnetic field seems to get weaker and

(Continued on page 3T)



When penny A strikes penny B, the "push" is passed along through C and D to E in a *compression wave* whose energy moves E just as P-waves from a suddenly moving rock mass in the earth move the surface of the earth above the rock mass.

Shaking one end of a rope up and down sends *shear waves* through it, moving the loose end just as S-waves from a suddenly moving rock mass in the earth move the surface above it. Can you send S-waves through a line of pennies?

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

SPECIAL-TOPIC ISSUE

nature and science

VOL. 6 NO. 4 / OCTOBER 28, 1968

WHAT'S HAPPENING IN THE EARTH'S CRUST

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find out why . . .

**ILAUEA BLOWS
TS COOL**

e page 10

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VOL. 6 NO. 4 OCTOBER 28, 1968

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This issue was prepared with the advice and assistance of Christopher J. Schuberth, Senior Instructor in Adult Education at The American Museum of Natural History.

PICTURE CREDITS: Cover, p. 12 by Robert Goodman, from Black Star; p. 3, Office of Public Information, The Colorado School Of Mines; pp. 4, 5, 7, 10, 11, 13, 14, 16, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 6-7, photos by Ruth and Louis Kirk; p. 8, top photo from Utah Travel Council (Parker Hamilton), bottom photo from Union Pacific Railroad; p. 9, top left and bottom left photos from AMNH, top right photo from Japan National Tourist Organization, bottom right photo by Christopher J. Schuberth; p. 9, drawings by Gail Winbigler; p. 15, drawings by René Moens; p. 16, upper left photo by David Webster, lower left photo by Joan Hamblin, right photo by Franklyn K. Lauden.

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

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What causes the breaks in the earth where earthquakes begin? A graduate student with a toy globe has discovered a new way to investigate—

The Faults of Earthquakes

■ Most *seismologists*, or scientists who study earthquakes, agree that earthquakes usually begin when a rock mass beneath the earth's surface moves suddenly. This sometimes happens when the hot gases and molten rock that feed a volcano push the surrounding rock hard enough to move it. Or it may happen when loosely packed rocks near the surface of the earth shift under the pressure of the rock layers above them *(see "Man-Made Earthquakes?", page*

This shifting, shaking, rising, falling, erupting, folding, cracking platform we live on

The earth's surface is never at rest. It is constantly being shaken by earthquakes; pushed up or covered over by molten rock from inside the earth; pushed up, pulled down, folded or broken by forces that we do not yet fully understand; and worn down by the force of *erosion*, which we do understand. The continents may even have been split apart from one "supercontinent" and moved to where they are now.

We don't know what causes these immense changes in the earth. The answers seem to be buried within the earth, and neither instruments nor men can go down very deep to investigate them. But without leaving the surface of the earth, scientists are finding out more and more about what goes on inside it. This special-topic issue tells you some of the ways they do this and what they are finding out about the forces that make our platform so unstable.

George Rouse *(left)* and Dr. Ramon Bisque draw circles on a globe where the planes of deep earthquake zones would meet the surface if they were "stretched out." The hoop is the same diameter as the hole in the cardboard "plane" *(above)* Rouse first used to find these "belts." The belts run through the sites of most of the world's earthquakes, volcanoes, and mountain ranges.

. But such quakes seldom shake a very large area of the rth's surface.

The sudden rock movements that cause most earth- akes seem to happen at places in the earth called *fault nes.* A *fault* is a break in the earth where the rock mass one side of the break has moved past the rock mass on e other side. The break itself, called the *fault plane,* may tend for miles. Most faults lie from 2 to 20 miles under e earth's surface. Some, however, reach up to the sur- ce, where the shifting of one rock mass past the other n be seen and measured *(see "Earthquake Lab," page 6).* ther faults are as deep as 400 miles, within the earth's per *mantle (see "Inside the Earth," page 5).*

The trouble seems to start when a gradually shifting ck mass is stopped, or slowed down—perhaps by rocks the two masses getting stuck together along the fault. e push or pull that moved the rock mass before now nds it like a bow. When there is enough strain to pull e sticking rocks apart, the rock masses on either side of e fault snap past each other, sending waves of vibrations rough the earth and shaking hundreds of square miles of e surface.

This may explain how most earthquakes happen. But e most scientific explanations, it raises further questions: hy are there faults in the earth? And what makes rock asses move along these faults?

vestigating with a Toy Globe

Questions like these bothered Dr. George Rouse when was working for his doctor's degree in earth chemistry last year at the Colorado School of Mines, in Golden. While studying for an exam, he came across a fact that puzzled him. An American seismologist named Hugo Benioff had discovered that the deeper faults in the mantle are arranged in flat "zones," or *planes,* and that these zones are slanted at an angle of about 60 degrees to the earth's surface. Rouse wondered why this should be.

He bought a toy globe for $1.50 and tried out an idea. He wanted to see what would happen if one of the deep-fault zones were "stretched out" far enough to reach the earth's surface on all sides. To find out, he cut a round hole in a piece of flat cardboard so that it would fit over the globe at a 60° angle to the surface of the globe *(see photo).*

Rouse first lined up the cardboard "plane" with the plane of an earthquake zone that lies deep in the earth off the coast of Chile. Along the circle where the plane met the globe, he found other places where there is a lot of earthquake activity—in the Pyrenees Mountains of France, in the Red Sea, and at the tip of South America.

He marked that circle on the globe. Then he lined up his cardboard plane with the planes of other deep-fault zones and drew circles where they would meet the surface of the earth if they were stretched out. In all, he drew 16 circles, or "belts" on the globe's surface *(see photo).*

To his amazement, Rouse found that these belts passed through all of the places where earthquakes occur most frequently. In fact, there were 19 places on the globe where three belts crossed each other, and most of these were

(Continued on the next page)

A million earthquakes a year! Scientists believe that many are strong enough to make you feel the earth shake if you were at the right place at the right time. Many, many more are too weak for you to feel, but they are detected by *seismographs* (*see page 5*).

Very few earthquakes cause much damage, either because they are too weak or because there is nothing much to damage where they occur. But each year several strong quakes shake the surface in areas where people live. Such quakes result in the deaths of thousands of people and damage millions of dollars worth of buildings and property each year.

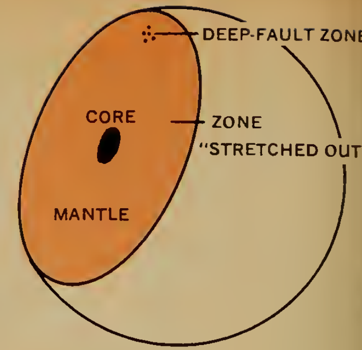
The Faults of Earthquakes (continued)

places where there is strong volcanic and earthquake activity *(see map on page 15)*.

Clues to the Cause of Faults?

Rouse and Dr. Ramon Bisque, a Professor of Geochemistry at the Colorado school, discovered that important deposits of minerals, large mountain systems, ocean-floor ridges and trenches, and volcanic island chains lie along what are now called the "Rouse belts." So do a number of places where the earth's magnetism and the force of the earth's gravity seem to change in strength.

Rouse also found that if the deep-fault zones were "stretched," they would all pass along the boundary between the earth's mantle and its *outer core (see diagram; also page 5)*. The scientists pointed out that there is some evidence that the magnetism of stars and other planets creates a *field of magnetic force* throughout space. Rouse and Dr. Bisque think this magnetic field may pull on the earth's iron core in a way that would make it turn differently from the rest of the earth if the mantle did not hold the core in line. This kind of "tug-of-war" between the core and the mantle would probably cause stresses and strains at the boundary where they meet.



These strains, the scientists suggest, are then passed upward through the mantle along the planes where the deep faults are found. If this is so, these strains could be the cause of the faults in the earth's upper mantle and crust, and they could cause the movements of rock masses along those faults.

Whatever the explanation, Rouse's discovery seems to show that earthquake zones nearly halfway around the globe from each other are somehow connected. This raises many questions, and it opens a new path for scientists who investigate the forces that shape—and shake—the earth ■

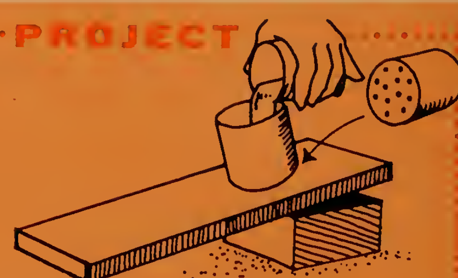
Man-Made Earthquakes?

The area around Denver, Colorado, hadn't been shaken by an earthquake for 80 years until April 1962. Since then, Denver has had more than 700 earthquakes—as many as 44 in one month. None of them caused much damage, but there was always the chance that they might get more severe.

In November 1967, a possible cause for these quakes was suggested by David M. Evans, a consulting geologist at the Colorado School of Mines, in Golden. He had discovered that the quakes all began within five miles of a 12,000-foot well that had been drilled into the rock at the United States Army's Rocky Mountain Arsenal near Denver. The Army began pouring poisonous waste water from the arsenal into the well in March 1962, and the quakes began in April.

Evans showed that the number of earthquakes per month seemed to rise or fall according to the amount of water that had been pumped into the well each month. The quakes continued, though, even after the Army stopped pouring wastes into the well in early 1966. In fact, the three strongest quakes were in 1967.

PROJECT



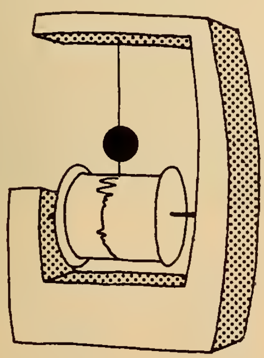
Remove one end from an empty pop can, and punch about a dozen holes through the other end. Place the can, punched end down, on a smooth board, and lift one end of the board until the can almost—but not quite—slides. Put a block under the board to hold it at that angle (*see diagram*). Move the can to the high end of the board and pour water into it. What happens as the water piles up in the can?

Evans used this demonstration to show that the water had probably seeped into faults in the rock layers around the bottom of the well and made it easy for the rocks to slide over each other. Like the water in the can, the water in the well is still pushing out through the faults in the surrounding rock.

As this is written, the Army is trying to pump the water back out of the well—but just a little bit at a time. They hope this will keep the rocks from slipping suddenly as the removal of water lowers the pressure in the well.—Esther S. Wilson

INSIDE THE EARTH

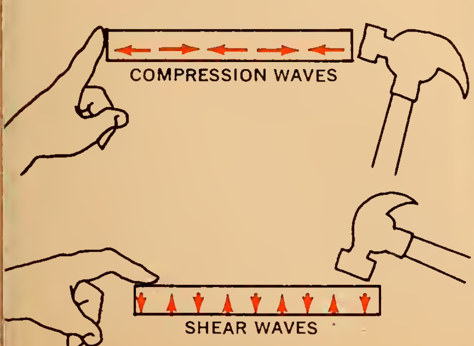
■ Have you ever wondered how scientists can tell that an earthquake has occurred thousands of miles away in a place where no one lives? The message is delivered by the waves of vibrations that spread out in all directions through the earth when an earthquake occurs. At more than 500 stations around the globe, these waves are measured and recorded by instruments called *seismographs (see diagram).*



Anchored in bedrock, this simple seismograph records earthquake waves that shake the frame and rotating drum, but not the weighted pen hanging on a wire. Electronic seismographs used by scientists *(see next page)* work much the same way.

The first kind of wave that reaches a seismograph from an earthquake is the *push,* or *compression* wave. You can feel a compression wave if you press your finger against one end of a metal rod and strike the other end with a hammer *(see diagram).*

The second kind of wave that reaches a seismograph is the *shake,* or *shear* wave. To feel shear waves, press your finger to the side of a metal bar and strike the side of the bar with a hammer *(see diagram).*



Compression waves travel faster than shear waves through the same kind of material. Because the compression waves from an earthquake reach a distant seismograph first, they are usually called *primary,* or *P-waves;* shear waves are called *secondary,* or *S-waves.* (When P- and S-waves reach the surface of the earth, they set up the *surface waves* that shake the ground and cause damage.)

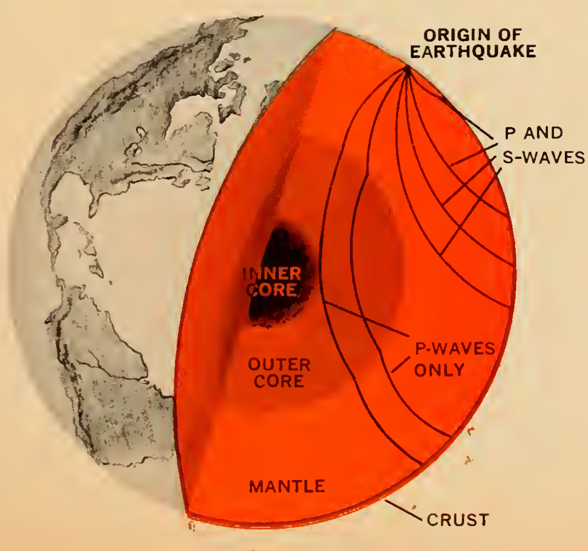
S-waves travel only about two-thirds as fast as P-waves through material of the same *density (see "How Dense Are You?",* N&S, *September 30, 1968).* So by measuring the time between the arrival of the first P-wave and the arrival of the first S-wave at a seismograph station, scientists can figure out the distance from the earthquake to the station. With this information from at least three widely separated stations, they can locate the earthquake's *epicenter* — the place on the surface directly above the shifting rock mass that started the earthquake underground.

But that's not all. Earthquake waves have also helped us get some idea of what the earth is like inside.

Seismologists know that the more *rigid,* or "stiff," a material is, the faster P- and S-waves move through it. And the more *dense* a material is, the slower it carries these waves. As the waves move from one kind of material into another kind, they are "bent," or *refracted,* so they follow curved paths through the earth *(see diagram).*

These paths show that the density of the earth increases with depth. They also show that the earth has a *crust* of rock about 20 to 30 miles thick under the continents, but only 2 or 3 miles thick under the oceans. Beneath the crust is the *mantle,* made of denser rock and reaching to a depth of about 1,800 miles.

Inside the mantle is the earth's *core,* which scientists believe is made of metal — mostly iron. But S-waves, which can only pass through solid materials, disappear when they reach the core. That is why scientists think the outer part of the core is a liquid—probably *molten* metal. P-waves pass through the core, however. Those that pass through the inner part of it are speeded up so much that scientists think the *inner core* is made of *solid* metal ■



The curved paths that P- and S-waves follow through the earth show that the earth's density increases with depth. S-waves can only travel through solid material, and they disappear at the outer core, which scientists believe must be a dense liquid — molten metal. The paths of P-waves that pass through the inner core show that it must be solid metal.

David Stuart examines the wiggly line that shows how the earth vibrated at a point 60 miles from the research center over a period of nearly 24 hours. A *seismograph* like this is wired to each of 30 *seismometers* (instruments that measure earth shakes) buried along the San Andreas fault and other smaller faults nearby. Scientists can tell by the sharpness of the "wiggles" whether the earth was shaken by, say, a truck or falling tree, or by an earthquake.

EARTHQUAKE

■ "Nobody can stop earthquakes, but we should learn to live with them." This is the purpose of the new National Center for Earthquake Research at Menlo Park, California, according to David Stuart, Assistant Chief of the Office of Earthquake Research and Crustal Studies there.

In 1965 the United States Geological Survey set up this station near the San Andreas fault (*see map and photo at right and "The Faults of Earthquakes," page 2*). The area along this fault is called the "earthquake capital" of the U.S., because more quakes happen there than anywhere else in the nation.

The photos on these pages show some of the ways that *geophysicists* (scientists who study the earth's structure) investigate quakes along a fault. Another way (not shown) is to drive stakes on opposite sides of a fault and keep track of how far and how fast they shift past each other. This shows how much *strain*, or pressure, is pushing the rock masses in horizontal directions. Sensitive *tiltmeters* (*see "Kilauea Blows Its Cool," page 10*) measure the strains that tend to shift the rock masses up or down.

The main goal of these scientists is not necessarily to predict when an earthquake will happen. "First," says Stuart, "we need to understand what happens during an earthquake. When we do, we can give advice about the danger of quakes—which really is as urgent as telling when they may happen. We can help architects decide what kinds of buildings will be safest, and where to build them."

San Francisco and Los Angeles are already built along

In the lab, geophysicist Jim Gibbs places a half-inch cylinder of rock into a chamber where it will be squeezed and heated like rock deep in the earth, where some earthquakes occur. Dr. C. Barry Raleigh, another geophysicist, is using the chamber to find out why rocks 400 miles or so within the earth seem to act like plastic, or putty.

LAB

by
Ruth and Louis Kirk

In a field test (*left photo*), electronic technician Herb Mills prepares to string out six seismometers attached to 1½ miles of wire over an area where small quakes following a large one are still shaking the earth (or where a test explosion will be set off). The vibrations detected at different places are recorded on a magnetic tape. Playing the tape back at the research center (*right photo*), geophysicist Rex Allen watches the vibrations on a TV-like oscilloscope screen. When he sees an earthquake pattern, he records it on paper for further study. Since the vibrations pass through different types of rock at different speeds, these tests help scientists find out what kinds of rock make up the quake zone.

ine of earthquake hazard, but some places along the line e worse than others. Geophysicists hope someday to see mes and schools and offices moved away from the fault elf and onto the most stable ground available. As it is w, many real estate developers build where scientists ow there is sure to be trouble some day.

"As for foretelling when a quake will come at a certain ace," Stuart says, "the most we may someday be able to is about what the weatherman does now. Someday we ay be able to say 'There is a 60 per cent chance of an rthquake' on a certain day. And when we do, we'll probly have as many people mad at us as the weatherman s now!" ■

is map shows where e research center is cated along the San dreas fault. The photo ows co-author Louis Kirk amining a break in the drainage tch at a winery near Hollister, lifornia. Part of the ditch has been ifted about six inches by the movement rock along the fault. This movement s been going on for about 100 million ars. If the land where San Francisco built has been moving at its present eed during all that time, it could have arted from where Los Angeles is now!

SHAPING THE E

■ No one knows exactly when or how the earth's crust formed, but we do know that the shape of its surface has been changing ever since.

The surface has often been pushed upward or broken open by molten rock rising through cracks in the crust. Where this molten rock spills out onto the surface it builds mountains and plateaus of volcanic rock. This kind of activity is called **vulcanism** (see diagrams and photos).

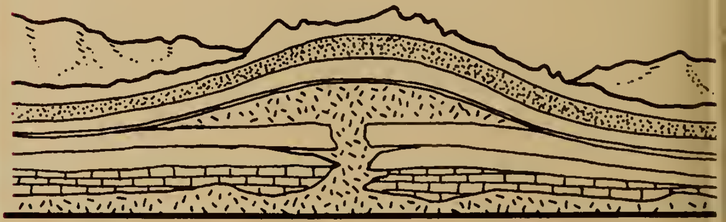
When parts of the surface are squeezed together, pushed upward, or pulled downward, the rocky crust is folded or broken, forming mountains and valleys. This kind of activity is called **diastrophism** (see diagrams and photos).

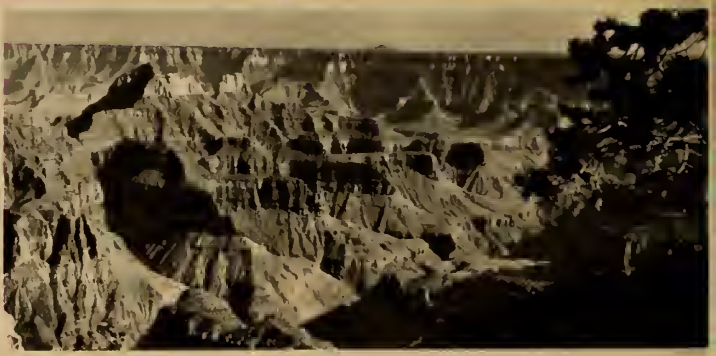
Tiny pieces of rock and soil are continually being rubbed off high places on the surface and being carried away to lower places by moving water and ice. As you probably know, this activity is called **erosion.**

Erosion is caused mostly by the pull of the earth's gravity on water and ice. But we don't know yet what causes vulcanism or diastrophism. One old idea is that the earth is cooling off and shrinking. A newer idea is that vulcanism and diastrophism are signs that the earth is heating up and expanding. Another theory says that heat from deep in the earth softens the rock under the crust and moves it around, disturbing the crust—and perhaps even spreading it. A few scientists even think some of the movements in the earth's crust may result from the magnetic pull of other planets and nearby stars on the earth's iron core.

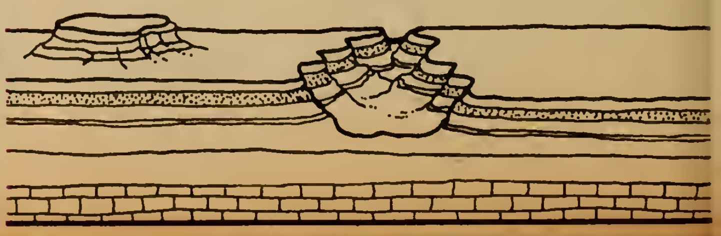
Whatever the causes, we know that the surface of the earth will continue to change—sometimes rapidly, but most of the time so slowly that we are usually not aware of it.—MARGARET E. BAILEY

Magma, or molten rock deep in the earth's crust, sometimes moves upward through cracks that don't reach the surface. With no outlet, the magma may push the surface layers of rock upward, forming dome mountains. In the background of this photo you can see the Henry Mountains in Utah, which are dome mountains.





Where part of the earth's crust rises and lifts up flat layers of rock without folding or twisting them, a *plateau* is formed. In this photo of the Grand Canyon, which is part of the Colorado Plateau, you can see the flat rock layers of the plateau which have been exposed by erosion.

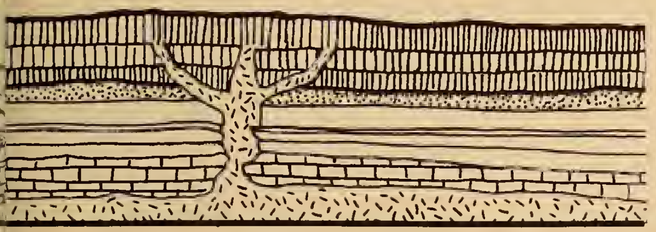


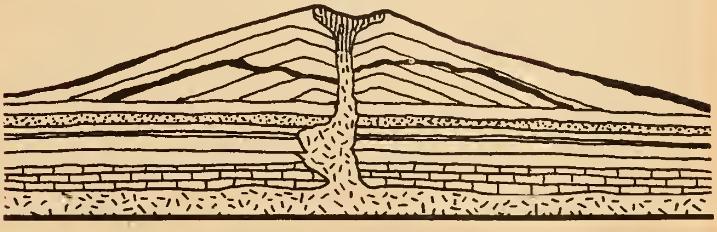
RTH'S CRUST

VULCANISM SHAPES THE EARTH

n magma pours out through a crack in the earth's ace, the flowing rock—called *lava*—may spread over st area. Repeated lava "floods" pile layer upon layer ılcanic rock to form a high, flat *lava plateau*. The o shows layers of lava rock *(basalt)* that form the *mbia Plateau* in the northwestern United States.

In some places lava and cinders pile up around openings in the earth's surface, forming the mountains we call volcanoes. This photo shows the volcano Fujiyama in Japan. Many islands are the tops of undersea volcanoes.



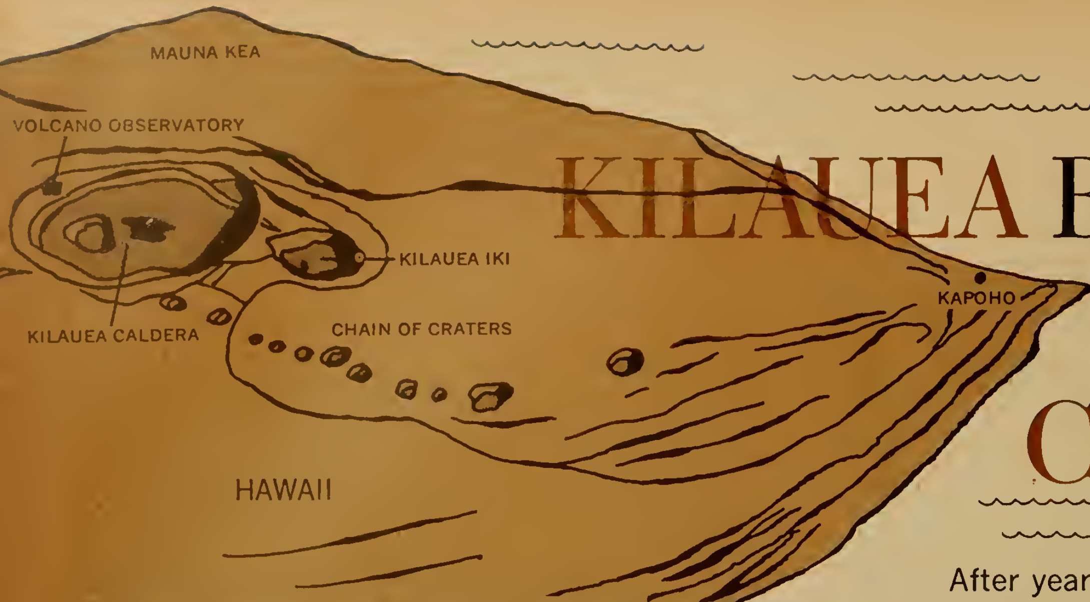


IASTROPHISM SHAPES THE EARTH

nents (particles of rock and of animal and plant remains) pile up in places where the crust has been pulled down by rbances deep within the earth. Gradually the sediments en into rock. Pressures inside the earth sometimes crumple old the layers of sedimentary rock. Over a long period of time crumpled layers may be uplifted to form *folded mountains*. hoto shows some of the curved layers of rock that have been d and pushed up to make Sheep's Mountain in Wyoming.

Forces within the earth seem to push or pull the earth's crust, causing breaks, or *faults*, in the rock layers. If the movement is up and down, it may push surface layers upward on one side of the fault and downward on the other side, forming a *fault-block mountain and valley*. The Mormon Range, in Nevada, is a fault-block mountain. The flat land in front of the mountain is a fault-block valley.

KILAUEA BLOWS ITS COOL



The island of Hawaii has been built by volcanoes through the ages. Kilauea, about 4,000 feet above sea level, is dwarfed by nearby Mauna Loa and Mauna Kea, both over 13,000 feet.

After years of preparation, scientists were able to study the day-by-day events as a Hawaiian volcano erupted into fiery fountains of lava.

■ A few years ago, scientists at the United States Geological Survey's volcano observatory in Hawaii began a race with a volcano. The volcano was Kilauea, and the observatory was perched near the edge of its crater, or *caldera* (*see map*). Scientists had been studying Kilauea for almost half a century.

But they still needed to know many things. What was the underground "plumbing" of Kilauea really like? Where did the hot liquid rock inside the earth (called *magma*) come from? How did it get to the surface and spill out as *lava?*

By answering these questions, the scientists might be able to predict the eruptions of Kilauea and of other volcanoes. So they set out to study all of the details of a volcanic eruption. They made plans to be ready when Kilauea erupted next.

A Race with Kilauea

For years, the scientists at the observatory worked to set up a network of *seismographs*—devices that record vibrations of the earth. Gradually they developed seismographs that were specially suited to measure the earthquakes within Kilauea.

For a long time, scientists had known that the top of Kilauea swells before an eruption, with the sides of the volcano tilting outward slightly. So they developed instruments called *tiltmeters* to measure these changes in Kilauea. Even as they made the tiltmeters and began using them, the scientists discovered that the surface of Kilauea was beginning to swell.

A strange, quiet race began. The observatory team worked night and day, taking more tiltmeter measurements around the caldera. The measurements showed that the entire rim of the volcano was tilting outward. During November 1959, they found that the top of Kilauea was swelling at least three times faster than during the months before. Then earthquakes just below the caldera suddenly became 10 times more frequent and violent than before.

On November 14, 1959, lava broke through a wall of Kilauea Iki, a smaller crater next to the main crater of Kilauea (*see map*). The eruption was on, and the observatory staff now faced a great challenge and opportunity—to use their skill and their instruments to discover the secrets hidden inside a volcano.

Lava Lakes and Fountains

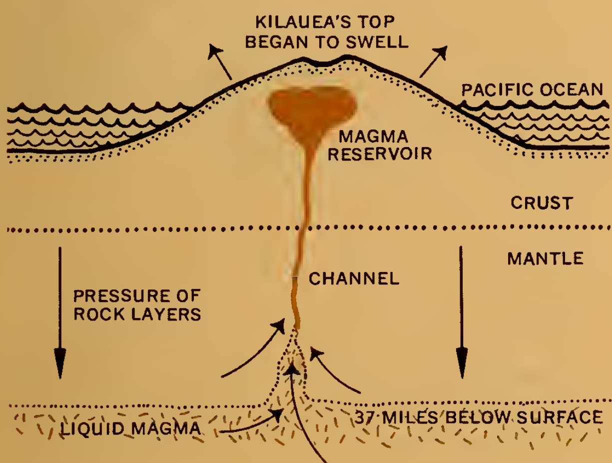
Beginning at dawn on that November morning after the first outbreak, the scientists went to the lava fountains in Kilauea Iki. One group hiked to the edge of the crater floor, now covered with lava 15 feet deep.

As they scrambled down the steep slope, the heat of the lava made them sweat. Puffs of smoke came from the ground around them—warning signals of underground pockets of pressure that could suddenly explode. The trail ended in a lake of flaming red lava. On the crater wall across the lake fountains of lava sprayed into the air (*see*

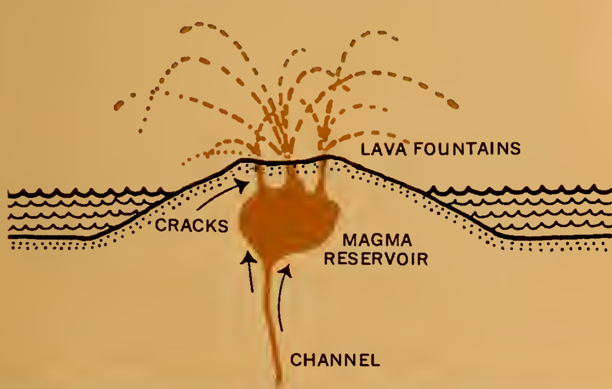
Case History of an Eruption

Here, in brief form, is the step-by-step history of Kilauea's 1959-1960 eruption, as pieced together from studies at the Hawaiian Volcano Observatory.

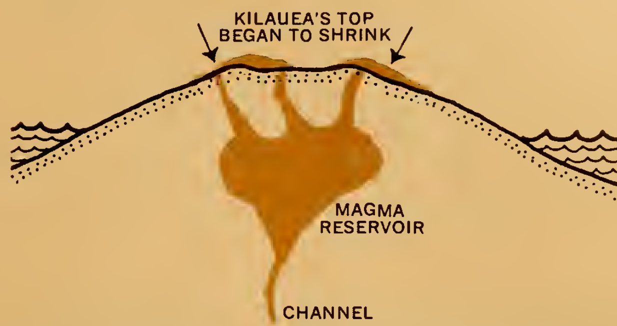
1) Deep within the earth's mantle, about 37 miles below the Pacific Ocean, some of the molten rock (magma) mixed with steam and other gases. (What caused the rock to melt is still a mystery.) When the magma reached the great crack that is under the volcanoes in Hawaii, the weight of the layers of rock above it squeezed it upward. The magma streamed slowly toward the heart of Kilauea through channels in the rock and began to build up in an underground reservoir just a few miles below the caldera. Slowly the volcano's top began to swell as the reservoir filled with magma.



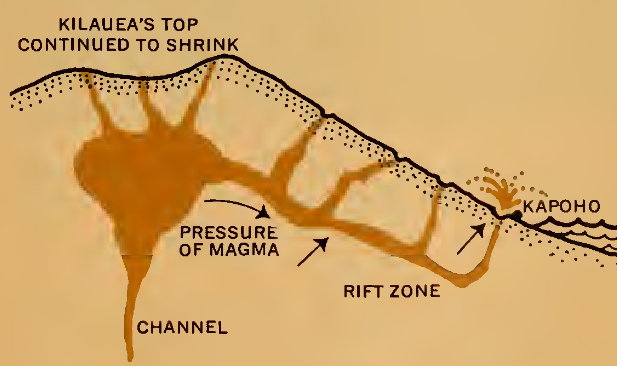
2) As the pressure of the magma in the reservoir increased, the rock began to give. There were many tiny, sharp earthquakes as the magma escaped from the reservoir and forced its way to the top. The pressure of the magma caused cracks that reached the surface, where the magma erupted as lava.



3) The eruption stopped when enough magma had escaped from the reservoir to lower the pressure that had forced the magma up to the surface. The eruption may also have been stopped by magma that hardened and formed a "plug" that blocked the route to the surface.



4) During the eruption, some magma from the reservoir flowed underground into an area of cracked rock (called a *rift zone*) far down the slopes of the volcano. (There was already magma in the rift zone from earlier eruptions. As this magma cooled, it heated the rocks around it, forming a liquid core in the rift.) As new magma flowed into the rift zone, it increased the pressure on the rocks around the liquid core. Pressure also came from the swelling of the volcano's reservoir. Under this double "squeeze," the molten core forced the crust to give and lava poured out of breaks in the volcano's side. This was what happened at the Kapoho eruption (see *text*). Since the lava poured out at a lower level than before, the pressure in the reservoir dropped quickly and the top of the volcano shrank.



cover). The scientists set up markers to measure the rise of the lava. Even as they worked the lava lake rose.

In the days that followed, the scientists took measurements and kept records of as many aspects of the eruption as they could see—the directions and spread of lava, the height of fountains, how fast the lava flowed. At night, men making temperature readings of the lava could be seen outlined against the glow of the volcano.

On December 21, the lava fountain sank from sight. But the top of the volcano was more swollen than ever. Somewhere within Kilauea, the magma was moving in a new direction. *(Continued on the next page)*

Soon there was a swarm of new earthquakes. The scientists located the main source of the quakes, 30 miles away at a small village, Kapoho, which was on Kilauea's side. Part of the land near Kapoho began to sink and the villagers left on January 13. The eruption near Kapoho started that evening, and once again a leaping curtain of fiery lava came from the earth. Two days later the lava had flowed to the coast and began pouring into the ocean. Clouds of steam rose thousands of feet into the air.

Ninety-seven days after the eruption began high atop Kilauea, it ended almost 30 miles away on the volcano's side. The scientists had had a rare chance to learn about the inner workings of the earth. After studying all of the information they had gathered, they had one of the most complete case histories of a volcanic eruption ever assembled (*see diagrams on page 11*).

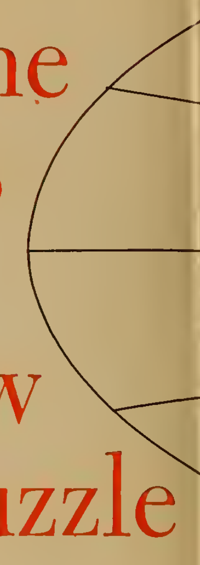
The scientists still cannot predict exactly what Kilauea

Wearing aluminum-covered suits for protection from the heat, the scientists were able to edge close to the lava to collect samples and to take temperature readings.

will do in the future. On August 22 of this year, for example, the Hiiaka crater of Kilauea erupted, sending lava 75 feet into the air. The crater had not previously erupted in historical time. There are more questions to be answered and more work to be done. The scientists would like to know how a huge volcano grows from the flat ocean floor. They would like to chart the places where the magma comes from, and to understand the forces that act on it. The study of volcanoes like Kilauea remains one of the greatest adventures ahead for scientists who wonder about the mysteries under the earth's crust ■

More and more pieces seem to be fitting togethe
as scientists keep trying to solve—

The World's BIGGEST Jigsaw Puzzle



by Diane Sherman

■ Were all the continents once joined together? Scientist who study the earth are beginning to think so. They ar coming to believe that all the continents were once part o a huge land mass that split up into separate continent about 200 million years ago and have been moving apa ever since.

Does this seem hard to believe? It was for the scientist who first heard of the theory of "continental drift" sug gested in 1910 by a German named Alfred Wegener. Lik other *geologists* (scientists who study rocks), Wegener ha noticed how the continents seemed shaped like pieces of jigsaw puzzle. South America and Africa, especiall looked as if they would fit together. North America an Europe seemed to match up, too. Wegener found he coul even fit in India, Australia, and Antarctica as part of th same huge continent *(see map above).* Surely, he felt, th could not be coincidence!

Wegener offered other evidence that seemed to suppo his theory: Some land formations were the same on bo sides of the Atlantic. India, Africa, and Australia had th same kinds of rock layers. Fossils of the same types of ear animals and plants were found in South America, Austr lia, Antarctica, and India. This last fact seemed especial strange. How could the same kinds of plants and anima evolve in places separated by thousands of miles of ocea

Wegener wondered, too, about evidence showing th far-apart places like Australia, South Africa, and Sou America had gone through an ice age at the same time. A

ıe evidence could be explained, he thought, if the con- nents were once joined together. In time, he said, they ıust have drifted apart to become the continents we know ›day.

Scientists argued about Wegener's ideas for years. Some ɜologists thought the notion of continents moving had ıerit. Others thought it was ridiculous. Meanwhile, new vidence of many different kinds was discovered.

itting the Pieces Together

Wegener had said the shapes of the continents seemed › match up. But nobody had made a scientific study of the ctual outlines of the continents to see whether they really /ould fit together. In 1964, Sir Edward Bullard did just ıat. Using a computer at Cambridge University in En- land to help him, he set about "lining up" the continents /here they fit best. He didn't try to match coastlines, be- ause those are not the real edges of the continents. (Coast- nes are carved by the sea and the wind. Besides, they hange over long ages. When large amounts of water are ›cked up in glaciers, the sea level is lower. When glaciers ıelt, the level of the sea rises.)

The real edges of the continents are about 30 miles out om the coastline. Out to this point, the land beneath the 'ater slopes gently downward. Then it drops sharply two ıiles or more to the deep ocean floor. This drop is called ıe *continental slope*. It was the slopes of the different con- nents that Bullard hoped to match up.

The shapes of the continental slopes had already been determined by bouncing sound waves off the ocean floor. When Bullard tried to match up the shapes, he made a startling discovery. If North America, Greenland, and Europe were put down side by side, they would still fit together today. Africa and South America also lined up neatly. The accuracy of the fit was almost perfect!

These findings interested Dr. Patrick M. Hurley, a Professor of Geology at Massachusetts Institute of Technology, in Cambridge. Dr. Hurley and other scientists working with him decided to test the idea further by comparing the rocks on opposite sides of the Atlantic Ocean.

West Africa, they knew, has two kinds of rock underneath the soil. One kind, to the west, is at least 2,000 million years old, and the other, to the east, is about 600 million years old. There is a very definite dividing line between the two kinds of rock. If Africa and South America were once joined together, then South America should have the same rock formations and the same dividing line. The way Bullard had fitted the continents together, the dividing line should come very near the city of Sao Luis in Brazil.

Dr. Hurley asked geologists at the University of Sao Paulo in Brazil to collect rock samples from around Sao Luis. It took time to gather and analyze the rocks, but Dr. Hurley learned that some rocks found to the west of Sao Luis were 2,000 million years old. Other rocks, collected east of Sao Luis, were 600 million years old. The rocks in

(Continued on the next page)

Areas of rock that is at least 2 billion years old (orange) and of rock about 600 million years old (gray) fit together, suggesting that South America and Africa may have been joined like this some 200 million years ago.

Brazil were the same ages as their African counterparts, and the dividing line came almost exactly where Dr. Hurley had expected to find it *(see map on page 13)*.

"Compasses" in Rock

Even stronger evidence that the continents had moved apart was discovered by scientists studying the magnetism of tiny bits of iron in certain kinds of rock. You have probably seen how the earth's magnetic poles attract the needle of a compass. In the same way, tiny bits of iron in melted rock tend to line up with the magnetic poles of the earth. When the rock hardens, these iron "compass needles" become frozen records that point to where the north and south magnetic poles were *at the time when the rock formed.*

The magnetic poles are known to move around a bit, and the scientists thought the directions of "compass needles" in widely separated rocks of the same age should show where the north magnetic pole was when the rocks were formed.

The "compass" rocks in North America seemed to show that the north magnetic pole had wandered over a wide path during the past few hundred million years. But the rocks in Europe showed a *different* path for the pole's wandering during that time! *(See map.)*

"Compass" rocks in North America seemed to show that the north magnetic pole has wandered along the black line during the past several hundred million years, but European rocks showed a different path (colored line). Scientists now believe the pole didn't move much, but the continents may have been moving apart during that time.

It seemed unlikely that the earth ever had *two* north magnetic poles wandering around in different paths. But what if the north magnetic pole had not moved far at all? What if it was the continents that had moved great distances during the past few hundred million years? The "compass needles" in the rocks that were formed during that time would be lined up just as they are today.

How Could It Happen?

Ever since Wegener first came up with the theory of continental drift, there had been one main reason why many geologists scoffed at the idea. For a long time, no one could figure out what force might be strong enough to split the continents apart. Wegener thought maybe it was a force related to the spinning of the earth. But he had no idea how such a force might work.

Today, new evidence seems to explain how the continents may have been moved apart. Winding through the oceans of the world is a huge undersea mountain range, called the *mid-ocean ridge (see map at right)*. A deep crack, or *rift*, 30 miles wide in places, runs the length of the ridge.

The temperature of the sea bottom is slightly higher in the rift and along the ridge than it is along the sides of the ridge. Geologists think that hot, almost-melted rock is slowly but continually coming up through the rift. As more rock rises and hardens, it keeps pushing the sea floor outward from the rift on both sides. This kind of constant pressure might have split the continents apart and pushed them to where they are today.

We know that the earth underneath the rift is unstable. Many earthquakes occur along the rift, and volcanoes spout up there, too. In the past four years, whole new islands have been formed near Iceland by lava pouring out onto the sea floor.

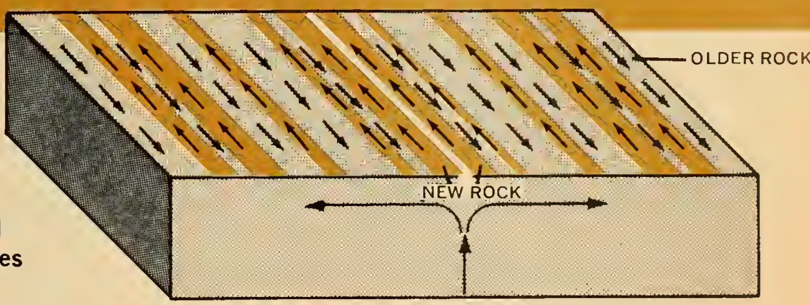
Patterns in the Sea Floor

There seems to be no question that hot rock is pouring out along the rift. But how do we know it pushes the ocean floor outward from the rift? Some evidence was recently discovered in the rock along the sides of the mid-ocean ridge. Scientists found a striped pattern in the magnetism of this rock. The stripes run parallel to the ridge, and the "compass needles" in each stripe are lined up in the opposite direction from those in the stripes next to it. The stripes are of different widths, and they are arranged in the same order on both sides of the ridge *(see diagram on next page)*.

We know that the *polarity* of the earth's magnetic field has been reversed nine times in the past 3.6 million years. (If this happened today, what we call the "north-seeking" end of our compasses would point to the south magnetic pole.) This would explain why rock that formed at the rift at different times was magnetized in opposite directions. And the striped pattern seems to prove that this new rock is gradually pushed away from the mid-ocean ridge, spreading the sea floor.

There is still more evidence to show the ocean floor has been spreading. Samples of the material lying on the sea

The colored area in this map shows the *mid-ocean ridge*, a huge undersea mountain range that winds through the oceans. The white line in the ridge is a crack, or *rift*, through which hot, new rock may be gradually rising from inside the earth and pushing the ocean floor apart. The black dots show where earthquakes occur most often (see *"The Faults of Earthquakes,"* *page 2*). The brown dots show where active volcanoes are located (see *"Kilauea Blows Its Cool,"* *page 10*).



Strips of rock along the rift have "compass needles" pointing in opposite directions, showing that new rock has been forming there and pushing older rock outward as the earth's magnetic poles changed polarity nine times in the past 3.6 million years.

bottom have been collected. This material, called *sediment,* is laid down very slowly. Year after year the shells of dead sea animals drift to the bottom. Silt washed to the sea by rivers may get mixed in. Ash from volcanic eruptions floats down. Gradually a thick layer of sediment builds up.

Along the highest part of the mid-ocean ridge, in a strip 100 to 150 miles wide, the sediment is very thin. Underwater photography often shows no sediment on this area at all. The absence of sediment may mean that this part of the ocean floor is new, and hasn't had time to accumulate a covering.

Fossils provide evidence, too. The fossils in sediment taken from some parts of the Atlantic floor are much older than those in sediment from other areas. Geologists think the sections of the floor where no ancient fossils were found may be newer.

The Search for Proof

Sir Edward Bullard's map, Dr. Hurley's matching rocks, magnetic maps, and ocean sediments—taken together, they seem to show that Wegener's theory of wandering continents was right. In the past year most scientists have come to accept the idea of continental drift. But an attempt is now being made to prove the matter once and for all.

The project is called JOIDES (for *J*oint *O*ceanographic *I*nstitution for *D*eep *E*arth *S*ampling). In over 50 separate ocean locations, a ship will send down a new, specially constructed drill through four miles of water into the sediment below. In some places, the drills may dig as far as 2,600 feet into the earth's crust to bring up samples of sediment and rock. Scientists will examine the samples, and try to determine which ones are oldest. If the ocean floor has really spread out from the mid-ocean ridges, then the oldest sediments should be from the northwestern part of the Pacific, or from the Caribbean, because those are the regions farthest from the ridges.

Scientists aboard the drilling vessel are also measuring the heat coming up from the ocean bottom, investigating the magnetic patterns in rocks, and studying the formation of islands and undersea mountains. With enough information from enough different places, they may be able to say positively that the continents have split apart.

Should that happen, one of the biggest scientific mysteries of recent years can be marked "Case closed" ■

BRAIN-BOOSTERS

prepared by **DAVID WEBSTER**

MYSTERY PHOTOS

The shadow of one matchbox was made by sunlight. The other shadow was made by light from an electric bulb. Can you tell which is which?

FOR SCIENCE EXPERTS ONLY

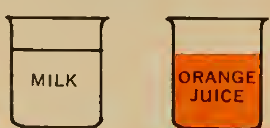
Why does the sun often appear to be almost round at sunrise, but egg-shaped at sunset?

WHAT WOULD HAPPEN IF?

The photo shows how a cube-shaped wooden block floats in water. The two blocks at the side were glued together to make a long block. In what position would the long block float?

FUN WITH NUMBERS AND SHAPES

Suppose you have a pan of milk and a pan of orange juice. First you take a cup of the orange juice and mix it with the milk. Then you take a cup of the milk-and-orange juice mixture, and put it back into the pan of orange juice. Is there more orange juice in the milk or more milk in the orange juice?

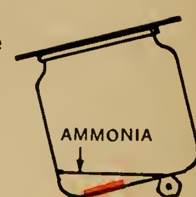


CAN YOU DO IT?

Can you make some ice inside your house without using the refrigerator or freezer?

JUST FOR FUN

Put a penny in a little household ammonia in a covered jar as shown. *(Be careful not to touch or sniff the ammonia.)* In a short time the ammonia should begin to turn a beautiful shade of blue. See if the color changes faster if part of the penny is sticking out of the ammonia.



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo shows a small waterfall, only a few inches high.

What would happen if? The marble would travel in a straight line (path C) after it rolled off the plate. Would the marble travel in a curved path if the plate were on a slanted tabletop?

Can you do it? It is possible to swallow water while you are upside down. Muscles in your throat contract and force the water up into your stomach. Why must birds lift their heads in order to swallow?

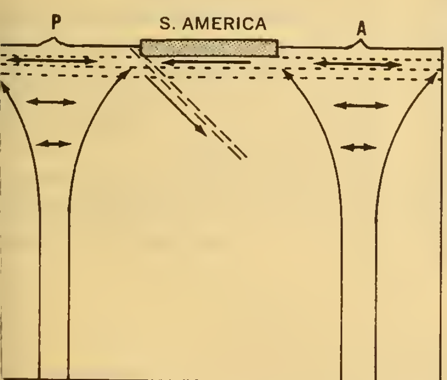
Fun with numbers and shapes: The minute hand of a clock passes the hour hand only 11 times in 12 hours.

For science experts only: Air pressing down on the newspaper would tend to keep the covered end of the yardstick in place while the other end of the yardstick is forced down by your hand. Since one part of the yardstick stays still while the other part is moving, the yardstick will break if you hit it hard enough.

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

weaker until it disappears completely, then begins to get stronger *in the opposite direction.* By studying the directions of "compass needles" in rocks formed at different times and places, scientists have found that the polarity of the earth's magnetic field has reversed nine times in the past 4 million years, staying the same for periods ranging from about 50,000 years to about 850,000 years, and taking something like 5,000 years to make a complete reversal. The reversal of polarity may be caused by some difference in the motions of the earth's mantle and core (which might be explained by the Rouse-Bisque theory suggested on page 4 of this issue).

- If your pupils wonder what causes new rock to rise up in the mid-ocean rift and push the older rock on both sides farther from the rift, they are not alone. Scientists wonder, too. Some think that the rock in the mantle acts something like Silly Putty, which "flows" under the force of gravity without seeming to become any less solid. According to this theory, the mantle rock slowly circulates in giant *convection currents,* moving slowly upward where it is hot and moving downward where it is cooler *(see diagram; also "Brain-Boosters: Just for Fun,"* N&S, *Oct. 14, 1968, page 4T).*



In giant *convection currents*, hot rock may be rising in the earth's mantle at the Mid-Atlantic Ridge (A), slowly moving westward under the American continents, and moving downward where it meets similar rock moving eastward from the East Pacific Rise (P). This apparent downward movement at the western coast of South America might be the cause of the folded mountains and of the faults that cause earthquakes in that area.

Brain-Boosters

Mystery Photo. The matchbox shadow with even shading and "sharper" edges was cast in light from the sun. Your pupils can discover this by comparing the shadows cast by a matchbox, or similar object, (1) in light from the sun, then (2) in light from a bright bulb within a few feet of the box. Can anyone explain why the bulb-light shadow is so much "fuzzier" at the edges than the sunlight shadow?

By moving the light bulb farther away from the box, your pupils can make its shadow less and less "fuzzy" at the edges, until it is nearly as evenly shaded and "sharp-edged" as the shadow made in sunlight.

When the bulb is close to the box, light from some parts of the bulb reaches into some of the areas shaded by the box from light from other parts of the bulb. This produces the mixture of light and shade that makes the edges of the shadow appear "fuzzy." While the sun is immensely bigger than the light bulb, it is so far away that the box blocks light from all parts of the sun from the shaded area.

What would happen if? Obtain some wooden blocks of various shapes and let your pupils float them in a pan of water, observing their different orientations. A long block made of two cubes will float as shown here.

Can you do it? To make ice without a freezer, put a small jar in the center of a pan and pack ice around it. Pour a large amount of salt on the ice, taking care not to get any in the jar. Then put a little water into the jar, and wait about 15 minutes for it to become ice.

No amount of ice alone would be sufficient to freeze the water in the jar. Adding salt, however, lowers the melting point of the ice, making it melt faster than it ordinarily would. The heat needed to melt the ice comes in part from the water in the jar, which drops in temperature as it gives up its heat. In time the ice melting in the pan takes enough heat from the water in the jar to cause it to freeze.

Fun with numbers and shapes. After the orange juice and milk have been mixed as directed, each liquid will contain an equal amount of the other liquid. This holds true no matter how much of either liquid you start with. For example, if one pan contains 2 cups of milk, pouring 1 cup of juice into it makes 3 cups of a mixture that is one-third juice and two-thirds milk. A cup of this mixture must then be made up of ⅓ of a cup of juice and ⅔ of a cup of milk. So pouring 1 cup of the mixture into the juice gives it ⅔ of a cup of milk and leaves ⅔ of a cup of juice mixed with the milk.

Have your pupils figure out what fraction of a cup of each liquid will end up in the other liquid if they start with 1, 3, 4, or some other number of cups of milk. (Someone may notice that the fraction always equals the number of cups of milk you start with divided by that number plus 1.)

For science experts only. During the day, air that has been warmed by the sun rises, pushing aside the cooler air, and producing currents in the atmosphere. By sunset, there are many moving masses of air at different temperatures. The warmer and cooler masses of air bend, or *refract,* the sunlight differently because of their different densities. This often makes the sun appear to be oval, or sometimes other shapes. At dawn the sunlight travels through cool air that bends all the light rays in about the same way, so the sun usually retains its normal round appearance.

You can demonstrate the bending of light by standing a ruler in a glass of water. The bending of light passing from the denser water to the less dense air will make the ruler appear to be bent.

Just for fun. If you do this in class, remember to caution the children against touching, tasting, or sniffing the ammonia. The blue color will appear faster if part of the penny is exposed to the air.

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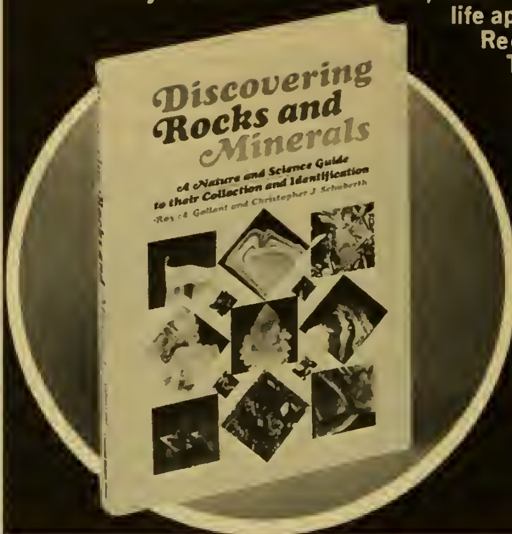
Recommended by The American Association for the Advancement of Science.



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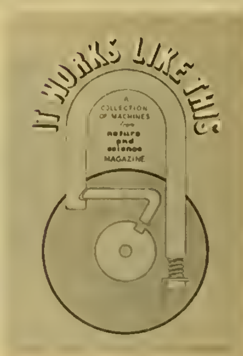

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nature and science

TEACHER'S EDITION

VOL. 6 NO. 5 / NOVEMBER 11, 1968 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Biological Birth Certificates

Most of the methods developed for finding the age of animals are applied to fish and game. By determining the ages of a sample of an animal population, state fish and game departments are better able to regulate the "harvest" of the animals. The information can also measure the success of game management methods; for example, to see how a change in vegetation has affected an animal population.

Some methods of age determination are useful only for distinguishing adults from juveniles. Fish scales, however, not only reveal the animal's age in years but also indicate how fast the fish has grown during those years. An added advantage is that a scale can be removed from a fish and the animal can be returned to the water. In many other methods of age determination the animal must be dead.

Some methods of determining age are more accurate than others. Tooth wear, for example, may be affected by the kind of vegetation an animal eats. For this reason, the amount of tooth wear might be different in animals of the same age that come from different areas.

Your pupils may wonder how the age of humans is determined (when no birth certificate or other record exists). Suppose archeologists find a skeleton and want to find out how old the person was at death. Two useful clues are the emergence of adult teeth and the replacement of cartilage with bone. Both of these processes are completed in the early teens. After that, the shape and texture of the pelvic girdle provides clues that enable scientists to determine the person's real age within four or five years.

Discovering an "Ocean"

Like Aesop's fables, this fascinating SCIENCE ADVENTURE story has a "moral": *An idea that is accepted without being questioned or tested can be worse than no idea at all.*

Unlike Aesop, we left this conclusion for your pupils to draw for themselves. You can help them by pointing out that Aristotle's idea—that everything was made of earth, water, fire, and air; that air had no weight; and that nature would not permit a *vacuum* (Latin for "nothingness") to exist—was accepted as "true" for nearly 2,000 years. During that time people learned practically nothing about air or the earth's atmosphere. But once Galileo questioned the idea (even though he didn't disprove it completely), scientists began investigating air and soon learned more about it and the atmosphere than people had discovered in all of man's previous existence.

This "snowballing" of knowledge has gone on at an ever-increasing pace since the time of scientists like Galileo and Torricelli, who were not afraid to question long-accepted ideas and test them against what really happens in nature. *(Continued on the next page)*

IN THIS ISSUE

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

Zoo Doctor
A veterinarian tells some of the problems of treating patients of 1,100 different species and trying to keep them all healthy.

The Wonders of Wood
By studying the structure of wood and combining wood with other materials, scientists have found ways to change its characteristics.

● **Biological Birth Certificates**
This WALL CHART shows some of the ways that scientists find the ages of animals captured in the wild.

● **Brain-Boosters**

● **Discovering an "Ocean" from the Bottom**
Your pupils will learn how an Italian mathematician opened a new field for scientific investigation by proving that we live in a "sea of air."

Make the Most of Yeast
A SCIENCE WORKSHOP investigation into the reactions of yeast with different foods.

IN THE NEXT ISSUE

How scientists are seeking ways to save elm trees from the Dutch elm disease...SCIENCE WORKSHOPS: Investigating how cells get food through their "skins" (osmosis), and the splash patterns of falling raindrops . . . WALL CHART on the physics of fasteners.

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

Topics for Class Discussion

• *Why was Aristotle's "no vacuum allowed" idea accepted for such a long time?* Aristotle was a keen observer of the things around him, both living and non-living. In addition, he invented the system called *logic*—reasoning that if one thing is so, then certain other things must also be so—which is the basis for modern science. He was convinced that "true" ideas could only be found through logical reasoning, and he tended to trust ideas reached in that way without trying to make sure that the ideas really described what happens in nature.

Aristotle's ideas were accepted as "true" for the next 2,000 years, during which few people even learned to read and write, and the few who learned more than that studied under teachers who accepted Aristotle's ideas.

You might point out that even Galileo didn't question the "no-vacuum" idea until he found out what miners had known for centuries—that a lift pump could only lift water about 30 feet. Using Aristotle's logic, he reasoned that if nature would not permit a vacuum to exist, then a lift pump should be able to lift water to any desired height. Again by logic, he reasoned that nature's ability to prevent a vacuum must be limited by the weight of water, which seemed to make a column of water more than 33 feet high fall apart. Galileo died before he could test this idea, but Torricelli, one of his students, questioned both Aristotle's idea and Galileo's modification of it.

Torricelli used logic to figure out that if air has weight, and if the air pressing down on the earth is heavy enough to balance the weight of a column of water about 33 feet high, then it should also balance the weight of a column of mercury (which is 13.5 times as heavy as water) about 30 inches high. The barometer he invented proved his prediction was correct, and this finding backed up his "sea of air" idea.

• *Besides stimulating other scientists to think and wonder about the air in new ways, why was the "sea of air" idea so useful to them?* It served as a "model" of the atmosphere on which they could base their investigations. For example, Pascal reasoned that if the atmosphere were like a "sea," then the higher you went in it, the less air there should be pressing down on you. His mountain-climbing experiment proved this so.

In the same way, scientists today depend strongly on "models"—sometimes actual physical models like the double-helix model of the DNA molecule or the "model" tornado shown in *N&S*, April 15, 1968, page 4, and sometimes *idea* models, like the "sea of air" idea.

• Your pupils may wonder how Torricelli got the idea for his barometer. You might tell them this story:

In 1641, two years before Torricelli invented the barometer, another Italian named Gasparo Berti tried to create a vacuum in a 40-foot tube with valves at the top and bottom. He placed the tube so that its top was near a window in a tower of his castle-like home *(see Diagram A)*. Then he filled the tube with water and closed the top valve. When the bottom valve was opened, some of the water flowed out, but not all of it. Berti closed the bottom valve and then opened the top valve from the tower window. Whoosh! Air rushed into the top of the tube. Berti had created a vacuum. He lowered a weight attached to a dry string through the tube, and found that the column of water left in the tube was about *34 feet high*. This was at least a foot higher than the very best lift pump could lift water in a pipe.

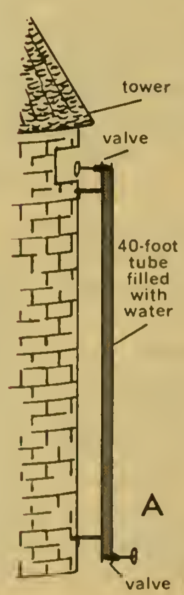
Obviously, the height to which a lift pump could raise water was not the most accurate measure of air pressure, so Torricelli adapted Berti's method of making a vacuum to measure air pressure with mercury.

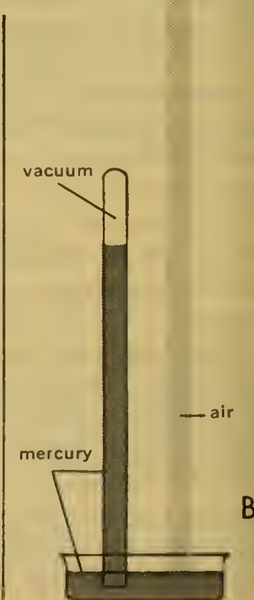
• *Does the height of the mercury in a barometer tube measure the weight of the air that is pressing down on the* entire surface *of the mercury in the bowl, or* reservoir*?* No. The weight of the mercury in the tube is supported (or "balanced," as on a balance scale) by the weight of a "column" of air the same diameter as the mercury column but extending from the surface of the mercury in the reservoir to the top of the atmosphere *(see Diagram B)*.

• *How could you use a barometer tube whose opening was one square inch in area to find out how many pounds of air are pressing down on each square inch of your body?* Mercury weighs about 0.49 pounds per cubic inch. If the top of the mercury in the tube is 30 inches above the reservoir surface, the column is made of 30 cubic inches of mercury, which weighs 30 x 0.49=14.7 pounds. (The average atmospheric pressure at sea level is 14.7 pounds per square inch.)

• *Why do meteorologists measure atmospheric pressure in "inches of mercury," while engineers measure it*

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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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nature and science

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DISCOVERING AN "OCEAN" FROM THE BOTTOM

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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 EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

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ZOO DOCTOR

In his job as an "animal doctor" at a zoo, Dr. Charles P. Gandal finds himself operating on snakes, deciding what to feed young gorillas, and checking on the health of about 3,000 animals from all over the world.

by Steven W. Morri

■ Gorillas with colds? A python sick with cancer?

I had recently read of such things in reports written b Charles P. Gandal, the "animal doctor" (*veterinarian*) the New York Zoological Park, which most people ca "the Bronx Zoo." I decided to visit the zoo hospital, small white building most zoo visitors never see.

The doctor's job there must be a big one, I thought. T zoo has about 3,000 animals of 1,100 kinds (*species* And caring for the animals that get sick each day is n Dr. Gandal's only job. He must also make sure no diseas are transferred to the animals from the more than tw million people who visit the zoo each year. And wheneve a new animal comes in, Dr. Gandal must be sure it is n bringing germs or parasites that might be dangerous the animals it will be living near. The doctor also tries see that the animals are kept in surroundings that will he

STATEMENT OF OWNERSNIP, MANAGEMENT ANO CIRCULATION (Act of October 23, 1962; Section 4369, Title 39, United States Code) 1. Date of filing: October 1, 1968. 2. Title of publication: Nature and Science. 3. Frequency of issue: Fortnightly September, October, December through March; monthly November, April, 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. Names 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 or holding 1% or more of 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 2781, 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. 2781, Grand Central Station, New York, N.Y. 10017; Ellen Doubleday, Nelson Doubleday, Janet Doubleday, Neltje Kings, 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, mortg and other security holders owning or holding 1% or m total amount of bonds, mortgages, or other securities are: 9. Non-applicable. 10. Extent and Nature of Circulation: The age number of copies each issue during the preceding 12 m are: (A) Total number of copies printed (net press run): 24 (B) Paid circulation (1) Sales through dealers and carriers, vendors and counter sales: 360; (2) Mail subscriptions: 20 (C) Total paid circulation: 210,102. (D) Free distribution (i ing samples) by mail, carrier or other means: 2,747. (E) distribution (Sum of C and D): 212,849; (F) Office use, lef unaccounted, spoiled after printing: 30,043; (G) Total (Su E&F—should equal net press run shown in A): 242,892 number of copies single issue nearest to filing date are: (A) number of copies printed (net press run): 283,000. (B) Paid c tion: (1) Sales through dealers and carriers, street vendor counter sales: 360, (2) Mail subscriptions: 174,309; (C) Total circulation: 174,669. (D) Free distribution (including sample mail, carrier or other means: 5,570; (E) Total distribution (S C and D) 180,239. (F) Office use, left-over, unaccounted, s after printing: 102,761; (G) Total (Sum of E&F—should equ press run shown in A): 283,000.
I certify that the statements made by me above are corre complete

James K. Page, Jr.
Publisher

ɔga, one of the young lowland gorillas raised at the ronx Zoo, often showed affection toward Dr. Gandal.

ıem stay healthy. For example, Dr. Gandal once had a roblem with four young gorillas.

ɪrowing Gorillas

Gorillas don't mate and reproduce nearly so often in ɔos as they do in the wild. Most gorillas that are in zoos ere caught when they were very young, before they had ıuch experience in living with other gorillas. In the zoos ıey are kept by themselves or sometimes in twos. As they row they sometimes get on each other's nerves, and may ght.

Would gorillas be able to get along with each other etter if they had more chance to play and live with other orillas when they were young?

To find out, the zoo got four baby lowland gorillas. The reparations for their coming took weeks. During their rst four months, no one was allowed to go near them xcept hospital staff and some keepers.

"We built sleeping boxes and put them across the backs of two big cages that had connecting doors," said Dr. Gandal. "The gorillas had plenty of room. The cage floors were deeply carpeted with wood shavings, and in one cage we put things for the gorillas to play with—rubber balls, a swing, a tire hanging by a rope.

"What should we feed them? People are wrong who think animals always know what foods to eat for good health. We decided to get the babies used to eating a kind of 'cake' that had been fed to apes in other zoos and had kept them healthy. It is a mixture of grain and other foods that contains all the vitamins, minerals, proteins, and starches that apes need for health. Usually we gave it to them along with vegetables and milk. Within a week, the little gorillas were eating the cake regularly. Another food they liked—perhaps because of the easy-to-hold shape—was carrots, which they liked to carry along as they explored and played. Every now and then they would stop to nibble.

"The babies didn't need much doctoring," Dr. Gandal said. "We knew they could easily catch human diseases such as colds and pneumonia, so even the zoo workers were warned to stay away if they had any signs of a cold or sinus trouble. Even so, all four babies had runny noses a couple of weeks after they came. Right away we made the cage warmer by about five degrees, and put in a vaporizer that sprayed water into the air, making it easier for the animals to breathe. This is the same treatment that your doctor might prescribe for you.

"On the third day, three of the gorillas were healthy and playing normally again. Only little Bendera, the smaller male, was slow and quiet and seemed not to have improved.

"I checked his pulse, body temperature, and breathing. He had a slight fever and his lungs were slightly 'stuffed up,' or congested. We gave him a sweetened germ-killing medicine that is often given to children with colds. His keeper saw to it that Bendera took his medicine every day, usually in a cup of specially sweetened milk. By the second day, Bendera was much better, and by the third he was playing with the others as usual.

"Checking for other possible diseases, we found that the babies had parasitic roundworms inside them. There were only a few, and a little medicine got rid of them. The babies seemed content most of the time they were in the hospital and after they were moved to the ape house. If we can keep them that way, maybe years from now they will produce young," Dr. Gandal said.

To Save a Snake

If you visit the Bronx Zoo, you may see a 12-foot

(Continued on the next page)

Indian python (*see cover*). You will have to look close to see the 2½-inch scar under the snake's jaw. Dr. Gandal told me how it got there.

"One day a keeper noticed a marble-sized swelling under the snake's jaw. The lump kept growing. Soon we were treating the snake daily, making cuts to drain the liquid out of the lump, and giving the snake medicine."

The zoo has a well-equipped hospital to care for its 3,000 animals. Here Dr. Gandal examines an X-ray of an antelope's broken leg.

The medicine cleared up an infection caused by bacteria, but the snake's jaw kept swelling. Dr. Gandal cut a small piece out of the lump and examined it under a microscope. He discovered that the swelling was caused by the disease called *cancer*.

By now the swelling had grown to the size of an orange. "We brought the snake to the hospital," Dr. Gandal said. "I put a tube down its windpipe and we pumped in a gas that 'knocked out' the snake.

"The surgery to cut the lump out was bloody, long, and tiring. Ninety minutes after we started, I tied the last of more than 100 stitches. We kept giving the snake oxygen for more than two hours. The lump weighed 1½ pounds.

"Of course, the snake couldn't eat after so much cutting," Dr. Gandal said. "We fed it by injecting liquid sugar and protein under its skin once a week. Thirteen weeks after the surgery, the reptile keepers excitedly told me that the python had eaten without help. It was well again."

On the day I visited the zoo hospital I could tell something unusual was happening. Dr. Gandal was peering into a microscope. A blackfoot penguin at the New York Aquarium had died mysteriously after acting strangely for three days. Dr. Gandal had been called to investigate.

What Happened to the Penguin?

Tests showed the penguin had died of *malaria*, a disease that kills by destroying an animal's red blood cells. This disease had never before been found at the aquarium. A bird catches the disease in the same way humans do, by being bitten by a mosquito that has taken malaria parasites into its body along with the blood of a diseased animal that it has bitten. Humans can't get the same type of malaria that penguins get, so there was no danger to visitors. However, the disease could have been passed on to other birds in the flock.

A small box near Dr. Gandal's microscope contained glass slides, each with a reddish smear on it. One by one, Dr. Gandal took out a slide, put it under the microscope, and moved it back and forth, searching.

"These are samples of blood we took from the other birds in the flock," he said. "Look here."

Through the lens I saw round red blood cells. Two of them had small darker red spots in them. "The bird we got this blood from has malaria," Dr. Gandal said. "We'll have to get it out of the flock right away."

With the penguin separated from the flock, the malaria would spread no further. When Dr. Gandal had finished looking at the rest of the slides and arranged for the

Dr. Gandal and his assistant often use a microscope to examine blood samples taken from the zoo animals.

Besides caring for sick snakes and young gorillas, on a "typical" day Dr. Gandal may be found giving a pill to an elephant with an upset stomach (*above*), putting ointment on the eye infection of a tortoise (*left*), and examining an agouti for a possible lung infection (*below*).

diseased bird to be taken out of the flock, he motioned for me to follow him on another job.

Why Do Zoo Animals Die?

We went to a small room next to Dr. Gandal's office. He opened a wooden refrigerator door set in a wall, walked inside, brought out some dead animals, and put them on a table.

"When animals die they're put in here with a note telling me when they died and any other information I should know," he said. "I examine the bodies to find out exactly why they died. This gives us clues to any possible dangers to other animals."

A king vulture had been sick for a long time before it died. It had refused to eat the dead mice that had been injected with medicine that might have helped it survive. The doctor first examined the vulture's head for signs of breaks in the skull.

"That's often the cause of birds dying," he said. "When you see a big beak like that, you can imagine why. One bird will often whomp another one on the head."

But this bird's head showed no signs of injury. Dr. Gandal then cut the bird's body open. Some of its organs were swollen. He cut pieces from them and put them in a jar to be sent away to a special laboratory to be examined.

He did such *autopsies,* or after-death examinations, on a duck, two prairie dogs, a small, monkey-like demidoff galago, a king snake, two chipmunks, and a toucan.

"See how discolored its liver is? Toucans often tend to develop liver disease," he said.

I asked, "Do they in the wild too?"

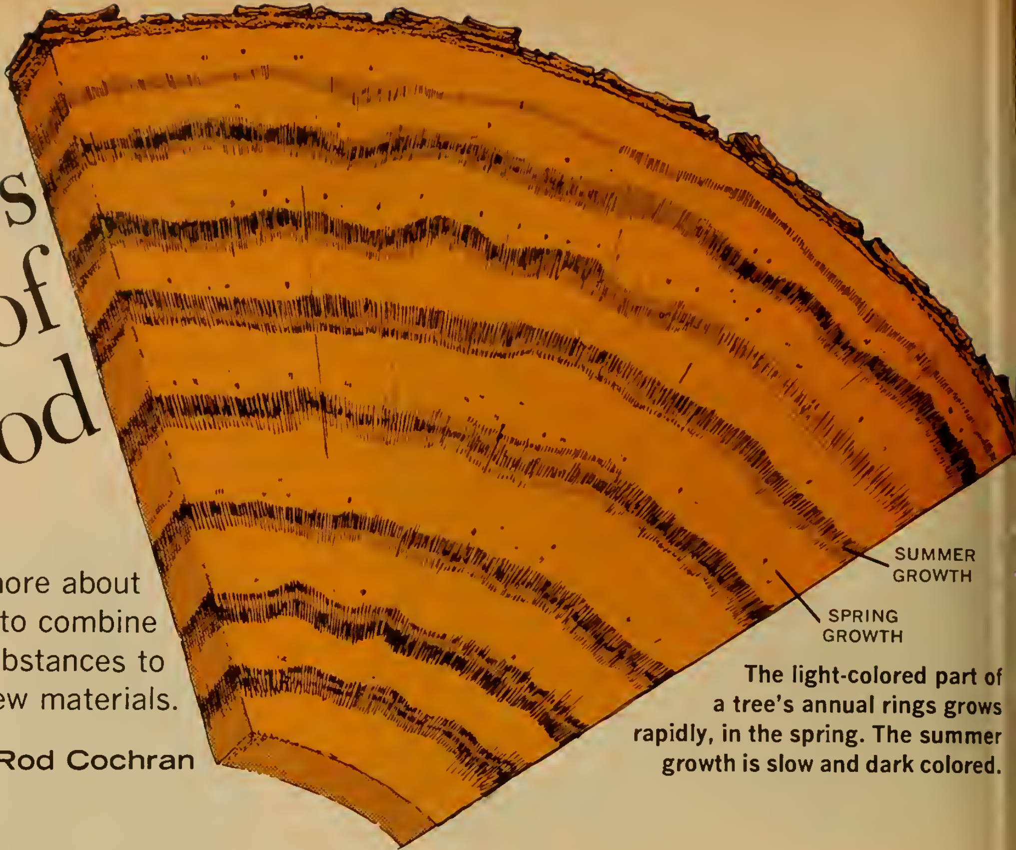
"We don't know. That's one of our troubles. We don't see many diseased animals in the wild, so we don't know how much of a zoo animal's illness is caused by captivity.

"Like human medicine, doctoring of animals has had great changes since I came to the zoo, 17 years ago," Dr. Gandal said. "There have been new vaccines, medicines, and equipment. But it seems that no matter how advanced the techniques of medicine get, the good zoo doctor will still have to like animals, and understand them, to do his job well." ■

The Wonders of Wood

As scientists learn more about wood, they are able to combine it with other substances to make new materials.

by Rod Cochran



The light-colored part of a tree's annual rings grows rapidly, in the spring. The summer growth is slow and dark colored.

■ Wood is one of the most useful materials man has found on the earth. It is strong, light, easy to work with, and can be stained, varnished, or painted in many ways. As scientists called *wood technologists* have studied wood and learned about its structure, they have begun to understand why wood is so useful. And the more they learn about wood, the more uses they find for it.

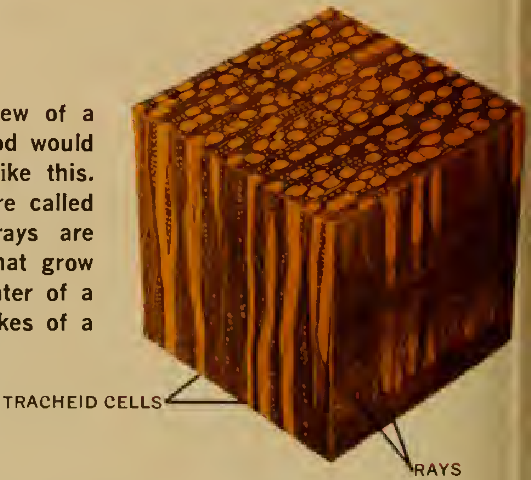
You probably know already that tree trunks and limbs are made up of rings of wood, called *annual rings.* (The age of many kinds of trees can be discovered by counting their annual rings.) All of the wood in a growth ring is not the same; the wood that grows rapidly in the spring is not as dense or as strong as the slower-growing summer wood (*see diagram*).

By examining wood with microscopes, scientists have found that wood is made up of long, hair-like cells called *tracheids* (*see photo*). A one-inch cube of Douglas fir wood may contain three million of these long cells. The tracheids are cemented together with a tough "glue" called *lignin.* The walls of the cells are made up mostly of another strong material, called *cellulose.* Wood is about two-thirds cellulose and one-third lignin.

Using powerful electron microscopes, scientists have been able to examine a single tracheid. They found that each tracheid has walls made up of three layers, with tiny strands of cellulose locked in different directions in each layer. This makes the cell wall especially strong for its size.

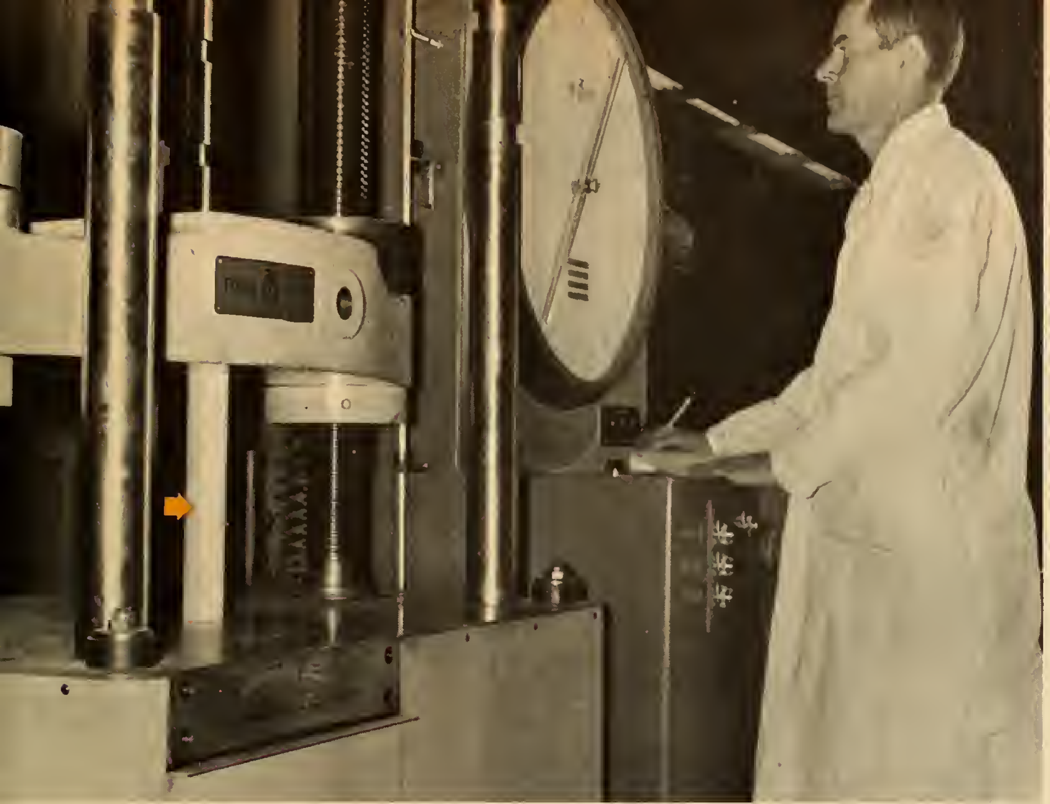
Chemists can separate the cellulose fibers from the lignin that holds them together. This is the first step in paper making. The fibers are then arranged in a layer and pressed into paper. Tear a piece of newspaper and hold it up to the light. You can see the fuzzy cellulose fibers along the torn edges. Cellulose fibers are used in such materials as plastics, rayon, and photographic film, and in the pages of this magazine.

A microscopic view of a tiny block of wood would look something like this. The long cells are called *tracheids.* The *rays* are bands of cells that grow out from the center of a tree like the spokes of a wheel.



Mixing Wood and Plastic

After wood has dried, liquids can be forced into the hollows where watery sap once was. Some liquids preserve wood for many years. Others can make it fireproof, or insect-proof. Technologists recently discovered that they can force liquid plastic into wood, then harden the plastic into a solid by heating.



This is the machine used by Dr. Siau to measure the compressive strength of wood. The arrow points to the piece of wood being tested. The dial near Dr. Siau shows the amount of pressure the machine is putting on the wood.

One of the men studying this new wood-plastic combination is Dr. John Siau of the State University College of Forestry at Syracuse, New York. His job was to find out how the plastic changes the properties of the wood.

One test compared the strength of a piece of basswood with an equal-sized piece of a basswood-plastic combination. Dr. Siau put a sample of basswood into a testing machine that can push on an object with as much as 120,000 pounds of force. (The machine measures what is called the *compressive strength* of objects.) Slowly the great machine began to press down on the wood. The hand on a large dial began to move, showing the amount of pressure. The piece of basswood was one inch square and four inches long. It supported five tons—the weight of three automobiles—before it broke.

When Dr. Siau tested an equal-sized piece of basswood-plastic, he found that its compressive strength was twice that of basswood alone. (Can you figure out why?)

Dr. Siau also found that wood-plastic is a better conductor of heat than wood alone. In another test, he measured the stiffness (rigidity) of the two materials.

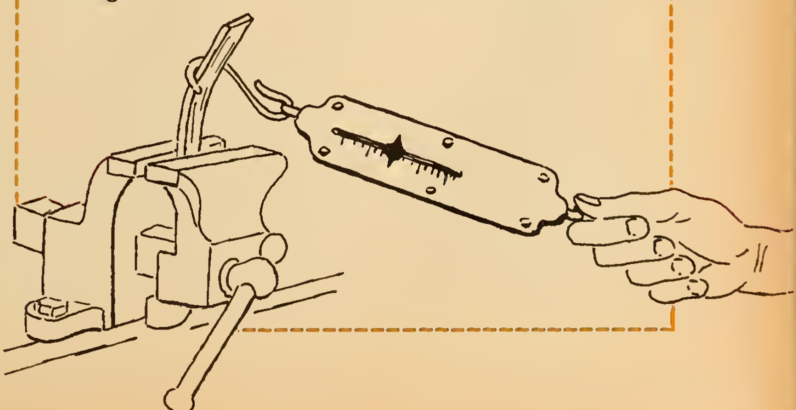
This time each sample was hung in the air by threads. Then a high-pitched sound was aimed at the samples, causing them to vibrate. A device called an *oscilloscope* measured the frequency of vibrations. The stiffer a material, the more rapidly it vibrates. Dr. Siau found that the wood-plastic was more rigid than the wood alone.

Since wood technologists have learned about the characteristics of wood-plastic, they have found many uses for this new material. It is being used for billiard cues, flooring, knife handles, table tops, and chair arms.

By learning more about the structure of wood and by combining wood with other substances, technologists hope to find new uses for this abundant, cheap material. For example, the lignin that makes up about a third of wood is usually thrown away as waste. Wood chemists are searching for ways to use lignin and add to the 5,000 ways in which wood is already used by man ■

PROJECT

You can test the stiffness of different kinds of wood by using a vise and a spring balance as shown in the diagram. Be sure to use wood samples of the same size, and be sure that the vise grips an equal length of each sample. As you pull on the balance (see *diagram*), watch to see how much force is needed to break each stick. Weigh the wood samples beforehand. Are the heaviest kinds of wood always the strongest?



Biological Birth Ce

MEASUREMENT

Length, height, and weight often reveal whether one animal is older than another. But measurements like these don't always depend on age alone. They are also affected by such things as the amount of food available, the animal's activities, and even the temperature of the animal's surroundings. Also, many parts of an animal stop growing when a certain age or size is reached.

In many animals, however, the lens of the eye grows throughout life. It apparently isn't affected by food or other factors that usually affect an animal's size. The weight of the eye lens is now used to find the age of cottontail rabbits, black bears, raccoons, and seals. The photo shows a lens (held on forceps) that was taken from the deer's eye on the right.

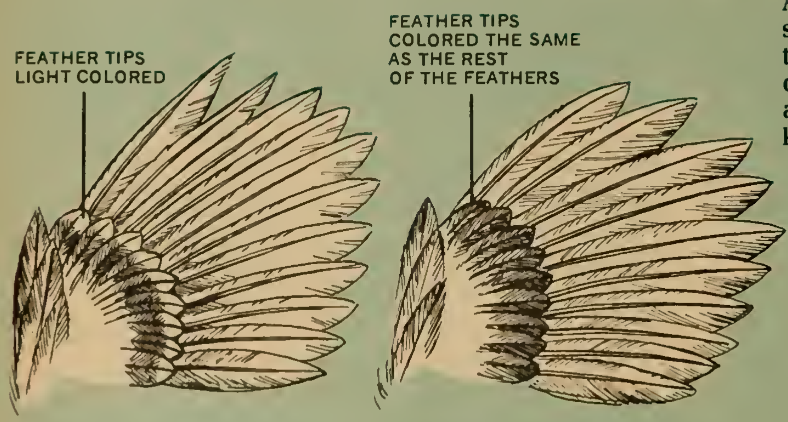
"How old are you?" can often be answered by a biological birth certificate. This record is not kept on paper—it is "written" into the structure of an animal.

Biologists have a number of ways of finding the ages of animals. Each method was worked out by studying animals whose ages were known (such as those born in zoos). This WALL CHART shows some of the ways in which scientists find an animal's age.

Once biologists know the ages of some of the animals from a **population** (a group of animals of the same kind living in an area), they have some idea of how the population is doing. If most of the population is old, for example, biologists know that the population is in danger of dying out. If the population includes many young, however, it means that the animals are reproducing well and may be increasing in numbers. This kind of information is especially useful to biologists who study populations of animals that are hunted and fished. It helps them set hunting and fishing seasons and other rules so that the animals don't become either too scarce or too abundant.—SUSAN J. WERNERT

DEVELOPMENT

As an animal gets older, there are often changes in the shape, color, and numbers of parts of its body, such as teeth. Any of these changes can be a good clue to the age of an animal if biologists know that the change occurs at the same time in the life of most animals of the same kind.



WING OF YOUNG QUAIL

WING OF ADULT QUAIL

The feathers that grow on a bird during its first year often look very different from the feathers that replace them. Many ground-living birds, such as quail and pheasant, shed their wing feathers one by one in a certain order. A bird's age can be figured out by seeing which feathers have been shed and replaced by adult feathers. Once a bird has all of its feathers, biologists have to look for other clues to its age.

Teeth reveal the age of deer, antelope, moose, and horses. The ages of the youngest animals can be determined by seeing which "baby" teeth they have. To find the age of slightly older animals, biologists see how many "baby" teeth have been replaced by permanent teeth. Finally, they look at the amount of wear on the grinding teeth—the premolars and molars. (People once thought that the number of points on a deer's antlers revealed its age, but the size of a deer's antlers depends mainly on the amount and kind of food it eats.)

ficates

COUNTING THE YEARS

The rate of growth of many animals changes from season to season. A drop in temperature during the winter can slow the growth of a fish. A limited food supply in the winter slows the growth of other animals. And, for still other animals, growth may slow down during the breeding season. Luckily, these changes in the rate of growth often show up in an animal's body, and the animal's age can be discovered by counting the different growth marks.

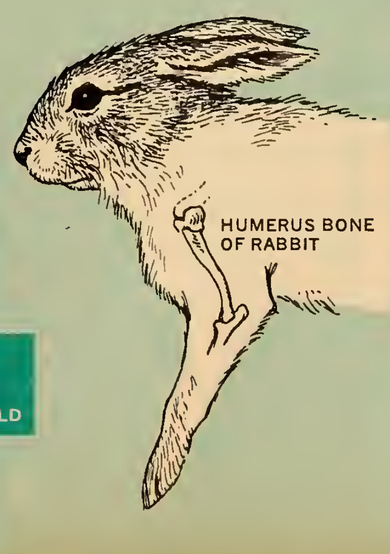
The scales of most kinds of fishes bear rings that reveal the age of the animal. The scales grow by adding rings in the center. The quicker growth in the summer produces more and wider rings than the slow winter growth. The drawing shows a scale from a four-year-old bluegill sunfish. In what year of its life did the fish grow the most?

The horns of animals like bighorn sheep and mountain goats often reveal their ages, for the winter slowdown of growth causes deep grooves on the outside of the horns. But the age of the females is hard to tell; the rings on their horns are much less clear than the rings on the males' horns.

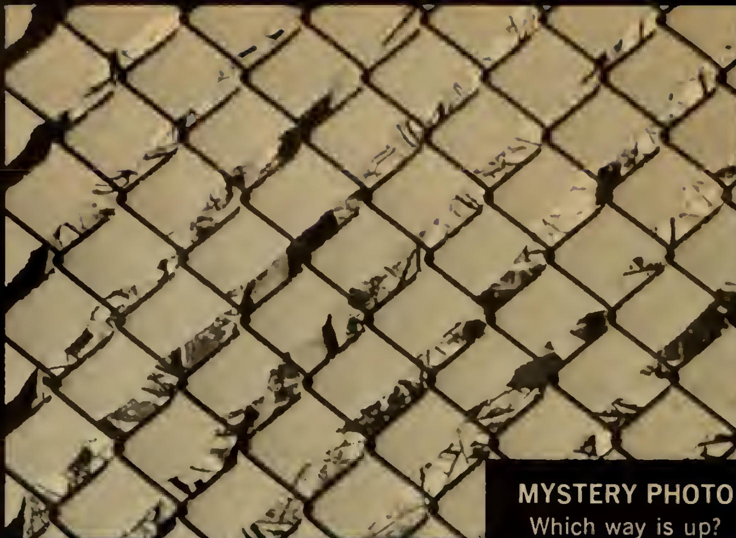
HORN OF DALL'S SHEEP

THE DEEP GROOVES ARE WINTER GROWTH MARKS

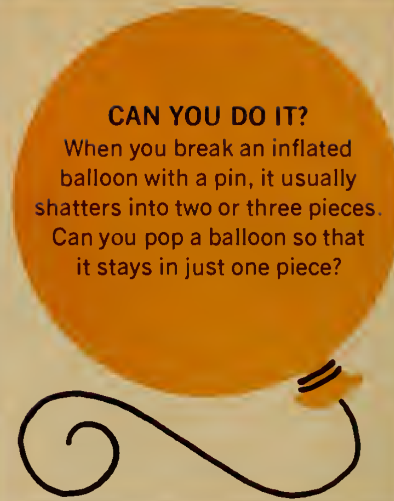
An animal's bones are often a clue to its age. Limb bones are first made of a soft material called *cartilage*. As an animal grows older, more and more of its cartilage is replaced by hard bone. To find the age of some small animals, biologists check to see how much of their limb bones is still cartilage. But all of the cartilage in the bones of these animals is replaced within one or two years after birth, so only the age of younger animals can be found in this way.



BRAIN-BOOSTERS



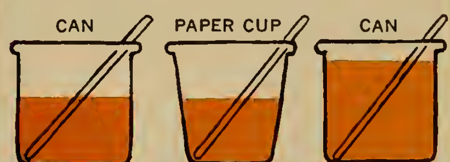
MYSTERY PHOTO
Which way is up?



CAN YOU DO IT?
When you break an inflated balloon with a pin, it usually shatters into two or three pieces. Can you pop a balloon so that it stays in just one piece?

FOR SCIENCE EXPERTS ONLY
Suppose you somehow became stranded in the middle of a frozen lake on completely frictionless ice. How could you get off?

WHAT WOULD HAPPEN IF . . .
. . . the three containers were filled with hot water as shown? Which one would cool off fastest?

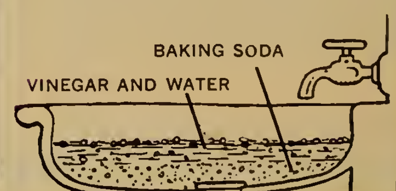


FUN WITH NUMBERS AND SHAPES
Each letter in this addition problem stands for a different number. Can you substitute the proper numbers to make the answer correct?

ABCD
ABCD
ABCD
ABCD
EBEA

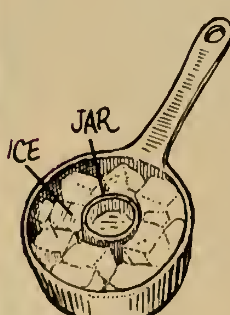
Submitted by Steve Painter, South Orange, New Jersey

JUST FOR FUN
Here is how to make bubbles float in "mid-air." Close the drain in a bathtub or large sink and dump in a box of baking soda. Then pour in a bottle of vinegar and add some water. The bubbling shows that carbon dioxide gas is being formed. Now blow soap bubbles and let them drop into the sink. The bubbles should float on the layer of carbon dioxide until they break.



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

What would happen if? Here is how the long wooden block would float. Would a square block made from four small blocks float this way?



Can you do it? To make ice without a freezer, put a small jar in the center of a pan and pack ice around it *(see diagram)*. Pour a *lot* of salt on the ice. (Don't get any salt in the jar.) Then put a *little* water into the jar. You should have some ice after 15 minutes. Can you make ice this way without using any salt?

Mystery Photo. The matchbox shadow with the "sharper" edges and even shading was made by light from the sun. Can you figure out why the shadow made in light from a bulb had such "fuzzy" edges?

Fun with numbers and shapes: After the milk and orange juice are mixed, the amount of milk in the orange juice is the same as the amount of orange juice in the milk. Can you figure out why?

For science experts only: During the day, the air that has been warmed up by the sun rises, and pushes aside the cooler air. By sunset, there are many moving masses of air at different temperatures between your eyes and the sun. The warmer and cooler masses of air bend the light in different ways, often making the sun appear to be oval, or sometimes other shapes. At dawn the sunlight reaches your eyes through cool air that bends all the light rays in about the same way, so the sun's round shape does not usually appear changed.

prepared by **DAVID WEBSTER**

Discovering an "OCEAN" from the BOTTOM

When an Italian mathematics professor tried to explain how a lift pump works, he discovered that we live at the bottom of a "sea of air."

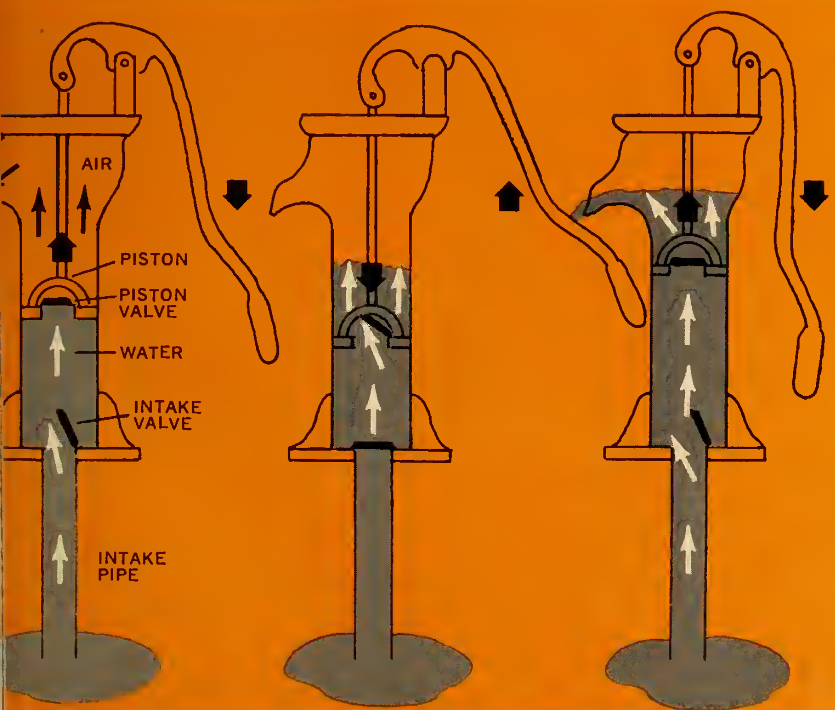
by Robert Gardner

■ Have you ever thought that people living on earth are like fish that live at the bottom of the ocean? This idea was suggested over 300 years ago by an Italian mathematics professor named Evangelista Torricelli. He said that we live at the bottom of a "sea of air," and that the weight of the air in this "sea" is constantly pushing on us just as the water in the ocean pushes on a fish or on a deep-sea diver walking on the ocean floor.

Torricelli got this idea in the early 1600s after one of the world's greatest scientists, Galileo Galilei, noticed something that men who worked in mines had known for a long time. The best of the lift pumps *(see diagram)* used to pump water out of mines would not lift water more than about 33 feet above the surface of a water pool. Galileo's discovery alarmed most scientists, because the operation of lift pumps had always been explained by an idea suggested by Aristotle, an early Greek scientist. Aristotle had said that nature *abhors,* or won't permit, a vacuum. Therefore, scientists in the early 1600s believed that water rushes in to fill the space below the rising piston of a lift pump because if it didn't, a vacuum would be created. *(Continued on the next page)*

PROJECT

Fill a straw with water and keep your finger firmly over the top. Does the water run out? Try to suck the air from a straw with its other end in a liquid. What happens? Does the same thing happen if you first punch a hole in the side of the straw above the level of the liquid in the glass? How could the idea that "nature abhors a vacuum" be used to explain these things?



A. Pushing down the handle of a lift pump raises the *piston* in the pump chamber. Air pressure keeps the *piston valve* closed, so the rising piston lifts air out of the chamber and water from a well or pool rises through the *intake pipe* and *valve* into the chamber. **B.** Pulling the handle up pushes the piston down, and water pushes through the piston valve into the chamber above the piston. **C.** When the piston is lifted again, the water above it is pushed out of the spout.

● Lift pumps were used in many kitchens as late as 50 years ago to draw water from a shallow well. But few lift pumps can lift water higher than about 30 feet above the surface of a pool. (Can you guess why?) See if you can figure out a way that several lift pumps could be used to pump water out of a mine that is, say, 100 feet deep.

● Usually you have to "pump" the handle up and down several times before water starts to flow out of the spout. Can you guess why?

Galileo realized that Aristotle's idea could not explain why a lift pump could not raise water more than 33 feet or so. He suggested another explanation: Perhaps a column of water more than 33 feet high was not "strong" enough to hold up its own weight.

Galileo probably never tested this idea, but we know it was wrong. When a lift pump is used at a high place, such as a mine in the mountains, it cannot lift water even 33 feet. The higher the location, the shorter the distance a lift pump can lift water. Galileo's idea could not explain this unless water weighed more on a mountain than near the sea. But water actually weighs a bit less the farther it is from the center of the earth. (Can you guess why?)

Torricelli did not know about this, but he disagreed with both Aristotle's and Galileo's explanations anyway. He knew that the deeper we go in water, the more water there is pressing down on us, and that the water pushes *upward* as well as sideways and downward. (If water didn't push upward, would a block of wood float in it?)

He also knew, from experiments done by Galileo, that air has weight, just as water does. So Torricelli reasoned that the air surrounding the earth is like a sea, and that we live at the very bottom of it, with the weight of the air pushing downward, upward, and sideways on us and everything else.

He argued that this "sea of air" could not push water up inside a tube that was open at the top because the air is also pushing downward through the tube. But when the air in a tube is removed by means of a lift pump at the top, the sea of air pushes the water at the bottom of the tube up into it.

Torricelli knew that mercury is 13½ times as *dense* as water; that is, a volume of mercury weighs 13½ times more than an equal volume of water. *(See "How Dense Are You?",* N&S, *September 30, 1968.)* So he figured that a lift pump should be able to lift mercury only about 30 inches. (How did he figure this out?) To avoid using very long tubes, Torricelli used mercury instead of water in his experiments.

The First Barometer

While testing his "sea of air" idea in 1643, Torricelli invented an instrument that enabled him to measure air pressure. He took a three-foot glass tube that was closed at one end, and filled it with mercury. He held his finger over the open end of the tube and placed it below the surface of some other mercury in a shallow bowl. Then he removed his finger and slowly lifted the closed end of the tube until the tube stood straight up in the mercury. As he lifted the end of the tube, some of the mercury fell out into the bowl, leaving an open space in the top of the tube. But when the top of the mercury was about 29 to 30 inches above the surface of the mercury in the bowl, it stayed at that height in the tube, just as Torricelli had predicted *(see photos).*

Torricelli made the first barometer like this: He filled a glass tube (closed at one end) with mercury, placed the open end in a bowl of mercury, and lifted the closed end (*left photo*) until the tube stood straight up in the mercury. As the tube was raised, some mercury dropped back into the bowl, leaving a vacuum in the top of the tube (*right photo*). The height of the mercury in the tube above the surface of the mercury in the bowl provides a measure of the weight of air that is pressing down on the mercury in the bowl.

He knew that no air bubbles had gone up the tube, so the space above the mercury must be empty. While inventing a device to measure air pressure, Torricelli had also found a way to create a vacuum.

Torricelli found that sometimes the height of his mercury column moved up or down as much as an inch or so from one day to the next. He believed that the air pushing on the mercury in the bowl kept the mercury from falling out of the tube. When the air pressure got stronger, more mercury was pushed up the tube; when the air pressure decreased, the column of mercury became shorter.

Testing the "Sea of Air"

Torricelli never checked the "sea of air" to see if it exerted less pressure at higher places than at the "bottom" of the "sea." It was the French scientist, philosopher, and mathematician Blaise Pascal who suggested a way to test Torricelli's basic idea. Pascal was not very healthy, so he asked his brother-in-law Florin Périer to do the experiment.

In 1648 Périer and several observers climbed a mountain, carrying a barometer with them. Another experimenter stayed at the base of the mountain to keep track of another barometer there.

At the base of the mountain both barometers read 28.2 inches—that is, the top of the mercury in the tube was

28.2 inches above the mercury in the dish. About halfway up the mountain, Pérrier's barometer read 26.6 inches. At the top it read 24.1 inches. When the climbers returned to the base of the mountain, their barometer again read 28.2 inches. The experimenter who had stayed below reported that his barometer had read 28.2 inches throughout the day.

The results of Pascal's experiment seemed to support Torricelli's idea that we live at the bottom of a "sea of air." (Can you explain why?) But it did not explain why the air pressure changes from day to day at the same place, as Torricelli had discovered with his barometer. After all, the water pressure at a particular depth in a lake or ocean does not change from day to day.

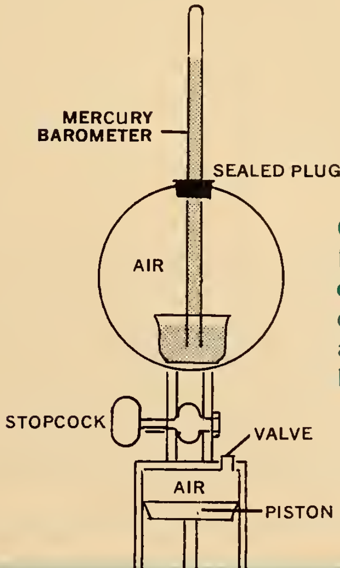
This question was answered about 1660 by Robert Boyle, an English scientist who had succeeded in building a very good air pump. To test Torricelli's idea that a change in air pressure moves the mercury up or down in a barometer tube, Boyle made a large glass vessel to cover the bottom of a barometer *(see diagram)*. When he

(Continued on the next page)

PROJECT

With an *aneroid* barometer (see *"Another Kind of Barometer"*), you can easily test the "sea of air" idea the same way Pérrier did in 1648. (An aneroid barometer usually costs $7.50 or more, but we found one in a discount store for only $4. Maybe there is a barometer in your school, or perhaps a friend has one in his house.)

Carry an aneroid barometer up a high hill or mountain and see what happens to the air pressure as you go up and as you come down. Take an aneroid barometer with you when you go on an auto trip. What happens to the air pressure as you go up and down hills? What happens to the air pressure as you go up and down in an elevator? Can you detect any pressure change when you carry the barometer up or down a flight of stairs? How about several flights?



Can you figure out how Robert Boyle used this device to increase or decrease the air pressure around the base of the barometer?

Another Kind of Barometer

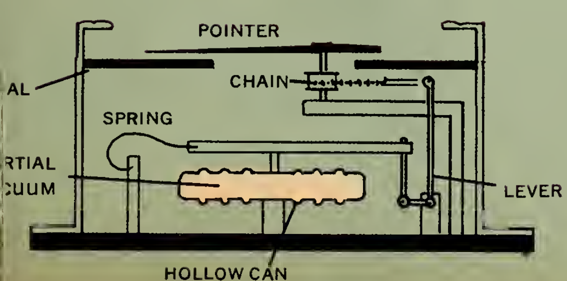
Mercury barometers are still used by *meteorologists* (scientists who study and predict the weather). You may have seen another kind of barometer, though, called an *aneroid barometer* (see *photo*). You may have one in your house or at school.

Air is free to enter this barometer through a hole in the back of its wood or metal case. Instead of pressing down on the surface of a pool of mercury, the air presses on the sides of a thin, round, hollow metal can (see *diagram*). Most of the air was removed from the can before it was sealed.

The outside of the can is attached to a spring, and the end of the spring is connected by a series of levers to a chain that turns the pointer shaft. When the air pressure increases, the sides of the can are pressed inward and pull on the spring. This motion pulls the chain, turning the pointer so that it points to a higher number on the barometer dial. The dial is *calibrated,* or marked, to show the pressure in inches, tenths of inches, and hundredths of inches (the height the mercury would be in a mercury barometer). (Why does the scale only measure from 27.5 to 31.5 inches?)

When the air pressure decreases, the walls of the can are pushed outward by the air in the can; the chain eases its pull on the pointer shaft, and a spring turns the pointer to a lower reading on the dial.

An aneroid barometer is much smaller and easier to carry around than a mercury barometer. But changes in *temperature* affect its metal can more than they affect a column of mercury, so a mercury barometer measures the air pressure more accurately.



Discovering an "Ocean" (continued)

pumped air into the vessel, the mercury rose, just as Torricelli had said it would. When he pumped air out of the vessel, the mercury level dropped in the tube.

Boyle discovered that, unlike water, air can be *compressed*, or "squeezed together," making the air more dense than before. He also discovered that the pressure exerted by air is *proportional* to the density of the air. This means that if you squeeze air into a container until the amount of air in it has been doubled, the outward "push" of the air will also be doubled.

Boyle showed that the day-to-day changes in air pressure at a particular place, which Torricelli had discovered with his barometer, must be caused by changes in the density of the air at that place. Soon scientists began to realize that the movements of the air that we call "winds" are currents in our "sea of air" caused by dense air masses sinking toward the "bottom" and pushing less dense air masses out of their way. Torricelli had "discovered" a vast "new ocean" for scientists to explore ■

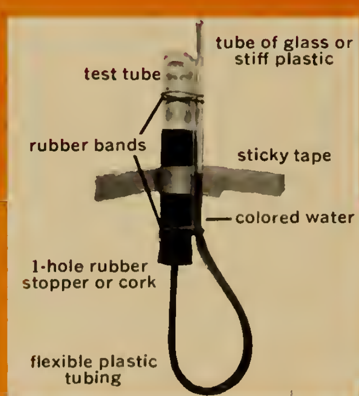
MAKE YOUR OWN BAROMETER

On a seacoast like Cape Cod, Massachusetts, fishermen and their families, hotel keepers, and vacationers are especially concerned about changes in the weather. The Cape Cod *barometer* (see *photo*) is a simple and inexpensive instrument for detecting the changes in air pressure that usually bring a change in the weather.

You can make a miniature Cape Cod barometer with a large test tube, a cork or rubber stopper, a short tube made of glass or stiff plastic, and a longer tube of clear, flexible plastic (see *photo*). Fill the test tube with water mixed with vegetable coloring before you push the stopper with the glass tube running through it into place.

What will happen to the level of the water in the flexible tube when the air pressure increases? When it decreases? Do you think the level of the water will be changed by changes in temperature as well as by changes in air pressure? Can you think of a way to find out?

CAPE COD BAROMETER

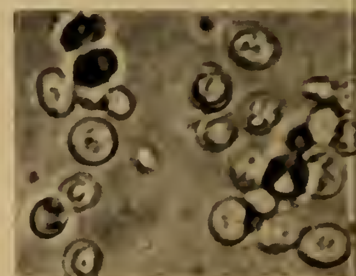


■ Cartoonists seem to like yeast. You may have seen cartoon that showed bread dough rising furiously, bur ing out of an oven and creeping across a table like a hu animal trapped in a shapeless sack.

Yeast does cause bread dough to rise, but as you pro ably already know, it doesn't act as wildly as cartooni picture it. In a way, however, the cartoons are partly rig Yeast is alive. It is a one-celled plant. Yeast cells rep duce rapidly when they have proper growing conditio

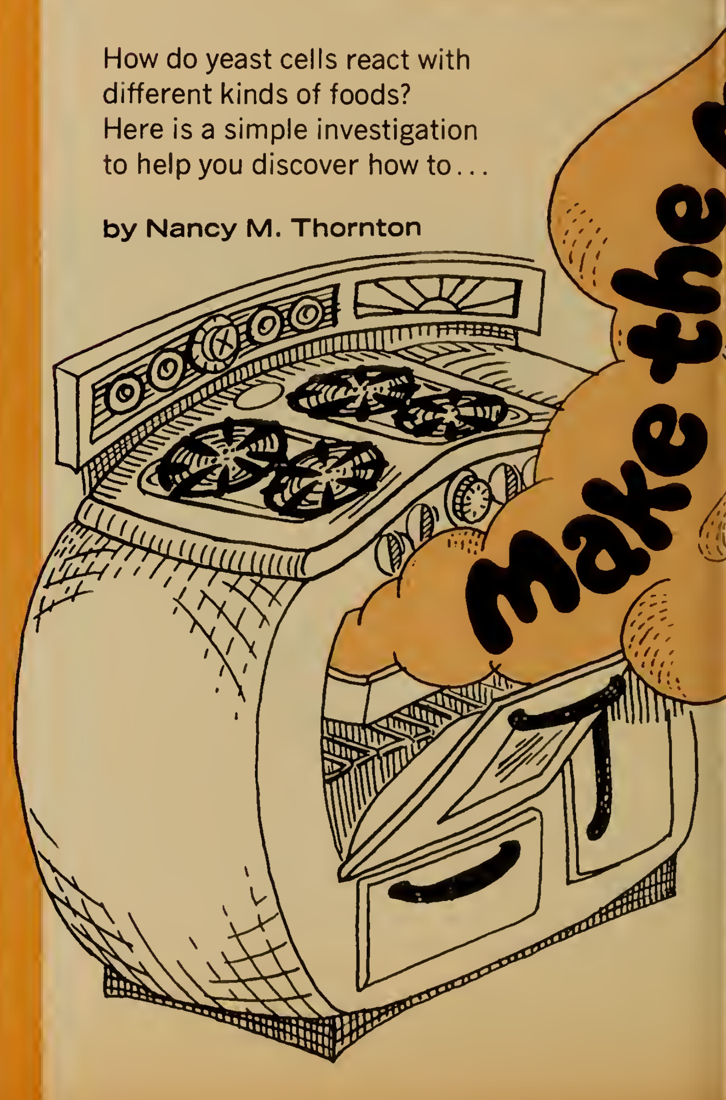
When conditions are right, yeast cells react with the su stances they are mixed with and give off alcohol and a g carbon dioxide. In baking bread, the yeast releases ti bubbles of carbon dioxide gas throughout the dough. The countless bubbles become trapped by the sticky flo

These yeast cells, photographed through a microscope, are magnified about 1200 times.



How do yeast cells react with different kinds of foods? Here is a simple investigation to help you discover how to...

by Nancy M. Thornton



ɔugh, causing the dough to grow in size and to become ɔonge-like. When the bread bakes, the soft dough surunding these bubbles hardens. Heat causes the carbon oxide to escape into the air. The small amount of alcohol at is produced also disappears.

ixing Yeast with Different Foods

You can try some simple investigations to find out what ɔnditions are best for the growth of yeast. It is hard to tect the alcohol given off by yeast without using special uipment. Carbon dioxide, however, causes a bubbly am that you will be able to see.

First make a yeast-water solution. Add one tablespoon dry yeast to one cup of warm water. Stir the water until ɔ yeast dissolves. Then put about a tablespoon of this lution into each cup of an empty egg carton (or each p in tins used to bake cupcakes or muffins). Number ɔ cups from 1 to 12, and make a table on a sheet of per, also numbered 1 to 12. (A sample table is shown on this page.) Use the table to keep a record of what you do with each cup.

Stir the contents of each cup, using a clean toothpick. After stirring, leave one cup alone. This will be a *control,* so that you will know how each cup of yeast solution would have acted without anything added to it. To each of the remaining cups, add about one-fourth of a teaspoon of one of the following: flour, cooking oil, syrup, milk, salt, white sugar, meat (cooked or uncooked; cut into small pieces), diet sweetener, powdered sugar, brown sugar, cornstarch.

Stir each cup well, using a clean toothpick for each. Do you see any foaming of carbon dioxide gas right away?

Put the carton in a warm place for 15 minutes. You can put it on a radiator or in an oven preheated to 150°. Then check to see if carbon dioxide gas is being given off. Put the carton back over the heat and check again in another 10 minutes. Does the total time that the yeast solutions are heated make any difference in the amount of carbon dioxide foam that is produced?

What kind of food reacted most with the yeast, as indicated by the amount of carbon dioxide foam produced? From these results, can you name an important ingredient in making bread? ■

t of YEAST

UBSTANCE ADDED O YEAST-WATER OLUTION	RESULTS AFTER 15 MINUTES OF HEAT	RESULTS AFTER 25 MINUTES OF HEAT
FLOUR		
COOKING OIL		
SYRUP		
MILK		
SALT		
WHITE SUGAR		
MEAT		
DIET SWEETENER		
POWDERED SUGAR		
). BROWN SUGAR		
.. CORNSTARCH		
). CONTROL (NOTHING ADDED)		

INVESTIGATIONS

- How does sugar concentration affect the production of carbon dioxide? Using a clean egg carton and the same strength yeast solution, add white sugar to several cups. Put ¼ teaspoon into one cup, ½ teaspoon into another, ¾ into another, and so on up to 2 teaspoons. Remember to have a control—a cup containing only water and yeast. Put the cups in a warm place and see which one produces the most carbon dioxide foam.

- How does temperature affect the production of carbon dioxide? Put a tablespoon of yeast solution and ¼ teaspoon of white sugar into each of five separate containers. Put one cup in each of these places: a freezer, the refrigerator, a room at about 70°F, an oven preheated to 150°, and an oven preheated to 300°. Observe each cup every five minutes for about 25 minutes. What temperature seems best for producing carbon dioxide?

WHAT'S NEW

by Roger George

An airport in a lake may soon be built near Chicago, where heavy air traffic is putting a strain on present airport facilities. Engineers would first erect a circular dam on the bottom of Lake Michigan. It would be four miles across and would rise 18 to 24 feet above the surface. Then the water inside the dam would be pumped out to expose the hard clay bottom of the lake, where a landing field and terminals would be built.

A tunnel, perhaps combined with a causeway, would span the 5½ miles between the airport and downtown Chicago. The airport would be close to the city, yet not in a heavily populated area. Approaches would be clear, noise would be less bothersome, and the field could be expanded easily.

Loud rock music in large doses can harm hearing, recent tests suggest. Ten Florida teen-agers, tested before and after a rock dance, all showed a temporary hearing loss at evening's end. A test of a young five-man combo in Texas revealed that one man had temporary hearing loss after playing, and three had already suffered some permanent loss.

In a test made by Dr. David M. Lipscomb, director of audio clinical services at the University of Tennessee, in Knoxville, a guinea pig was subjected to the listening habits of an average discotheque-goer. After a total of 88½ hours of music as loud as the noise of a jet engine, many of the guinea pig's inner ear cells had been destroyed. And, notes Dr. Lipscomb, the music he played to the guinea pig was not so loud as the music he had heard in some of the noisier discotheques around Knoxville.

The strongest glue known to man may be the adhesive that barnacles use to stick themselves to rocks, wharves, ships, and even whales (*see photo*). The glue is produced in liquid form by these small, hard-shelled sea animals. It flows out through their antennae and hardens after 15 minutes in the water. It sticks tightly to all surfaces—even slippery ones—and is extremely hard to dissolve.

A strong, quick-drying glue that they produce holds these barnacles to an aluminum plate that was used to collect them. Scientists are studying barnacles to see whether their glue can be used to hold fillings in teeth.

Scientists at the University of Akron, in Ohio, are studying barnacle glue for the National Institute of Dental Research. They think it may be ideal for gluing fillings into teeth. In filling teeth today, a dentist has to remove the decay and then drill a hole in the healthy part of the tooth to anchor the filling. Even so, many fillings eventually fall out. Barnacle glue might hold fillings in place longer—and without the need for drilling holes in healthy tissue.

Walking catfish are causing concern in Florida. These fish, often two feet long, are at home both in water and out. On land they move along on short, thick fins. Breathing through special organs located just above their gills, they can stay out of water for several hours. The catfish sleep by day and hunt food by night. In captivity they've attacked and killed fish their own size. They've even snapped at dogs during overland trips, according to some reports.

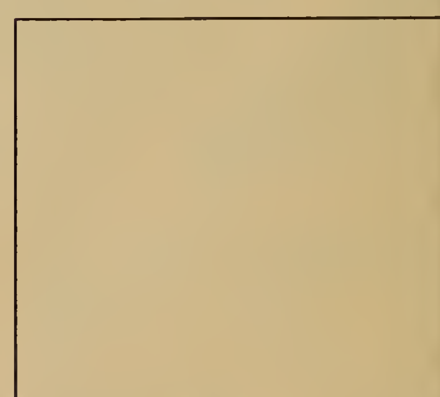
Originally from Asia, the walking catfish were introduced to the Fort Lauderdale area several years ago by a fish farmer. They have now multiplied and are taking over ponds and waterways, replacing bass and other local fish. Efforts to reduce their numbers have failed so far. Poisoning a pond, for example, may not work if a fish can walk to the next one.

An orbiting repairman may be able to fix disabled space satellites. The two-armed, three-legged robot would be attached to a small satellite and placed in orbit. Radio signals from the ground would send the robot from its "home" satellite to a disabled satellite. Television pictures transmitted by the robot would enable a man on the ground to operate it. After the robot had completed repairs or refueling, it would return to its own satellite to wait for the next distress signal.

The General Electric Company, which is developing the robot, says it could be placed in orbit by the mid-1970s and could stay there four or five years.

74 billion cans, bottles, and jars are produced in the United States each year. Many of these end up littering the landscape—a sorry sight and an expensive mess to clean up.

Bottles or cans that dispose of themselves may help solve this problem. A Swedish company has developed a container made of stiff plastic inside a paper sleeve. The container is strong enough to withstand shipping and storage. But when it is exposed to acids in the soil and to sunlight, the paper rots and the plastic disintegrates. In South Carolina, a self-destroying bottle is being developed by Dr. Samuel F. Hulbert, a ceramics professor at Clemson University. When this bottle is broken, the pieces will mix with the water in the air and melt away.



If food producers begin using the disappearing cans, bottles, and jars now being developed, our litter heaps may someday look like this.

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

in "pounds per square inch"? In predicting the weather, it is more important to know whether the pressure is going up or down, and how rapidly, than to know the exact pressure. Engineers need to know the average air pressure at different altitudes. For example, the air pressure inside a high-flying airplane is kept about the same as at sea level, so the body of the plane must be made strong enough to keep it from bursting open when it is flying in air at much lower pressure.

Answers to Questions in the Article

• *Why can't most lift pumps lift water farther than 30 feet at best?* (Page 11.) The piston must be loose enough to move in the chamber, so a little air seeps by it, back into the lower part of the pump chamber. Also, some of the atmosphere's "push" is used up in overcoming *cohesion* (the tendency of water to stick together) and *adhesion* (the tendency of water to cling to the walls of a pipe). *(See "Climbing Water,"* N&S, *Sept. 16, 1968.)*

Water could be pumped out of a deep mine by placing lift pumps at different levels so none had to lift water farther than 28 feet or so.

It usually takes several "pumps" of the lift pump handle to get most of the air out of the pump chamber.

• *Why does water weigh less the farther it is from the center of the earth?* (Page 12.) The pull of the earth's gravity on an object determines its weight, and this pull is weaker the farther the object is from the earth's center of mass *(see* N&S, *Nov. 13, 1967, page 2T).*

• *How did Torricelli figure out that a lift pump should be able to lift mercury only about 30 inches?* (Page 12.) He divided 408 inches (34 feet) by 13.5 (the number of times mercury is heavier than water).

Activities

• Have your pupils punch three nail holes in the side of a tall fruit juice can, near the top, near the bottom, and halfway down. Hold the can over a sink and fill it with water. The distance the water is pushed out of the holes shows that pressure increases with depth in a liquid.

If you have an aneroid barometer, place it in a clear plastic bag (without holes!) and seal the top with a tie band, string, or tape. Have your pupils move it slowly up and down in a tank of water and observe how the pressure changes *(see photo).*

• Place an aneroid barometer in a plastic bag and seal it as above, but

ROBERT GARDNER

To demonstrate increase of pressure with depth in a liquid, seal an aneroid barometer in a clear plastic bag and move it slowly up and down in a tank of water.

without squeezing the air out of the bag. Let your pupils squeeze the bag and explain what happens to the barometer needle.

• Have your pupils make a simple barometer by stretching a piece of rubber from a balloon over the top of an empty glass milk bottle, fastening it with a rubber band, and gluing a soda straw to the center of the rubber. Cut the end of the straw to a point and use a ruler as a scale *(see diagram).* Have your pupils test this barometer near (but not *over*) a warm register or radiator to see how it is affected by changes in temperature. Is it more sensitive to heat than an aneroid barometer? Less? How about a Cape Cod barometer? Have your pupils think about which expands faster when heated — air, water, or mercury.

• You might have an interested pupil find out about Otto von Guericke and the Magdeburg hemispheres, and test the experiment with two suction cups (the kind used by plumbers to clear drainpipes, or even the kind used to hold some plastic coat hooks to a wall).

Brain-Boosters

Mystery photo. The photo, showing a portion of a chain-link fence covered with snow, has been printed upside down. Turn it right-side up and you can see some trees through the open spaces of the fence.

What would happen if? Fill a paper cup and two tin cans with hot water to the levels shown, put an inexpensive thermometer in each, and let a pupil record the temperatures every 15 minutes.

Since metal is a better conductor of heat than is paper, and since a small volume of water drops in temperature faster than a large one, the can half full of water will show the fastest cooling. (Both cans of water lose heat at about the same rate; but because the full can contains twice as much water as the half-full can, it has twice as much heat to lose when both cans are at the same temperature. So the temperature of the full can drops about half as fast as that of the half-full can.)

With several identical cans filled to the same level with various liquids, you and your pupils can determine the relative cooling rates of the liquids. Heat the liquids uniformly by placing the cans on a radiator or in a pan of very hot water; then measure their temperature drops every quarter hour. Of course, the liquids that lose heat slowest will also *gain* heat slowest, so you must allow sufficient time for all the liquids to reach the same temperature before beginning your readings.

Some liquids you could test would
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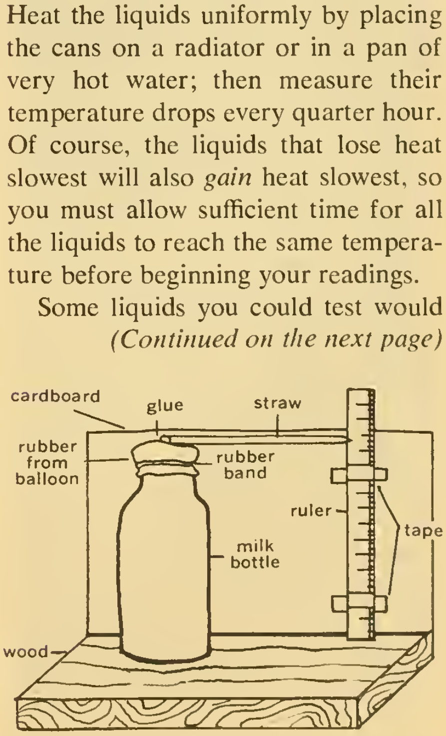

Using This Issue . . .
(continued from page 3T)

be alcohol, milk, oil, liquid soap, and syrup. One of the pupils could draw up a simple graph showing the relative rates at which the liquids lose their heat.

Can you do it? Let your students pop a few fully inflated balloons with a pin and count the number of pieces into which each one breaks. If a balloon is only partly inflated, it will often remain in one piece after a pin-prick. Another way to make the balloon stay in one piece after being punctured is to fill it with water.

The children can also find out what happens when they break a balloon in other ways—by over-inflating it, for example, or by sitting on it.

Fun with numbers and shapes. Here is one solution to the addition problem: There could conceivably be others. Some pupils may enjoy devising similar problems for their classmates to solve.

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  2348
  2348
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  9392
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For science experts only. Of course, neither ice nor anything else is ever completely frictionless. But if you *did* find yourself stranded on frictionless ice, you could get off by utilizing Newton's Third Law of Motion: *For every action, there is an equal and opposite reaction.* Blowing, or throwing an object away from you, would thrust your body in the direction opposite to the blow or throw.

For more information on Newton's Third Law, and related investigations, see "The 'Law' of Pushing," *N&S*, Feb. 5, 1968.

Just for fun. You can do this demonstration in the classroom with an aquarium tank, using about half the amounts of baking soda and vinegar. Since carbon dioxide is a fairly dense gas, it does not rise and the bubbles do not fall through it.

You can make the carbon dioxide layer visible by dropping a burning paper towel into the tank; the smoke will become mixed with the gas. If you rock the tank back and forth, your pupils can see the smoky carbon dioxide sloshing back and forth like water.

nature and science
TEACHER'S EDITION

VOL. 6 NO. 6 / DECEMBER 2, 1968 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Books That Will Help You Teach Science

by Dulcie I. Blume

This is the first of several reviews of some books published in the past five years that have earned a front-row position on the shelves of elementary school teachers of science. Many were written by people with years of experience in teaching science to children. All of these books will help you to answer questions . . . to develop and direct investigative activities . . . to create classroom situations from which your pupils will be propelled to their own investigations, observations, and books.

Nature in the City, by John Rublowsky (Basic Books, 1967, 152 pp., $4.95). More than a few of us live and teach in urban communities, yet do we see the nature there? Did *you* know that the fox, the coyote, or the opossum live in the city?

"Not many people come to the city to study nature," begins the author; "yet this is exactly what we are going to do." He then gives us an introduction to the ecology and natural history of the city, discussing birds, beasts, insects, trees, and the sometimes ruthless, sometimes pleasant relationships between man and the other animals and plants he displaces. In addition to an account of the plant and animal life of the city today, there is a brief history of living things in cities, telling the changes that have occurred from pre-Colonial days until now.

Experiences and Demonstrations in Elementary Physical Science, by Richard F. Thaw and John E. Morlan (Wm. C. Brown Company, 1964, 187 pp., $4.50). A whole book of experiments—one to a page and each well illustrated. The experiments are grouped under 12 headings: light, astronomy, sound, chemistry, geology, magnetism, electricity, gravity and flotation, air, heat, weather, and aerospace study.

The book is organized around specific problems dealing with basic principles of science, but the various concepts are not presented in a definite sequential order. A problem is presented and materials needed to find a solution are listed. Step-by-step, fully illustrated directions are given to ensure successful completion of each activity. Because emphasis is placed on simplicity and directness, the book tends to increase confidence in the teaching of science.

In addition to the experiences and demonstrations, the authors present 13 bulletin board designs that can provide for motivation and student involvement, and can present useful scientific information in an artistic manner.

Teaching Science through Discovery, by Arthur Carin and Robert B. Sund (Charles E. Merrill Books, 1964, 514 pp., $11.35). This is a book for those of you who would like to try teaching science through the discovery method, or who would like to become more skilled in the method. The first three parts of the book can help to build an appreciation and understanding of a modern science education program in the elementary school. Part 4 (more than half the book) will probably be the section that you will appreciate most. Entitled "Discovery Lesson Plans and Other Activities for Teaching Science," it contains elementary science experiences and lesson plans,

(Continued on page 4T)

Mrs. Dulcie I. Blume is Coordinator of Curriculum Materials of the Alameda County School Department, Hayward, California.

IN THIS ISSUE

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

Exploring Drops and Splashes
Your pupils can investigate how falling water drops interact with different surfaces and erode soil and rock.

"Treasures" in a Ton of Dirt
By sifting gravel from ancient ant hills, young people are helping scientists find rare fossils.

Ladders for the Leapers
Man-made dams block salmon from their upstream spawning grounds. Here is how scientists are trying to help the fish get over the dams.

• **Brain-Boosters**

• **The Physics of Fasteners**
Showing how fasteners work, this WALL CHART should whet your pupils' curiosity about other common "tools."

How Fast Do Your Fingernails Grow?

• **Can the Elm Be Saved?**
How the Dutch elm disease is spread, and what scientists have learned so far in trying to control it.

• **The Moving Story of Osmosis**
A SCIENCE WORKSHOP: investigating how water passes through membranes.

IN THE NEXT ISSUE

The mystery of the Easter Island monuments... Why does a sea turtle lay about 100 eggs? .....SCIENCE WORKSHOPS in radio signal transmission and how plants are affected by light.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Physics of Fasteners

There are so many different kinds of fasteners that your pupils may keep discovering them all year long. They can be classified in many different ways—a good exercise in scientific observation and thinking.

Suggestions for Classroom Use

Before your pupils see the chart, you might ask them to think of as many different kinds of "fasteners" as they can—things that hold other things together. Mention paperclips, glue, and nails as a starter. Ask about fasteners on their clothes: buttons and buttonholes, hooks and eyes, snaps, zippers, belts, buckles, stitches, shoelaces, and —in shoes—cement and nails. In the classroom: clips, clamps, staples, thumbtacks, rubber bands, string, nails, screws, bolts and nuts, rivets, glue, paste, containers of all kinds, locks, ringbinders, stitches (in books), and so on. Can they think of other fasteners in their homes, or outdoors?

When you have a list of 20 or so fasteners, have your pupils think of ways to classify, or "group" them. Here are some possible ways: (1) by the materials the fasteners are made of; (2) by the kinds of materials they usually hold together; (3) by whether or not they allow the fastened objects to move in one or more directions; (4) by whether they are easy or hard to unfasten; (5) by whether they are designed for temporary or "permanent" fastening; (6) by the kinds of force they have to withstand (pull, push, bend, stretch, squeeze, impact, slide, and so on); (7) by the kinds of wear they have to withstand (rubbing, weathering, rotting, heat, cold, and so on); (8) by whether or not they have to be fastened to objects with other kinds of fasteners (locks do, screws don't). Your pupils may even think of other ways to classify fasteners.

Have them look especially for similarities in the way certain fasteners work. Paperclips, spring clips, and rubber bands all "squeeze" objects together; adhesives "stick" things together. But what do nails do? Why does a buttoned button hold two pieces of cloth together? Does a zipper work anything like a snap fastener? (Both are blocking spring fasteners.)

• Here are answers to some of the questions posed in the chart: A nail holds two boards together by blocking them from sliding apart... A wedge holds a door fast by "pushing" the door and floor apart as well as by "blocking" the door..."Suction discs" are held to a smooth surface by atmospheric pressure when the air is squeezed out from between the disc and the surface.

An adhesive usually works better on smooth surfaces that can be fitted together with a thin, even coating of adhesive between them. (Rough surfaces cause an uneven layer of adhesive; where the adhesive is thick the bond may be weaker than where most of the molecules in the coating are in contact with molecules of the bonded surfaces.)

Water forms a surprisingly strong adhesive bond between sheets of glass. (Have your pupils test this by lifting one microscope slide off another slide without sliding it sideways, then doing the same thing with a layer of water between the slides.)

Plastic bags are often sealed closed with heat (welding)... If the cohesion of glue is weaker than its adhesion to, say, wood, the glue itself might be pulled apart.

• The discussion of how matter is "fastened" together by electrical (and other) forces is limited by space, but it should convince your pupils that fasteners are important. You might emphasize that while an electric current can produce magnetic force *(see "Electricity from Magnets,"* N&S, *March 18, 1968),* the attraction between unlike charges of electricity is *not* the same force as the attraction between opposite poles of two magnets.

• Can your pupils think of some "fasteners" that occur in nature and explain how they work? Containers, such as cell membranes *(see page 15),* seed pods, nests, cocoons, and skin, hold things together by blocking their movement. So do plant roots and spider silk and the hooks on plant burrs, climbing vines, and animal claws. Barnacle glue and spider silk are adhesives, and so is the "cement" (often hardened clay) that holds small rocks and pebbles together to make *conglomerate* rock. An animal skeleton has many interesting joints that fasten bones together while permitting them to move. A few animals—the octopus for one—have "suction discs" to hold them to solid objects or their prey.

Can the Elm Be Saved?

The Dutch elm disease offers an example of the troubles that result when an organism is moved from one environment to a new one where it has few or no natural enemies. *(For more information on this subject, see "The Animal Movers,"* N&S, *Oct. 2, 1967.)* The fungus disease is more of a problem in North America than in Europe, where the bark beetles that help spread the disease are kept in check by a wasp that kills up to 70 per cent

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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. 6 NO. 6 / DECEMBER 2, 1968

How do paperclips, boxes, nails, glue, and electricity hold things together?

see page 8

THE PHYSICS OF FASTENERS

CAN YOU GUESS HOW MILK GOT THIS WAY?

see page 2

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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 EDITOR R. J. Lefkowitz; ASSISTANT EDITORS Margaret E. Bailey, Susan J. Wernert; EDITORIAL ASSISTANT Alison Newhouse; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Donald B. Clausen • CONSULTING EDITOR Roy A. Gallant

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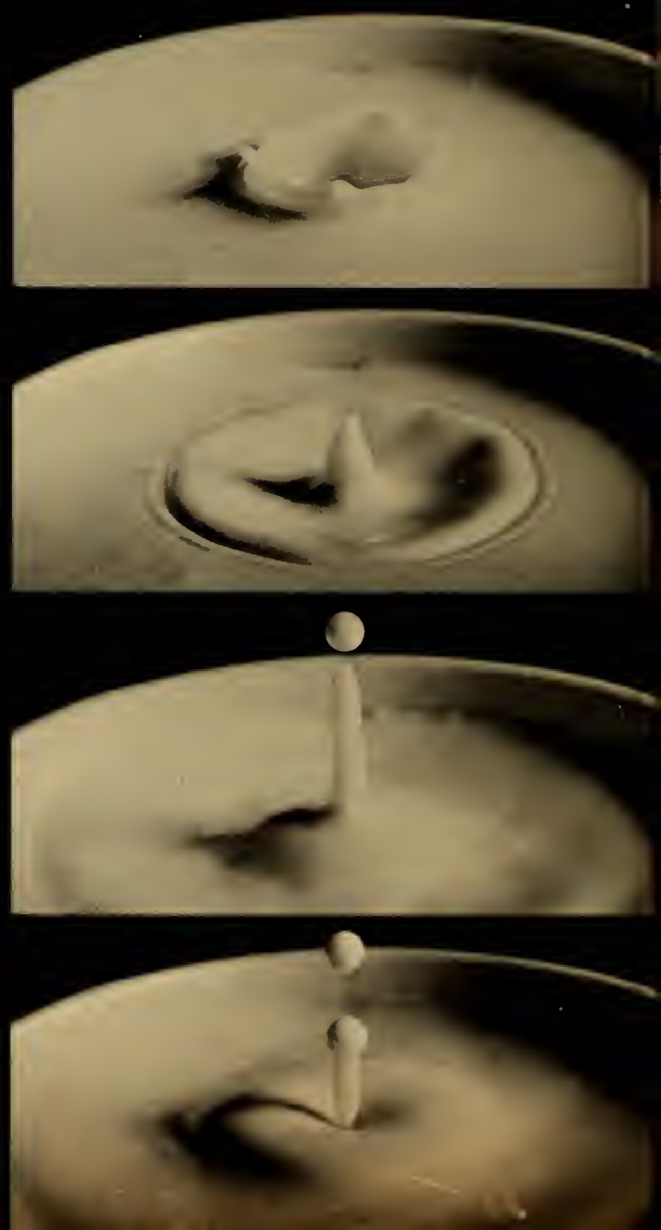
What happens when a drop of water strikes the surface of a puddle, a sidewalk, or the soil? With a medicine dropper, try—

Exploring Drops and SPLASHES

by Robert Gardner

These photos were taken at high speed just after a wat drop fell into milk. The splash changed from a "crater" to "jet" that broke up into drops shooting upward. Can you s where the cover photo fits into this series?

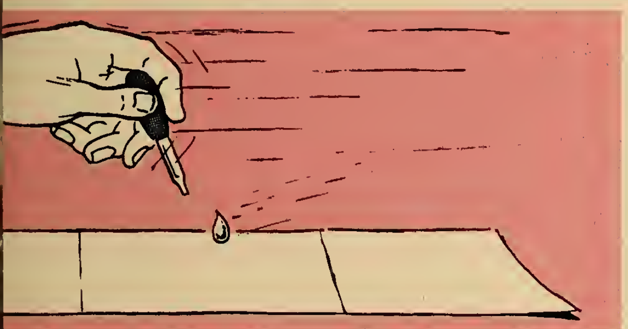


You have probably watched raindrops as they strike a ewalk, pond, or puddle. But have you ever looked ›sely to see what happens when a raindrop makes its ıding?

The photographs at left show what happens when a ɔp of water strikes and enters a body of milk. If you try see this happening by letting drops fall from a medicine ɔpper into a glass of water, you won't be able to see all : details, because everything happens so quickly. But ,ou watch carefully you can see a "jet," like the one in : photographs, rise out of the water after the drop hits. ›w far must the drop fall through the air before it proces a "jet"? (To make the drops easier to see in all your ɔeriments, you can color the water with a few drops of ›d coloring.)

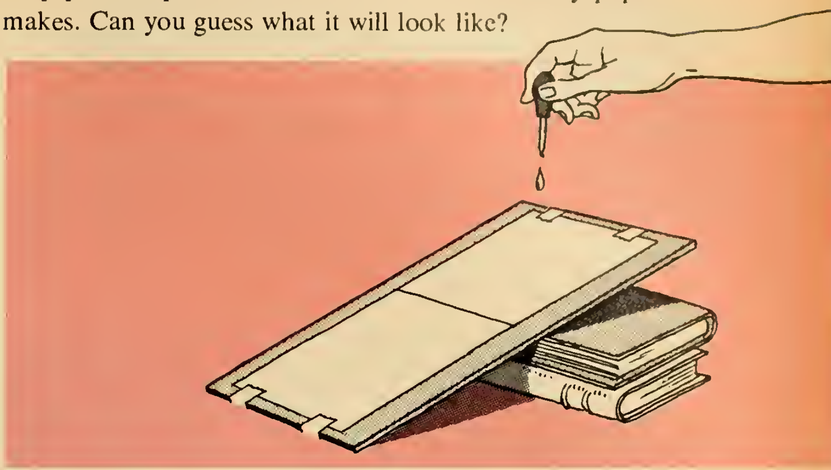
·ard" Landings

What happens if the drops fall onto a sheet of paper ting on a flat surface? Let the drops fall from different ghts—½ inch, 1 inch, 6 inches, 1 foot, 2 feet, 3 feet, l so on. Does the pattern made by the "splashed drop" ınge as the height changes? What happens if the drop moving sideways when you drop it? (*See diagram.*)



n you guess what the splash pattern will look like when ı increase the speed? (It may be useful to have a num- · of paper sheets laid end to end when you try this ɔeriment. Why?)

Suppose you let the drops fall onto different surfaces. ll this change the "splashed drop" pattern? You could wood, concrete, dirt, aluminum foil, and so on. Be sure to try waxed paper. It repels water and makes the drop pattern quite different from the one ordinary paper makes. Can you guess what it will look like?



What will the "splashed drop" pattern look like if the drops fall on a piece of paper that is *inclined,* or tilted, instead of lying flat? To find out, tape a sheet of paper to a piece of cardboard. Place one end of the cardboard on some books or blocks (*see diagram*). Can you guess what will happen to the pattern if you make the incline steeper? Less steep? ■

PROJECT

CATCHING RAINDROPS

Next time it rains, cover a piece of cardboard or a cookie pan with waxed paper and catch some raindrops. How big are the raindrops? Are they always the same size?

Why is it easier to measure the size of a raindrop on waxed paper than on ordinary paper? *Could* you use ordinary paper to measure the size of raindrops?

The photograph above shows what happens when raindrops fall on a steep dirt-covered slope. Over many centuries whole mountains may be stripped of their soil by raindrops. What could be done to prevent this kind of erosion?

Why do farmers plow *around* hills, as shown in this photo, rather than *up* and *down* them?

"Treasures" in a Ton of Dirt

■ More than a ton of gravel had been stored in the basement of the Peabody Museum of Natural History for over 70 years. The gravel had been sent from Wyoming to the museum in New Haven, Connecticut, back in 1892. Scientists suspected that it contained some *fossils,* the remains of ancient life.

The gravel had been piled up long ago by ants that were digging underground. Along with the gravel, these ants brought up many small bones and teeth. *Paleontologists,* the scientists who study ancient life on earth, have often found many small fossil "treasures" in ancient ant hills.

Last summer, 50 New Haven children helped scientists search through some of the gravel. They discovered more than 30,000 fossils from animals that lived about 75 million years ago, at the very end of the "Age of Dinosaurs." They found teeth from all the varieties of dinosaurs of that time—horned dinosaurs, armored dinosaurs, plant-eating dinosaurs, meat-eating dinosaurs.

The Hunt for Tiny Fossils

But huge creatures like the 50-foot-long Tyrannosaurus were not the only creatures living 75 million years ago. There were many small animals, whose bones are often not noticed by fossil-hunters. Many fossils from these smaller animals were found by the boys and girls. They discovered fossils of fish similar to sturgeon and garpike. They found remains of reptiles other than dinosaurs—crocodile-like ones, lizard-like ones, turtle-like ones. There were parts from an animal like the opossum, and from a rat-like mammal that has no living relatives.

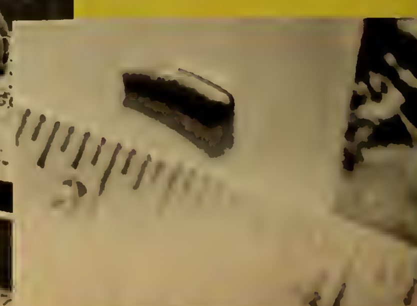
But it was a fossil from a bird that stirred the most excitement. Fossils from ancient birds are rare, because the bones of birds are light, hollow, and easily broken. Often they do not remain whole long enough to become fossils *(see "How the Fossils Formed," on this page).* Yet a 12-year-old girl discovered a claw *(see photo)* from a meat-eating bird like an owl or eagle. It is the oldest fossil of a meat-eating bird yet discovered—25 million years older than the fossil that formerly held that record.

The children in the summer program at the Peabody Museum of Natural History looked through just a small part of the gravel. Some of the children have continued the search in their spare time. Mrs. Kathryn Walton, assistant to the director of the museum, and Mr. Robert Bakker, director of the fossil hunt, report that there's still almost a ton of gravel left. Perhaps more fossil treasures will be found by other boys and girls when they continue the search next summer ■

HOW THE FOSSILS FORMED

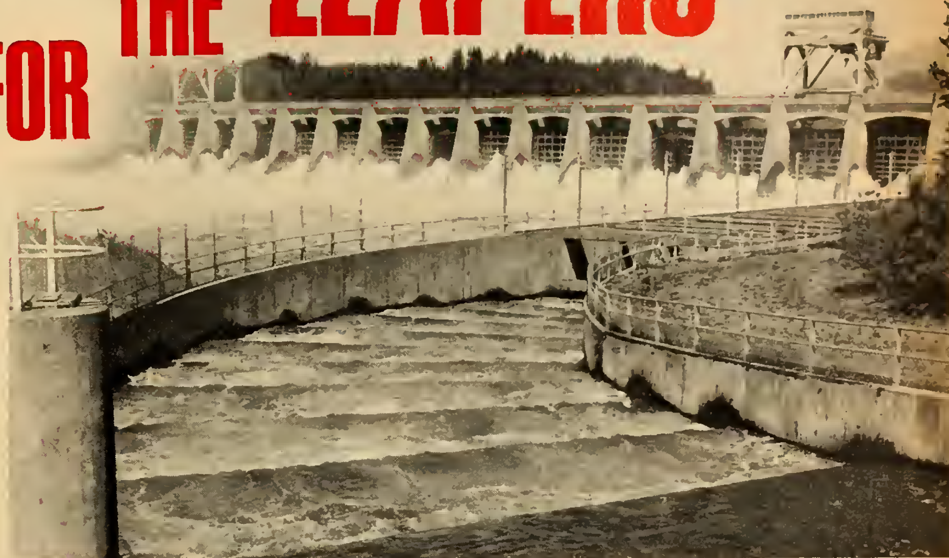
The fossils that the New Haven children discovered were not like the bones and teeth of animals that have just died. Even these hard parts are usually worn away as time passes. But sometimes they soak up water that contains minerals from nearby rocks. Gradually, small open spaces in the bones and teeth become filled with the minerals that seeped in with the water. The minerals might include *silica* if the nearby rocks were made of sandstone, or agate if they contained quartz. These minerals make fossils that are harder than the original bones and teeth.

Some of the New Haven children search through the gravel. The photo below shows the claw they discovered, the oldest fossil from a meat-eating bird ever found. Compare its size to the rule, numbered in inches.



How can a fish swim upstream when its way is blocked by a huge concrete dam? An unusual laboratory is now testing...

LADDERS FOR THE LEAPERS



by Susan J. Wernert

■ There's enough concrete in the Grand Coulee Dam, in the state of Washington, to build a six-lane highway around the border of the United States. The huge dam stores water from melting snow, and the water is used to produce electric power and to irrigate farmlands. But to a salmon trying to swim up the Columbia River to *spawn,* or lay its eggs, a dam like this one is just a gigantic roadblock.

Most kinds *(species)* of salmon live in the oceans, but they spawn in fresh water. After the eggs have hatched, the young fish travel out into the sea—sometimes as far as 2,500 miles from where they were born. After several years in the ocean, they swim back to their birthplaces. Each fish recognizes *its own* rivers and streams in a way that is not completely understood. Once "home," the fish reproduce and then usually die. If they do not reach their *spawning grounds,* they usually will not reproduce.

Each year, the upstream salmon "runs" take place. And each year, the runs on many North American and European rivers get smaller and smaller. This is the result of over-fishing for salmon, of pollution that kills salmon in the rivers, and of dams that keep the salmon from reaching their spawning grounds.

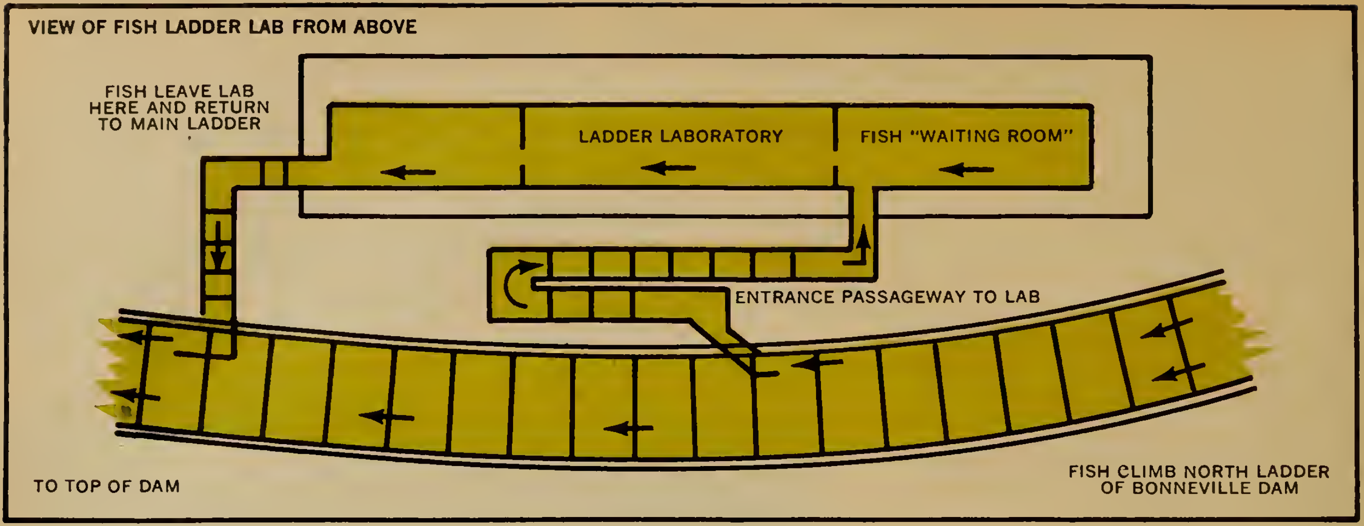
How Fish Climb Ladders

The name *salmon* comes from the Latin word for "leap," and the highest salmon jump is said to be 11 feet, 4 inches. But the Grand Coulee Dam is 550 feet high. Men have to help salmon over the dams that lie between the sea and the spawning grounds.

The salmon are helped over some dams by use of special "fish ladders," like those at the Bonneville Dam, on the Columbia River at the Washington-Oregon border *(see photo).* Each watery "step" on these man-made ladders is one foot high. The fish—salmon, steelhead trout, shad, and others—swim 16 feet between steps. In this way, they climb the dam gradually. But they don't jump into the air while going from step to step, as many disappointed tourists have discovered. It is possible for the fish to swim up the entire ladder without coming to the surface at all.

> When the United States was still a British colony, servants in New England were sometimes fed so much salmon that they refused to work unless they were given different food. Salmon was then plentiful and inexpensive, but the situation today is very different. The number of Atlantic salmon is dropping so quickly that soon there may be none left.

To find out which sizes and shapes of ladders are best for fish, scientists working for the United States Army Corps of Engineers have set up a fish-ladder laboratory in a wooden building at the Bonneville Dam. Fish swimming up the dam's north ladder are guided into a passageway. The only way out is up the ladders in the laboratory *(see diagram on next page).* When the testing is finished, the fish leave by a passageway running to the north ladder over the dam. They usually are not handled by humans during the testing. *(Continued on the next page)*



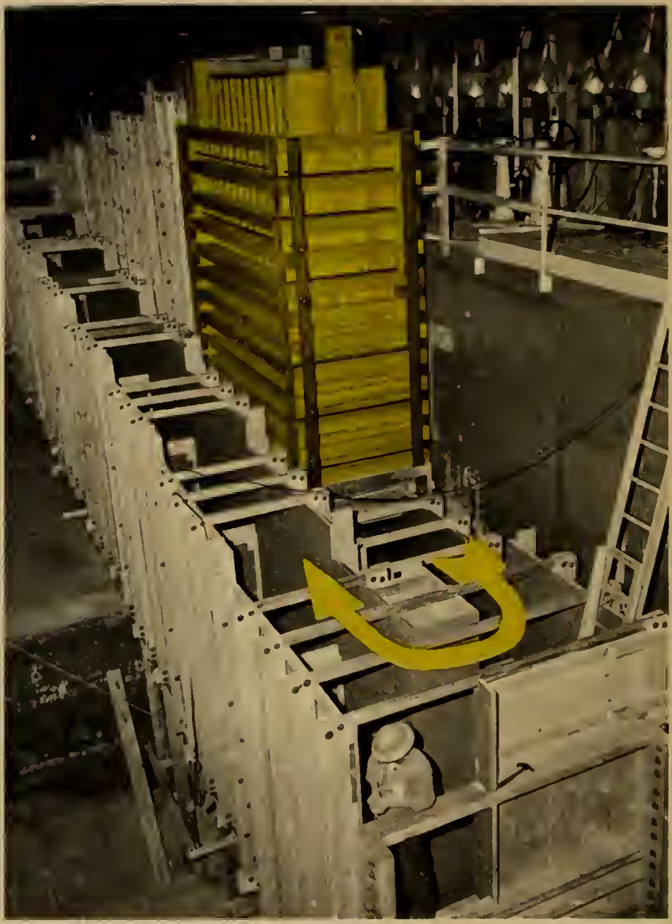
Inside the lab, wooden steps of different heights, lengths, and widths can be put together to form a variety of ladders. Scientists can then figure out which ladders are best by measuring the time that the fish take in climbing and the energy that they use for climbing. A good ladder is one that the fish can climb quickly and easily. Most Pacific salmon do not eat during the entire trip from sea to spawning ground. All of their energy comes from what was stored in their bodies. If they use up too much time or too much energy in ladder-climbing, they may never reach their spawning grounds to reproduce.

The Endless Fishway

To find out how much energy different kinds of fish use in climbing, the scientists use the laboratory's endless fishway *(see photo)*. Here a fish climbs 16 steps arranged so that the lowest and highest steps are near each other. When the fish has reached the highest step, a gate drops behind it, and water is quickly let out of the step to bring the fish down below the lowest step of the fishway. The gate to the lowest step then opens, and the fish starts all over again. One sockeye salmon climbed for five days and five nights in this endless fishway, and his health was still good when scientists stopped the experiment!

Results from the Bonneville laboratory show that the fish need ladders only half as wide as many now in use, and that the ladders can be much steeper. If the designers of new ladders use these findings, the fish ladders can be built at lower cost.

But work at the fish-ladder laboratory is by no means ended. One of the best features of the laboratory is that a variety of problems can be studied. Wastes from industrial plants may raise the temperature of the Columbia River, and scientists at the Bonneville Dam are now investigating how this heat pollution affects the climbing behavior of the fish. When they know *how* the fish are affected, they may be able to suggest what can be done about it. Those suggestions may help the salmon survive yet another problem caused by man ■



Workers build the endless fishway. A fish travels in the direction of the arrow. When it reaches the highest step (shown in color), the fish is brought down below the next step so that it can continue climbing.

prepared by **DAVID WEBSTER**

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.

WHAT WILL HAPPEN IF?

If you pour different amounts of water into two bottles of the same size and shape, then tap each bottle with a pencil, which bottle will make the higher sound?

CAN YOU DO IT?

Can you make a glass of water that contains just one eighth of a drop of milk?

MYSTERY PHOTO

Can you guess what is in this jar?

FOR SCIENCE EXPERTS ONLY

A man in Massachusetts placed a pan of old engine oil behind his garage. A few months later, in December, he looked in the pan and found it filled with ice. Can you explain how this happened?

FUN WITH NUMBERS AND SHAPES

Suppose you keep your socks in a drawer that is the fourth from the top and the third from the bottom. How many drawers are there in the chest?

Submitted by Andrea Benedett, Jamestown, New York

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The photograph is an upside-down view of a chain-link fence that is covered with snow. Turn it right-side up and you can see some trees through the open spaces of the fence.

What would happen if? The can half full of water would cool off fastest. Would a can of oil cool off faster than a can of water?

Can you do it? If a balloon is only partly blown up, it might stay in one piece when popped. Also, a balloon filled with water should break in one piece. Does a balloon that is popped by being filled with too much air break in the same way as one that is stuck with a pin?

Fun with numbers and shapes: Here is the solution to the addition problem:

$$\begin{array}{r} 2348 \\ 2348 \\ 2348 \\ 2348 \\ \hline 9392 \end{array}$$

For science experts only: You could get off frictionless ice by blowing or by throwing some object.

the physics of fasteners

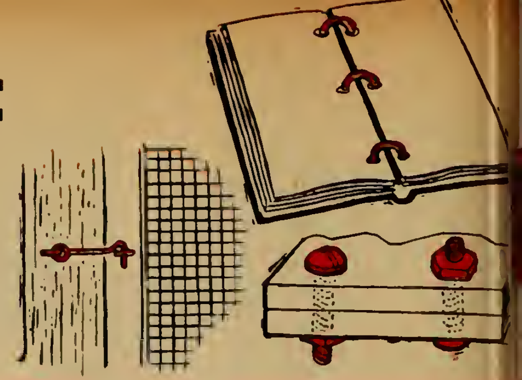
☐ How many ways can you think of to fasten two objects together? Two pieces of wood, for example. You could hold them together with nails, screws, bolts and nuts, hooks and eyes, glue, clamps, rubber bands, string, a paper wrapper, or a box. You could cut parts out of each piece of wood to make them lock together (called *mortising*), or you could attach a ready-made mortise—a door lock—to them. Can you think of other ways to fasten them together?

What about other kinds of materials? Can you think of at least six ways to hold two pieces of paper together? Two pieces of metal? Of plastic?

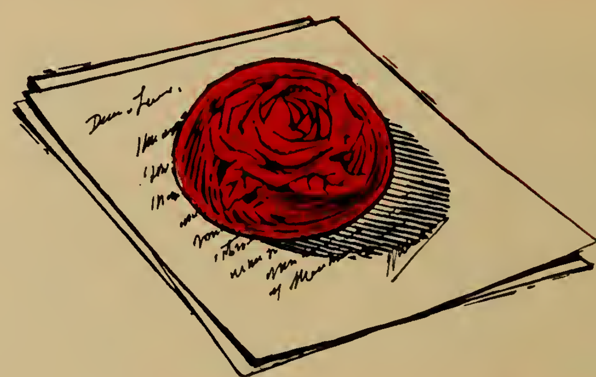
Do you usually use the first kind of fastener you think of—or whichever kind is handiest—to hold things together? If so, you have probably found that sometimes you can't *un*fasten objects as fast or as easily as you need to. Or perhaps the fastener you used didn't hold things together as well or as long as you intended.

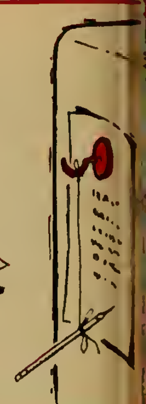
When engineers or designers choose a fastener, they first think about how the objects it must hold together will be used. Should they be held together so that *neither* object can move without moving the other, or so that *either* part can be moved without moving the other? Should the fastener be as strong as the objects it holds together, or should it be weak enough to "let go" before the objects it holds together are torn or broken apart? Will the fastener have to survive rubbing, pulling, pushing, soaking, heating, freezing, or other kinds of wear? How much? If you think about these things, you are more likely to choose a fastener that will do what you want it to.

Many kinds of fasteners have been invented, or are found in nature (plant roots, barnacle glue, and spider silk, for example). If you think about a particular kind of fastener, you will probably find that it works in one of the ways shown in this WALL CHART.—F.K.L.



Fasteners that block objects from moving apart and also press on the objects are usually made of *elastic* materials. An elasti material tends to spring back to its original shape after it has stretched, squeezed, or bent. Wood is an elastic material, so it presses on a nail driven into it. How does a nail hold two piec of wood together? Can you think of a fastener made of wood that holds two objects together by pushing them apart?

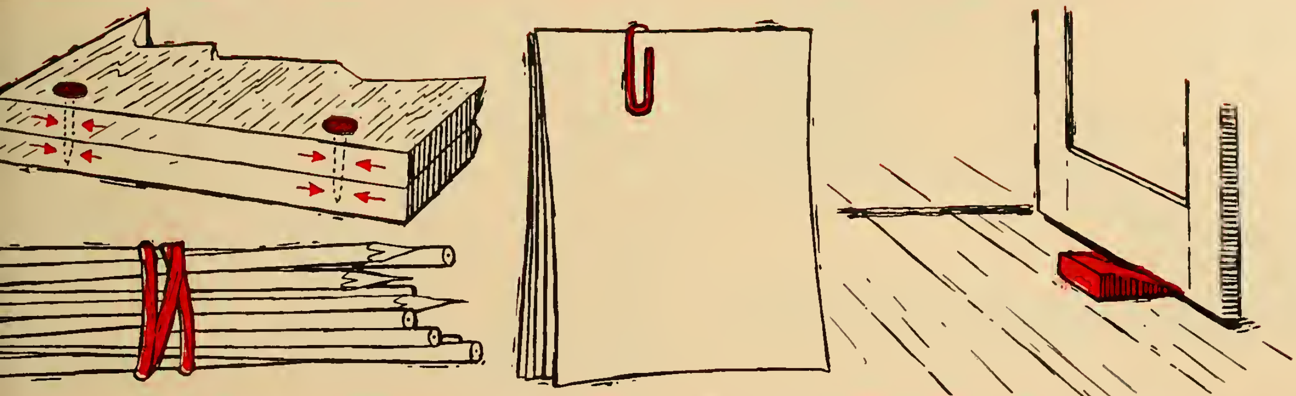


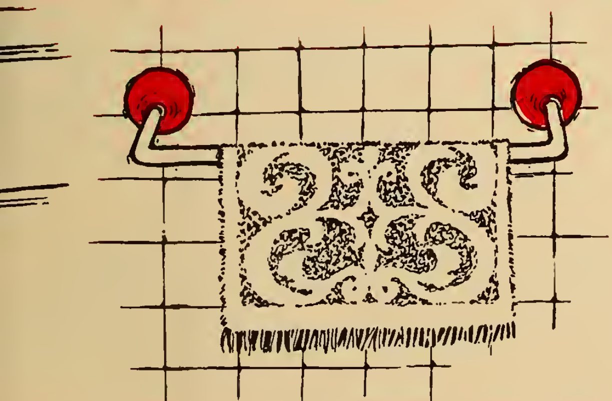


A coating of glue pressed between two pieces of wood holds th together because the *molecules*, or tiniest particles, of glue are strongly attracted to the molecules of the wood. This attraction between molecules of different kinds is called *adhesion*. Will a adhesive fasten two pieces of wood together more firmly if the surfaces are smooth, or rough? Why? Can water be used as an adhesive? What for?

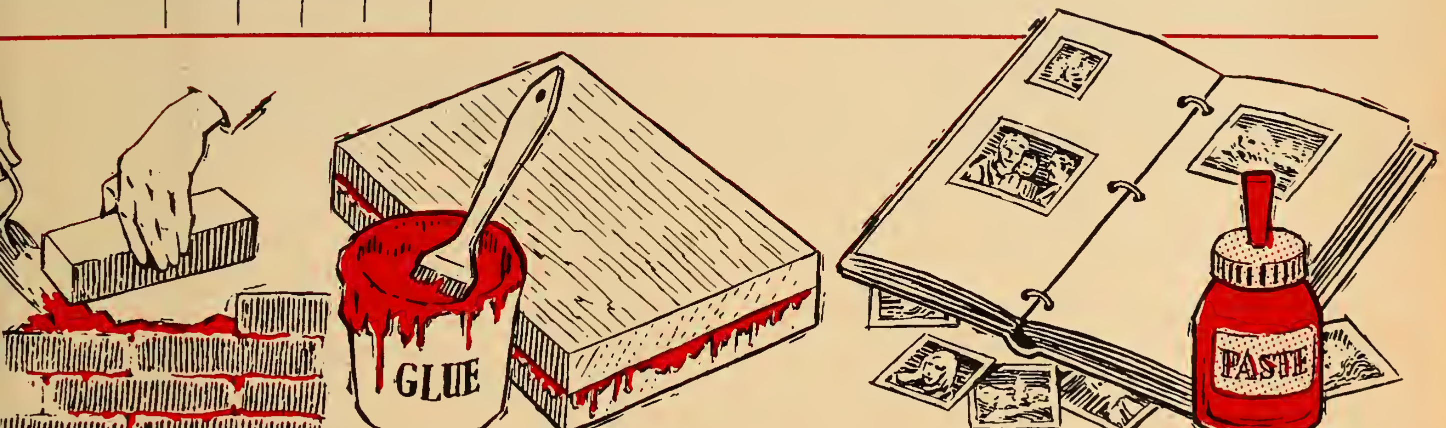
Objects made of the same metal can be *welded* together by heating adjoining parts of the objects until the metal melts, run together, and hardens. This fastener works by *cohesion*—the attraction between molecules of the same kind. Can you think a common plastic material that is fastened together by "weldin Does glue have to be strongly *co*hesive as well as *ad*hesive? W

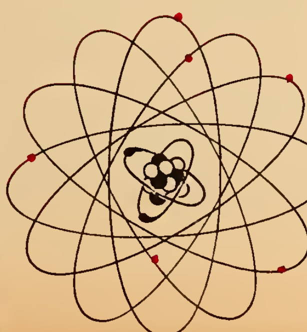
Each of these fasteners holds objects together by simply "blocking the path" so the objects can't move apart—at least not in certain directions. They work because two objects can't occupy the same space at the same time. For example, a button can't pass through the *cloth* around a buttonhole, even though it can pass through the hole. Where is the "block" in each of the other fasteners? Can you think of other fasteners that work this way?





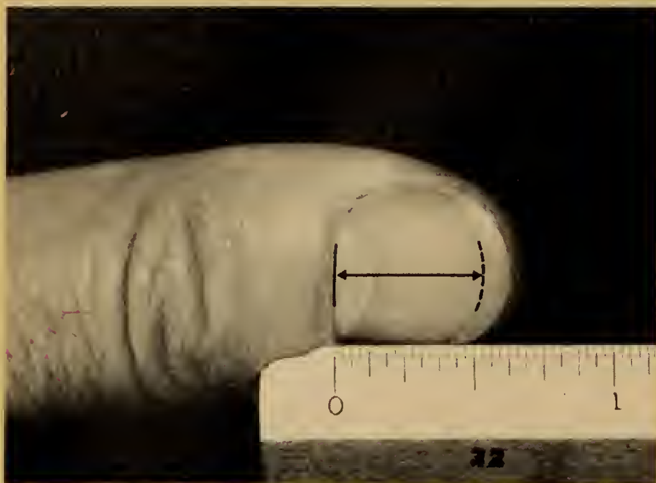
The downward pull of the earth's gravity makes a heavy object hold papers together on a desk. The pull of a magnet on the iron frame of a refrigerator holds a shopping list in place. When the hollow, curved, rubber discs on the ends of the towel rack are pushed flat against the wall, what holds them there?





The force that holds tiny particles together to form matter is electricity. There are two kinds of electricity, *positive* and *negative*, and a particle that carries a "charge" of positive electricity is attracted to a particle that carries a negative charge. This is the attraction that holds electrons near protons to make an atom, holds atoms together to make a molecule, and makes molecules cohere to other molecules of the same kind to make solid, liquid, and gaseous substances. (There are two other kinds of forces that hold neutrons and protons together to make the center, or *nucleus*, of an atom. Scientists are still trying to find out how these tiny but powerful "fasteners" work.)

How Fast Do Your Fingernails Grow?



Find out how fast your nail grows by measuring each week the distance from a scratch to the edge of the white tip.

■ Do you have any idea of how fast your fingernails grow? Here is a way you can find out. Start your investigation on one particular day of the week, say Monday.

With the edge of a fingernail file (do *not* use anything sharper than that), file a short straight line across your thumbnail right up against the *cuticle* at the base of the nail (*see photo*). Next measure the distance from the scratch to the edge of the white band around the tip of your nail. Make a chart like the one shown here on a sheet of lined paper, and write down this measurement and the date you made it.

THUMBNAIL GROWTH CHART

Date	Distance—Scratch to White Band	Growth per Week

_______ Weeks for scratch to reach white band

One week later, on the same day, measure the distance from the scratch to the edge of the white band. Has the scratch moved any closer to it?

Subtracting your second measurement from the first one will show how much your nail has grown in one week. This will not be very much the first few weeks, but keep measuring it on the same day each week, and write down the date and measurement on your chart. (Every once in a while, you may have to deepen the scratch a little so that it doesn't wear away.)

After four weeks, you will be able to tell from the measurements you have taken how many sixteenths of an inch your thumbnail has grown in one month. This will be the *rate of growth*. We say that our *rate of travel* during a trip was 50 miles an hour. At the end of a month you will be able to say that the rate of growth of your nail is 4/16 (or whatever) of an inch a month. When the scratch reaches the edge of the white band, your chart will show how long it took for the nail to grow one full length.

Do you think that your thumbnail grows at the same rate all the time? Probably not, according to Dr. William B. Bean, who is a physician at University Hospitals in Iowa City, Iowa. Dr. Bean started measuring the growth of his thumbnail 27 years ago, when he was 32 years old, and has been taking measurements regularly ever since.

Sometimes his thumbnail would grow more rapidly than usual, sometimes more slowly. Dr. Bean compared his record of measurements with such things as changes of seasons and changes of location (when he made long trips to Europe). But he didn't find any connection between these changes and the "spurts" and "lags" in his thumbnail's growth. The doctor did find, though, that as he grew older, it took longer and longer for his thumbnail to grow out to its full length.—F.K.L.

INVESTIGATION

Do your classmates' thumbnails grow out as fast as yours? Do the boys' nails grow as fast as girls'—or faster? Try to find answers to these questions. You might ask some teen-agers and some grown-ups of both sexes to help, too.

On a chart like the one shown here, write the name, age, and sex of each person, and the date on which he or she marked a thumbnail. After about two months, keep reminding each person to watch his nail and report to you the date on which the scratch reaches the white band at the end of the nail. From these dates, you can figure out the "grow-out" period, in days, for each person.

Whose thumbnail grew out fastest? Slowest? Add all of the grow-out periods together and divide the sum by the number of people involved. This gives you the average grow-out period for the entire group. Can you figure the average grow-out period for all the boys and girls who are about the same age? The average for teen-agers? For adults? Which group's nails seem to grow fastest?

Is the average grow-out period for the boys in your age group longer or shorter than for the girls? Can you think of any other questions your figures might answer? Do you think your findings would be the same if you had been able to compare the grow-out periods for, say, 100 people?

CHART OF THUMBNAIL GROW-OUT PERIODS

Name	Age	Sex	Date Started	Date Ended	Grow-out Period

Can the Elm be saved

by Dave Mech

A combination of a simple plant and two kinds of beetles is threatening to wipe out the elm trees of North America. Scientists are still trying to find a way to halt the deadly Dutch elm disease.

■ When I moved to West Lafayette, Indiana, the streets were lined with tall, spreading elms, and the cool shade gave the area a calm and peaceful look. Four years later, however, the town seemed more like an open, sun-baked desert. Its elm trees were gone. Only long rows of stumps remained.

Much the same thing has happened in several other eastern and midwestern cities. During a six-year period, Toledo, Ohio, for example, lost six out of every 10 of its elms. Kansas City, Missouri lost over 40,000 trees in just five years.

What is this powerful force sweeping the country and threatening to wipe out all the elm trees? How does it work? Where did it start? Is there any way of stopping it?

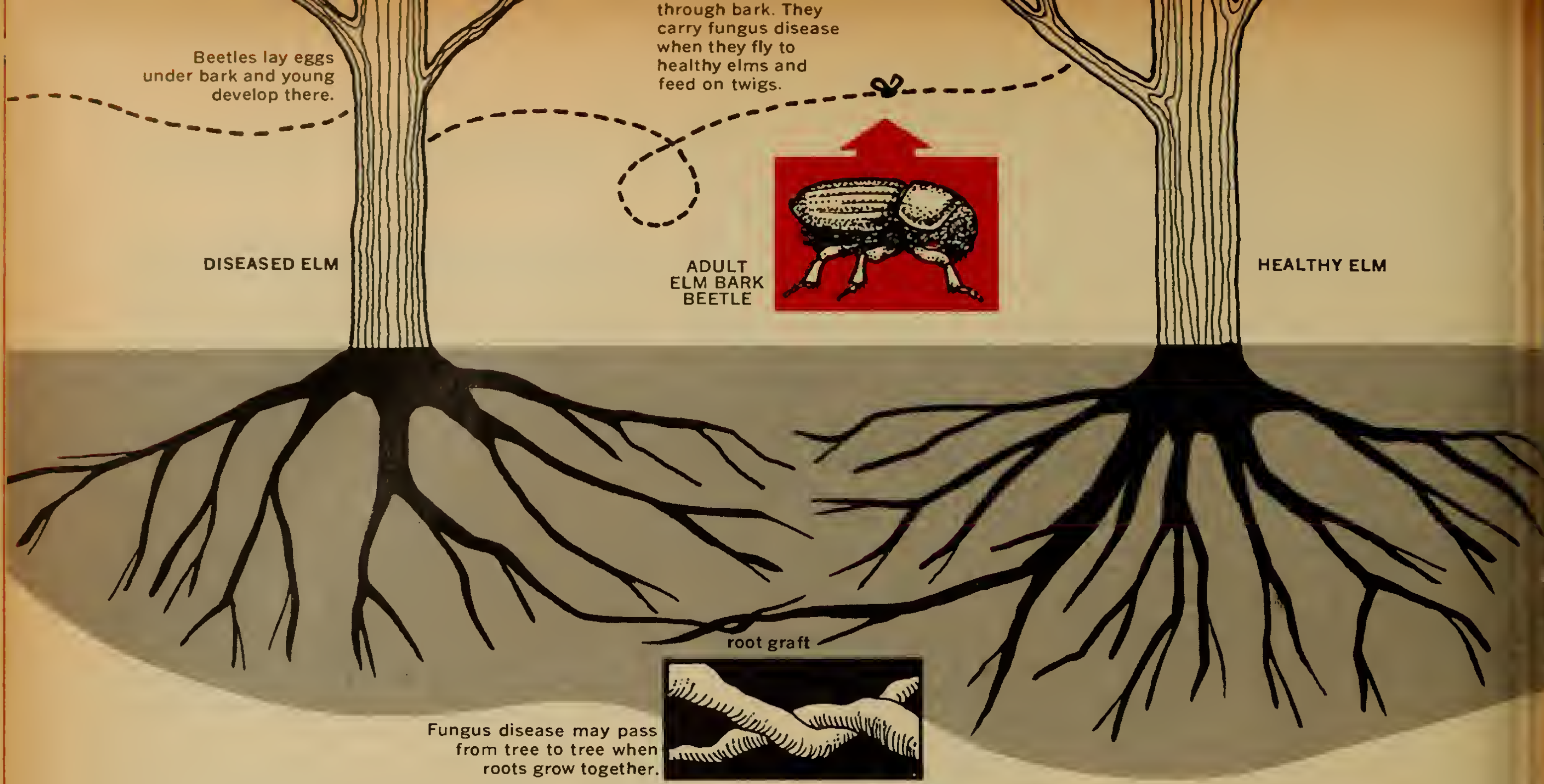
The powerful elm-killer is a *fungus*—a simple plant that cannot make its own food. Mushrooms and molds are common examples of fungi.

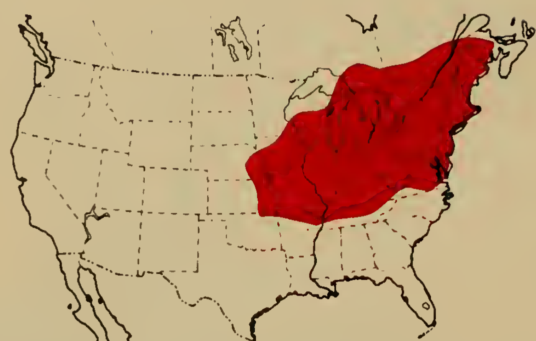
The fungus that does so much damage to elms lives inside these trees. It clogs the tiny tubes that carry water from the roots to the leaves. The leaves then wilt and dry up, and the tree dies. This condition is called "Dutch elm disease," and there is no known cure for it.

The disease got its name because it was first discovered in Holland. It then spread throughout Europe and Russia. Some of the tiny, seed-like *spores* of the fungus were brought across the Atlantic Ocean to North America in a load of logs. They probably arrived in the late 1920s, for in 1930 Dutch elm disease was discovered in Ohio.

Since then, the disease has swept throughout half of the

(Continued on the next page)





The Dutch elm disease has spread over the area shown in color, which is about half of the range of elm trees in North America. The diagram above shows how the Dutch elm disease is spread from tree to tree.

Can the Elm Be Saved? (continued)

United States (*see map*). Cities that do little or nothing to stop it usually lose 50 to 90 per cent of their elms within 10 years. This is very serious—elms are the most common trees in many cities. In Minneapolis, Minnesota, for instance, more than 90 per cent of the 650,000 trees are elms. Detroit and Cincinnati each have 400,000 elms; Dallas has 300,000; Chicago, 200,000; and Oklahoma City, 150,000.

These cities do not have to lose their elms. Scientists have now learned much about Dutch elm disease and the way it spreads. A look at what they have discovered gives us clues about how the disease can be controlled.

From Root to Root, from Tree to Tree

The disease is spread in two ways. The fungus from the roots of an infected tree can enter directly into the roots of any healthy elm within about 50 feet of it. This is because the roots of such trees often join together, forming a *root graft*. One method of controlling the disease is to dig a deep trench around an infected tree. The trench cuts the root grafts and stops the disease from spreading underground.

The second way the disease is spread is not so simple. It is carried from one tree to another by two kinds of beetles. The European elm bark beetle is the more important carrier, although the American elm bark beetle will also do the job.

Elm bark beetles lay their eggs under the bark of dead and dying elms. After the eggs hatch, the *larvae* (young) tunnel through the dead wood. Eventually they become adults and bore out through the bark. The beetles then fly to healthy elms, where they feed on the new twigs. If the beetles came from an elm that was infected with Dutch elm disease, they may carry the sticky spores of the fungus to the healthy trees.

The moment a disease spore falls on an open wound in an elm, the tree is doomed. It may be lost in just one summer. Sometimes it may not die for several years.

Every branch of a dead or dying elm gives the beetles a new place to lay eggs. It also leaves them a large supply of spores to carry to healthy trees. Thus one small infection can have almost explosive results. This was shown only recently in Nebraska. In 1960 the fungus was first found in one county. Today it infects elms in 60 counties.

Burn Those Beetles

One of the main methods of controlling Dutch elm disease is to stop the spread of the fungus. This is done by *sanitation*—burning every bit of dead elm wood in an infected area. Then the beetles have no place to breed.

The only problem with sanitation is that it must be complete. Even a small amount of dead elm wood can support many beetles. Dr. Dale Norris of the University of Wisconsin, in Madison, studied elm bark beetles in a laboratory. He found that as many as 2,500 beetles can hatch from just one square foot of dead elm. "In nature, the average is 75 to 100 beetles," says Dr. Norris.

Because sanitation has rarely worked alone in controlling Dutch elm disease, most cities use other methods along with it. These involve spraying trees with poisons to kill the beetles. Both DDT and methoxychlor have been used. Although DDT is especially dangerous to birds and mammals, it does a better job of controlling the beetles.

Because of the dangers of DDT, some communities have stopped spraying elms with this poison. In many places, however, city officials have decided to risk using DDT.

When a combination of spraying, sanitation, and root-graft control is used, most elms can be saved. The city of Lincoln, Nebraska, followed this program and in three years lost only 165 of its 130,000 elms. Most cities are able to hold their yearly losses to about one tree out of every 100, *if they take these steps.*

But this is where a big problem comes in—a people problem. Most people don't take the disease seriously enough. Because the disease spreads so quickly, it must be stopped as soon as it is discovered. This takes money, and some cities won't spend that money. The people often do not believe they will lose their elms. In other cases, the cities may take good care of city-owned trees, but private owners leave their dead elms standing. This ruins the city's sanitation program unless laws are passed that force people to burn their dead elm wood.

Not controlling Dutch elm disease is expensive. Every large elm that must be removed costs a city from $100 to $200. In addition, tree experts say that each such tree, when alive, is worth about $200 for its shade and beauty. Control of Dutch elm disease, on the other hand, costs as little as $3 a tree each year.

Knowing these cost figures, the city of Detroit decided to control the disease. In 12 years, the city spent $1½ million. But during this time it saved at least $57 million worth of trees.

If you tear the bark from the wood of a diseased or dead elm, you may find tunnels eaten into the wood by the *larvae* (young) of elm bark beetles.

Wasps *Versus* Beetles

Scientists are trying to find new ways of stopping the spread of Dutch elm disease. Some of their methods show promise.

One new idea is to speed up the discovery of diseased trees. To do so, scientists have taken pictures from airplanes with special film. They can then look at thousands of trees quickly and spot the diseased ones. If this method works well, it might allow foresters to find and wipe out Dutch elm disease as soon as it hits an area.

Another new idea involves a tiny wasp from France. A female wasp lays her eggs next to the larvae of European bark beetles. When the eggs hatch, the wasp larvae feed on the beetle larvae and kill them. In Europe, this wasp preys only on elm bark beetles and destroys up to 70 per cent of them.

Thousands of these wasps have been released in Ohio, Missouri, and Michigan. Already the insects have begun to seek out beetle larvae. If they do as well in this country as they have in Europe, they might really cut down on the spread of the disease fungus. Great numbers of these little wasps could be raised in laboratories. Then when a new outbreak of Dutch elm disease occurs, they could be released to kill the beetles.

With these ideas and many more being studied, Dutch elm disease may someday be only a worry of the past. But meanwhile the fungus continues to spread, and millions of beautiful elms remain threatened ■

WHAT'S NEW

by
B. J. Menges

Feeding charcoal to dairy herds might save farmers millions of dollars a year. Dairy cattle often eat plants that have been treated with pesticides; then their milk becomes contaminated. Because federal law forbids the sale of milk that has any traces of pesticides, farmers must now discard large quantities of milk each year.

Dr. Robert M. Cook, a dairy scientist at Michigan State University, in East Lansing, has found that activated charcoal can quickly rid an animal's body of pesticides. Charcoal becomes "activated" when it is exposed to high temperatures. Activation increases the ability of the charcoal to "soak up" and hold a liquid or gas. In a cow's body, activated charcoal takes up the pesticides, which are then eliminated from the body with the charcoal. Dr. Cook's studies suggest that in addition to helping the dairy industry, activated charcoal might be useful for treating people who have eaten pesticide poisons.

A metal with a "memory" has been made by scientist William Buehler for the Naval Ordnance Laboratory, in Maryland. The metal is a combination, or *alloy*, of nickel and titanium, called 55-Nitinol. If the alloy is formed into a complicated shape at a high temperature, then cooled and crushed into an entirely different shape, it will return to its exact previous shape when heated (see photos). How the Nitinol alloy can do this, when other materials can't, isn't known.

The alloy could be useful in many fields, including space flight. Huge antennas and radio telescopes could be made of the alloy at high temperatures, then cooled and crumpled into a form compact enough to be carried into space. There, heat from the sun could expand the structures to their former size and shape.

Poisonous milkweed plants don't harm Monarch caterpillars. In fact, they help them. Monarch caterpillars feed on milkweed plants that contain substances that are harmful to most other animals. The caterpillars then become poisonous themselves, and are avoided by most animals that would otherwise eat them. Even after the caterpillars turn into Monarch butterflies, which sip nectar from nonpoisonous flowers, the poison remains.

This blue jay is vomiting up a Monarch butterfly that scientists forced it to eat. Ordinarily the blue jay would never have eaten one of the poisonous insects.

Eating the milkweed helps Monarchs in another way: Since so few animals are able to eat the poisonous plants, there's usually plenty of food for Monarch caterpillars. These facts, long suspected by naturalists, have been confirmed in recent experiments by American, English, and Swiss scientists.

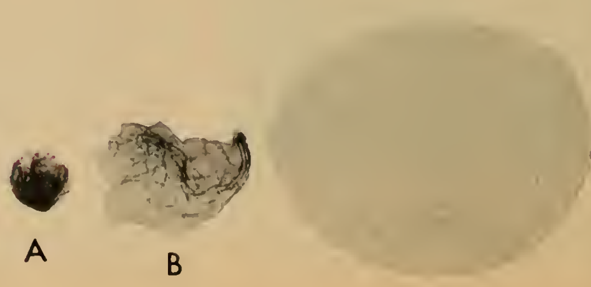
The dawn of life on earth may have occurred 200 million years earlier than scientists have thought. Until recently, scientists had never found a fossil that was more than 3 billion years old. But now tiny specks of matter, believed to be fossils, have been found in rocks at least 3.2 billion years old. (The earth itself is believed to be about 5 billion years old.) The new discoveries are of many shapes and sizes. All are microscopic, some as small as 1/25,000th of an inch.

The specimens were discovered in South Africa by a team of researchers working with Dr. Albert E. J. Engel, a geologist at the University of California, in San Diego. Dr. Engel says it's unlikely that older fossils will be found. Earlier forms of life—if there were any—probably would have been destroyed by the pressure and movement of the rock layers that built up through the ages.

Birds guard the health of the people who live in New York City. Ducks, pheasant, quail, and chickens are kept in three locations around the city. A small amount of blood from each bird is examined weekly by health authorities, who look for signs of certain insect-borne viruses. Some viruses, such as those of yellow fever and encephalitis, affect both birds and men. If present in the birds, the viruses also pose a threat to city residents. The birds are being watched especially closely these days for signs of encephalitis, also known as "sleeping sickness" or "brain fever." In nearby New Jersey, six people have recently died from the disease, which is spread by mosquitoes.

An artificial arm that moves in response to signals from the brain, much as a real arm does, has been developed by scientists of the Harvard University Medical School, Massachusetts Institute of Technology, Massachusetts General Hospital, and Liberty Mutual Insurance Company, all in the Boston area. A man who lost most of his left arm 26 years ago recently had the new artificial arm attached to the stump of his upper arm. Soon he was bending the artificial arm at the elbow by just "thinking" about it.

Signals from his brain cause muscles in the stump of his arm to contract. The contractions produce weak electrical signals that are strengthened by electronic equipment inside the artificial arm. A small electrical battery, worn at the waist, supplies the power. The strengthened signals run an electric motor that makes the arm bend. The inventors hope eventually to develop artificial hands and fingers that will also respond to "commands" from the brain.



A B C

A bulky antenna could be formed of 55-Nitinol at high temperature, then cooled and crushed into a compact ball (A). The ball could then be easily sent into space, where heat from the sun would make it gradually unfold (B) until it regained its original shape (C).

Inside your body right now, water is moving in and out of cells and from cell to cell through a process called osmosis. With some simple equipment from around the house, you can investigate...

the moving story of OSMOSIS

by Nancy M. Thornton

■ Our lives are controlled by thin, soft "skins" called *membranes*. Each of the cells in your body is surrounded by a membrane. The membrane holds the cell together.

Membranes have other jobs besides holding cell contents inside. All cells must get food, water, and gases, such as oxygen, or they die. These materials pass into the cell through the membrane. Wastes must pass out of the cell through the membrane, or the cell would become poisoned or would burst when it became too full.

This SCIENCE WORKSHOP tells how to investigate the way in which water passes through membranes. The movement of tiny molecules of water through a membrane is called *osmosis*. It is just one of several ways in which materials pass through membranes, but it is one of the most important ways. Here is how you can observe osmosis in action.

Eggs, Straws, and Cardboard

For this investigation you will need at least four clear plastic straws. Cut them into lengths of about three inches. You will also need some thread and some eggshells.

Probably you remember looking at eggs and finding a thin white membrane just underneath the shell. If you are careful, you can peel large pieces of this membrane from eggshells. You can easily get plenty of shells if you save them from being thrown away after baking a cake or fixing breakfast. It doesn't matter if they dry out a little. In fact, the membranes are easier to peel if you turn the shells upside down for a while and drain off some of the egg white.

Tie a big piece of egg membrane over one end of each of your straws. Be careful not to tear the membrane. If you do, make sure that the tear is above the place where you tie the membrane to the straw. Otherwise, the membrane will leak and you cannot be sure of your results. Wind the

(Continued on the next page)

thread tightly around the straw several times, then tie it.

Support the straws in strips of cardboard *(see diagram on this page)*. Do this by making X-shaped cuts in several places along the cardboard. Then push the open end of the straw through each hole. Don't try to push the membrane end of your straw through the hole; it might tear.

Next, set the membrane-covered ends of the straws in water by supporting the strips of cardboard over a pan of water. The lower ends of the straws should not touch the bottom of the pan.

Now you are ready to put liquids inside the straws. Use another straw for this. Push it down into a liquid, then cover the top end of the straw with your finger *(see diagram)*. Lift the straw out of the liquid and put its bottom end inside the top of the straw you want to fill. When you remove your finger from the top of the straw, the liquid will drip out. Hold the straw so that the liquid flows down the side of the straw you are filling. This helps keep air bubbles from blocking the straw. If an air bubble forms (and it probably will with thick liquids), poke the bubble with a toothpick until it is broken and the air escapes. Rinse off the toothpick and "filler" straw with warm water before working with the next liquid.

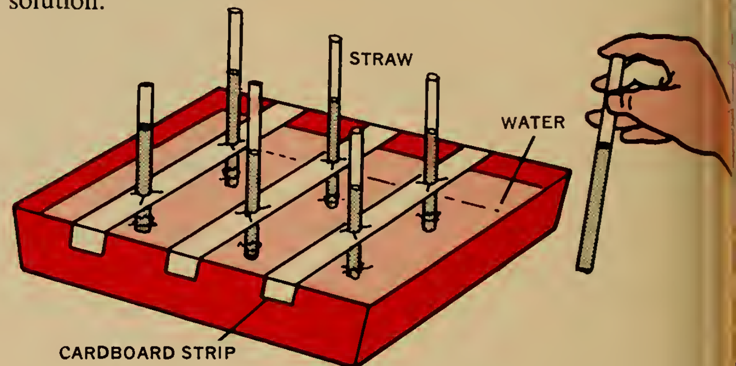
INVESTIGATIONS

- Fill one straw with water, and another with syrup. Suspend both in syrup. What happens? Does it make any difference if you put each straw in a separate syrup container instead of in the same container? (You can use the same straws for different investigations if you empty and wash them thoroughly before use.)
- Suspend an empty straw (covered with a membrane) in water and see what happens. You might also try empty straws suspended in different syrups.
- Try different membranes. Instead of using egg membrane, use a straw poked into a very thin slice of raw potato or carrot. Try a man-made membrane, such as cellophane or waxed paper. Use a double egg membrane and see if this makes any difference in the flow of liquids in or out of a straw. You might even try filling a plastic bag as full of water as possible, then suspending it in heavy syrup and seeing what happens.
- Now that you've observed osmosis with sugar solutions, try other types of solutions. For instance, make a salt solution and suspend a straw filled with this in water or different syrups. You might also try milk or other liquids.

Which Way Do the Liquids Flow?

After you put a liquid inside each straw, write the name of the liquid on the cardboard near the straw, so you will know what is in it. Fill the first straw about halfway with water. This will be your *control,* with which you can compare the other liquids. Use a piece of tape to mark the level of the water.

Make a sugar solution by stirring as much sugar as you can into warm water. Stop adding sugar when you see sugar collecting at the bottom of the container. Fill a straw halfway with this solution and mark the level of the solution.



Fill other straws to the same level with syrup, using different kinds such as corn syrup, maple syrup, and so on. Remember to mark the level of the liquid on each straw. Also use a very thick sugar solution, such as molasses or sorghum. If these liquids are too "stiff," you can increase the flow by warming them slightly. Don't mark the level until each of the substances has flowed down the inside of the straw. If any of the liquid drips on the outside of the straw, clean it off before it reaches the water in the pan. To avoid this problem, you can "load" the straws before setting the cardboard supports over the water.

Leave the straws undisturbed, making sure that the membrane-covered ends do not touch the bottom of the water container. Check the levels each hour for about three hours.

You will probably find that the liquid levels have changed. If the liquid inside the straw has risen above the mark you made, then water has passed through the membrane into the straw. If the liquid has dropped below the mark, then some of it has passed through the membrane out of the straw. Remember that the weight of the liquid column within the straw will have some effect toward emptying the straw. Does it in the control straw?

Have some of the sugar solutions (including the syrups) risen or fallen farther in the straws than others? What do you think might happen to a cell, full of dissolved sugar, that is surrounded by water? What might happen to a water-filled cell that is surrounded by a very thick sugar solution? ■

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

of the beetle larvae. Also, some species of elm, such as the Siberian elm, have evolved a resistance to the fungus disease. (In the United States, botanists are trying to produce a hybrid elm with the appearance of the American elm and the disease-resistance of the Siberian species.)

The use of natural enemies, such as this wasp, to control diseases and disease-carriers, is getting more attention from scientists who are seeking substitutes for indiscriminate control methods such as DDT. *(For more information on the far-reaching effects of DDT and other biocides, see "Can We Save the Eagles?",* N&S, *March 18, 1968.)*

Even if the European wasp is successful in reducing the numbers of elm bark beetles, the Dutch elm disease may continue to be a problem in North America. Where elm trees grow close together, up to 60 per cent of the infections occur underground, through root grafts.

Osmosis

After investigating the effects of osmosis, your pupils will wonder how and why it takes place. You might explain it in this way:

The molecules *(see bottom right caption on page 9)* of a substance are always moving around in different directions (the movement is faster in a gas than in a liquid, and faster in a liquid than in a solid). When two molecules collide, each bounces away in a new direction. If there are many molecules in a small volume (such as an open jar with perfume in it), a molecule moving in any direction except out of the jar will eventually hit another perfume molecule or the wall of the jar. It will change direction as a result of the hit. But a molecule moving out of the jar will hit only the lighter molecules of oxygen and nitrogen (air), which do not deflect the heavier perfume molecule very much. So it keeps moving away from the jar. As more and more molecules move out of and away from the jar, the perfume becomes more and more evenly distributed throughout the air.

This movement of molecules from a place where they are plentiful to a place where there are fewer molecules of the same material is called *diffusion. Osmosis* is a special case of diffusion—*the diffusion of water molecules through a semi-permeable membrane* (one that lets certain kinds of molecules pass through it more easily than others).

Egg membrane is semi-permeable and allows water molecules to move from the reservoir, where they are plentiful, into the straws, where they are fewer. (The stronger the sugar solution, the fewer water molecules it contains.) Sugar molecules are larger and do not pass through the tiny holes in the membrane as easily as water molecules. Otherwise, many sugar molecules would probably diffuse from the straws into the reservoir.

Osmosis helps keep a living cell in balance with its liquid environment. For example, when salt builds up in the watery solution in a cell, water enters the cell by osmosis and weakens the solution; if the interior solution is too weak, some water leaves the cell by osmosis, strengthening the solution inside.

Brain-Boosters

Mystery Photo. The jar in the photo contains oil, a melting ice cube, and large drops of meltwater from the ice cube. The fact that the ice floats while the water sinks means that the density of the oil is somewhere between that of ice and water *(see "How Dense Are You?,"* N&S, *Sept. 30, 1968).*

What would happen if? Your pupils can discover for themselves that the bottle containing the smaller amount of water will make the higher-pitched sound when it is tapped. Can they guess which bottle will make the higher-pitched sound if someone blows across the top of each bottle?

Tapping a bottle makes the glass vibrate back and forth, producing sound waves in the air. The faster the glass vibrates, the more sound waves reach your ear each second and the higher the pitch of the sound you hear. Water in a bottle slows down the vibration of the glass, so the more water there is in a bottle, the lower the sound it will make when tapped.

When you blow across the opening of a bottle, however, it is the *air* in the bottle that vibrates and produces sound waves in the surrounding air. The shorter this "column" of air, the faster it vibrates and the higher the pitch of the sound you hear.

Can you do it? Some of your pupils may try to release "one eighth of a drop" from a medicine dropper or a straw. Let them see that no matter how hard they try, they cannot change the size of the drop coming from the same straw or dropper.

One way to obtain a glass of water containing one eighth of a drop of milk is by *serial dilution:* First use a straw to place one drop of milk into a glass of water. Stir the mixture, then dump out half and add more water until the glass is filled again. If you repeat this procedure twice more, the final glass of water will contain one eighth of a drop of milk. If you use food coloring liquid instead of milk, the effect of each dilution will be more visible.

Have your pupils try to think of other ways to dilute the milk. One easy way would be to put the drop of milk into a half-gallon (64 fluid ounces) of water; then pour off one cup (8 fluid ounces), which will contain one eighth of a drop of milk.

Fun with numbers and shapes. Pupils who answer this question too quickly will probably say that the chest has seven drawers. Have someone draw a model on the blackboard to show that the chest can only have six drawers.

For science experts only. There are many possible ways for the oil to have "changed" into ice. (Someone could have dumped out the oil and filled the pan with water.)

In this case, the pan had been placed under the edge of the garage roof, where rain could run into it. The rainwater sank through the less dense oil to the bottom of the pan. As water filled the pan, the oil floating on the water ran over the top of the pan and onto the ground. When winter came, the water froze.

Books That Will Help You . . .
(continued from page 1T)

plus several student experiments and pictorial riddles.

The topic areas of the lessons are those suggested by the recent national Feasibility Conference on elementary science education sponsored by the American Association for the Advancement of Science. Outstanding scientists, teachers, supervisors, and science educators listed these topics as the most important for the elementary school. The concepts involved in each lesson are taken from the list of principles of science considered by scientists to be important for any person having a general education. No effort was made, however, to cover all the concepts and principles that may be embodied in an elementary curriculum.

The lessons are organized in departmental areas (physical science, earth science, biological science), and suggestions for using the lesson plans are made in the introduction to each section. Each plan has designated grade levels and an easy-to-follow form—Concepts, Procedure (step-by-step), and Student Activities. Twelve suggestions for using the discovery approach can be found on pages 167-168.

Science in Elementary Education, by Peter C. Gega (John Wiley and Sons, 1966, 451 pp., $8.95). This is "a book on how to teach science in elementary schools," as states the author's preface. The first part of the book introduces the basic things teachers need to know, while the 12 chapters (or "units") of Part II are the heart of the book. They contain model lesson plans arranged in teaching sequences that encourage children to learn through the development of their own critical thinking skills. These skills are clearly identified as they are used within each lesson. A subject-matter discussion before each sequence of lessons provides the background needed to teach the sequence confidently and successfully.

There are four units each at the primary, intermediate, and upper-grade levels—enough material in the life, earth, and physical sciences to make up most of a year's work at each level. Each unit has the same format: an introductory statement, a list of Basic Generalizations, a brief discussion of the topic, then a development of each Basic Generalization with materials, activities, and explicit directions.

nature and science

TEACHER'S EDITION

VOL. 6 NO. 7 / DECEMBER 16, 1968 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Books That Will Help You Teach Science

by Dulcie I. Blume

This is the second of three reviews of some books published in the past five years that have earned a front-row position on the shelves of elementary school teachers of science. Many were written by people with years of experience in teaching science to children. All of these books will help you to answer questions . . . to develop and direct investigative activities . . . to create classroom situations from which your pupils will be propelled to their own investigations, observations, and books.

Elementary Teacher's Classroom Science Demonstrations and Activities, by David E. Hennessy (Prentice-Hall, 1964, 308 pp., $8.95). Here is a book particularly designed to help elementary school teachers who are not specialists in science. The demonstrations and activities presented can be incorporated into any elementary science program, and the areas of science included should be of interest to all elementary school children. Plants and animals, electricity and magnetism, earth and sky, and rockets and space travel are some of the topics covered.

The demonstrations and activities—all tested in school situations—emphasize the use of inexpensive materials and equipment that can be easily obtained at home, from the school custodian, from the local junkyard or at the five and dime. Cautions are included where necessary.

Each activity and demonstration is developed according to the same pattern—Materials, Procedure, Discussion. One of the simplest activities, called "Seeing Behind You," requires just five lines for development, while one of the more complicated activities—making a schoolyard map by triangulation—is given more than two pages. Grade levels from kindergarten through grade six are suggested for each activity, but this does not mean that the activity is limited to those levels. Each teacher can plan the science program to suit the children's needs.

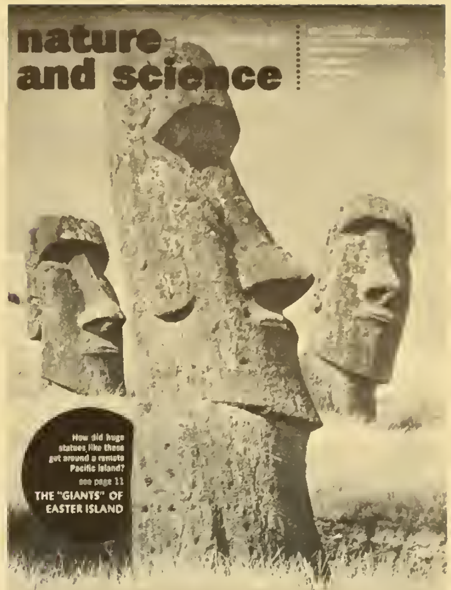
With its many clear illustrations, its simple language, and its easy directions, this is a book that could be used by the children themselves.

Mrs. Dulcie I. Blume is Coordinator of Curriculum Materials of the Alameda County School Department, Hayward, California.

Experiences with Living Things: an Introduction to Ecology for Five- to Eight-Year-Olds, by Katherine Wensberg (Beacon Press, 1966, 143 pp., $4.95). The book is planned as a guide for the teacher who undertakes backyard explorations with boys and girls of kindergarten and early primary age. Children are eager to learn about the natural world around them, and a study of ecology will prove most successful if it involves their own exploration. Guiding such a venture means providing resources for the answering of questions, and giving the kind of adult leadership, stimulation, and direction that can keep the activity exciting and rewarding.

The book presents a rich variety of experiences that are not planned to be covered in any specific length of time. When the teacher feels that the children have had ample time to savor the experience and have gained all that they are going to gain at this time, then there is a story to turn to at the end of each experience. These stories are emphatically *not* introductions to the experiences, but rather summaries of them. There are also

(Continued on page 4T)



IN THIS ISSUE

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

IN THE NEXT ISSUE

How to investigate the formation of ice in lakes and ponds . . . Tracking animals in the snow . . . The mysteries of how sea turtle hatchlings find their way to the sea and where they go when they get there.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

100 Turtle Eggs

For a species of animal or plant to survive, it must produce some young that live long enough to have offspring of their own. Through the process of natural selection, green sea turtles have evolved a way of reproduction that has enabled them to survive for millions of years.

Whether sea turtles can survive exploitation by humans is still in doubt. Humans prey upon sea turtles where they are most vulnerable—on the nesting beaches. Adult turtles are killed and their nests robbed. Huge nesting colonies have been wiped out and the number of wild, protected beaches is becoming scarce.

There are six main ways in which organisms are adapted to reproduce successfully *(see "Six Ways to Success,"* N&S, *March 27, 1967, or* WALL CHARTS—*Set 2)*. For sea turtles, the key to success is producing many young. A female turtle comes ashore about four times in the nesting season, each time laying about 100 eggs in a nest.

Have your pupils name examples of other species that produce great numbers of young. Fish and insects are good examples; some species of fish produce millions of eggs. Other animals, such as mice and rabbits, have only about four young per litter, but have several litters a year.

Your pupils can probably guess the key to reproductive success in humans: *parental care*. Humans provide more of this than any other animals do. Sea turtles give no parental care; the adults never see their young. Animals that give no parental care are usually adapted to produce many young. Those species that give parental care can survive by having fewer young, since more individuals survive.

For more information about the lives of sea turtles, see "The Voyages of the Green Turtle," *N&S*, Nov. 1, 1965.

Exploring Radio Waves

(This SCIENCE WORKSHOP *and the Activity suggested below are based on ideas from "Radio Waves" and "Direction Finding by Radio," by Hy Ruchlis, in* Science and Children, *Sept. and Oct., 1967, and are published by permission. Mr. Ruchlis is Adjunct Professor of Education and Director, Educational Media Center, Fairleigh Dickinson University, Rutherford, N.J.)*

Have your pupils make these investigations alone or in small groups, at home or in the classroom, keeping records of their findings to report and compare in a class discussion. Where their results from a particular test agree, have your pupils try to make up a simple statement that summarizes their findings. For example, they should find that starting and stopping the flow of current through the "transmitter" wire causes a noise to come from the loudspeaker of the radio receiver. They know that the receiver is made to detect radio waves in space and change them into sound waves. So they might summarize their finding thus: *When an electric current is made to start or stop flowing through a wire, radio waves are sent out from the wire and can be detected and changed into sound waves by a nearby radio receiving set.*

When your pupils report different results from a particular test, suggest that each individual (or group) repeat the test to see whether he gets the same results as before. If results from the test still vary widely, have your pupils try to find out why. Making the tests with each others' equipment might show that weak cells in a transmitter or receiver would account for the differences. Or watching each other make the tests may turn up some differences in procedure that make results differ.

As agreement is reached on the results of each test, have your pupils summarize the findings in a statement that describes their findings but does not go beyond them. When this has been done for each of the tests suggested in the article, have your pupils compare the summary statements with each other to make sure none are contradictory. (This is a good project in perception and descriptive writing, as well as in scientific research.)

• Your pupils can get a good idea about how radio waves are made by reading and doing the projects in "Electricity from Magnets" and "Seeing Things in Different Lights" (N&S, *March 18, 1968*).

Activity

Using a portable receiver to locate the transmitter of a radio broadcasting station will help your pupils find out for themselves how scientists use radio receivers to locate and "follow" a wild animal that has had a tiny radio transmitter attached to its body.

You will need a transistor radio with an inside bar antenna whose position in the set can be seen by removing the back. As your pupils have probably discovered, the broad *side* of a bar antenna detects radio waves more effectively than the narrow *end* of the antenna does. This means that when the set is turned so that it receives a station's signal *least well*, one end of the receiver's bar antenna must be pointed toward the transmitter *(see diagram on page 3T)*.

A road map of your area and a compass to help your pupils to turn the map's north end toward the North Pole will be helpful. Have your pupils find and mark the location of your school on the map.

When your pupils have seen how the bar antenna "points" inside the receiver, replace the back and stand 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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

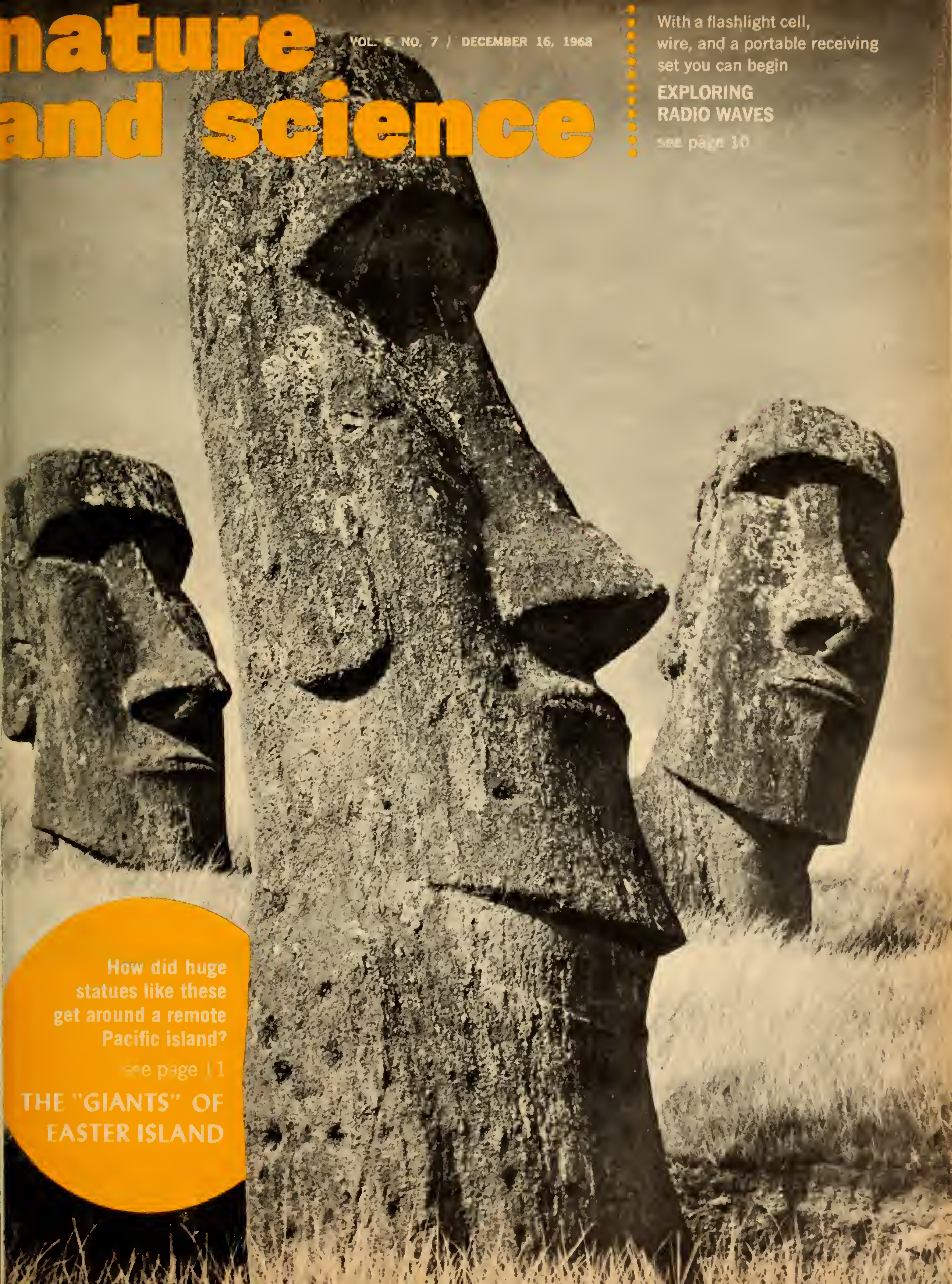
nature and science

VOL. 6 NO. 7 / DECEMBER 16, 1968

With a flashlight cell, wire, and a portable receiving set you can begin

EXPLORING RADIO WAVES

see page 10



How did huge statues like these get around a remote Pacific island?

see page 11

THE "GIANTS" OF EASTER ISLAND

nature and science

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PICTURE CREDITS: Cover, pp. 11-14, photos by George Holton; pp. 3, 5-11, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 2, Dr. Archie Carr; p. 4, top from Dr. Archie Carr, bottom by Jo Conner; p. 5, photo from David Webster; p. 16, courtesy of Lockheed Aircraft Corporation.

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

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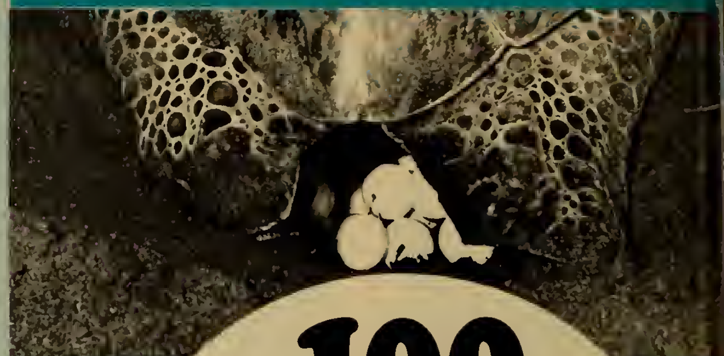
This female green turtle was photographed on a beach in Costa Rica, just after she had scooped out a nest in the sand. She then laid about 100 eggs in the nest *(below)* and covered them with sand.



100 Turtle Eggs

by Archie Carr

It is no accident that a sea turtle lays about this number of eggs in a nest in the sand. Fewer eggs, or more, and the turtle species might not survive.

This article is adapted in part from the book, So Excellent a Fishe, *by Archie Carr, published by The Natural History Press, Garden City, N.Y. Copyright © 1967 by Archie Carr.*

■ When I set out more than 10 years ago to write a book about North American turtles, I found that little was known about big sea turtles. This bothered me, and I began roaming the Caribbean Sea looking for whatever could be learned about them.

There are two times when a *zoologist* (a scientist who studies animals) can count on observing sea turtles: when a female goes ashore to lay her eggs in a hole in the sand, and when the young turtles hatch from the eggs. One of the most amazing things zoologists have learned is that the female usually lays about 100 eggs in her nest. She may lay as few as 20, or as many as 200, but the average number of eggs in a nest is 100 for sea turtles. But why? Why not 2 eggs, or 30, or 1,000?

I'm sure that the number is no accident. As sea turtles have *evolved,* or slowly changed over millions of years, 100 eggs to a nest became the average because this is the number that helps to ensure the survival of the sea turtle species. By studying sea turtles for many years, I learned some of the reasons for this special number.

A Gauntlet of Death

One reason that sea turtles lay 100 eggs is that most of the eggs—or the young that hatch from them—are bound to be eaten by other animals. The turtles' enemies range in size from ants and crabs to bears and tigers.

A turtle nest is safe from most enemies during most of the 60 days it takes the eggs to hatch. The egg-eaters are a menace while the eggs are being laid and for a day or two afterward. After that, however, there is a peaceful period when no animal seems able to find the turtle eggs buried in the sand. Why this is, nobody knows.

But then comes the time for hatching and coming out of the nest. For a few weeks there may be little turtles *(hatchlings)* by the thousands on the beach. For them, the danger begins when they have dug almost to the surface of the sand.

They lie there for a while as if waiting for some signal —for the thin crust over the nest to reach a certain temperature, perhaps. Whatever it is they wait for, it usually happens at night, most often after midnight, and most often during or after light rain.

When the turtles come out of the nest, they waste no time about it. Their trip across the sand to the surf is fast and direct. This time of greatest danger is only a minute or two, or a little longer if the way to the sea is blocked by many objects. The little turtles come out into a world eager to eat them, and they have to go fast and straight toward the ocean even though they can't see it and have never seen it. This is certainly one reason the mother turtle has to lay so many eggs.

Spying on Turtle Nests

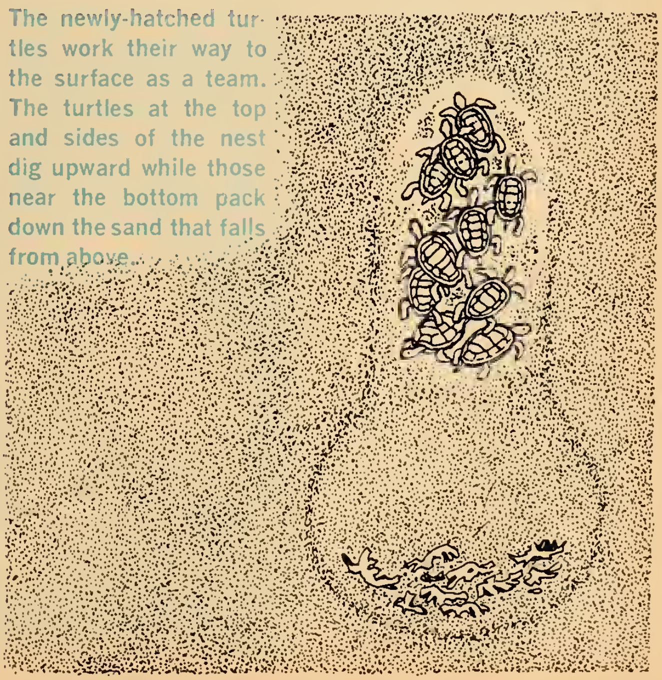
It seems that many eggs being laid together helps more turtles to survive than if the eggs were laid singly. Some other scientists and I were able to watch the things that go on in sea turtle nests by digging up to a nest from one side and replacing the sand wall with a pane of glass. Or we reburied eggs at the usual depth in a box of sand, putting them against a glass pane at one end of the box.

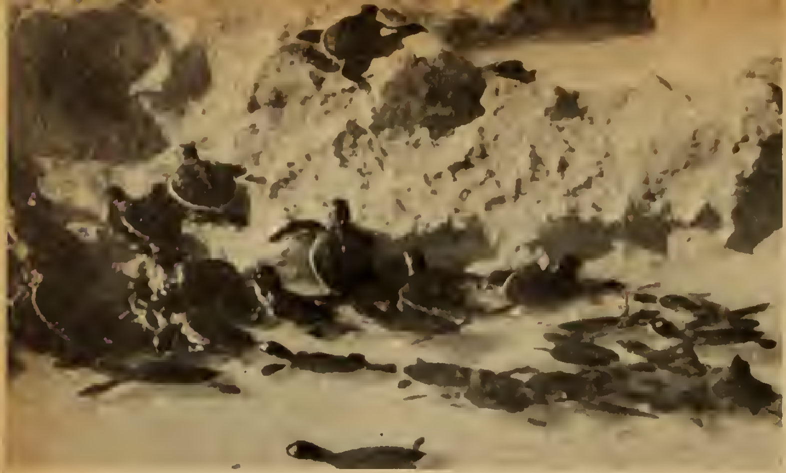
The first turtles that hatch from the pile of eggs do not start digging at once, but lie still until some of their nestmates are free of their eggs. Then turtles on top of the pile scratch down the nest's ceiling. Those around the sides dig at the walls. Those on the bottom trample and pack the sand that filters down from above, and they keep the hatchlings above them stirring. The ceiling falls, the floor rises, and the roomful of turtles working together moves toward the surface *(see diagram).*

To test the real usefulness of this teamwork, we buried single eggs as deep as in a typical nest and watched what happened to them. Out of 22 eggs that hatched singly, only six of the young reached the surface of the sand—and all these were too weak to go on across the sand to the water. As we added more eggs to these test groups, more hatchlings got to the surface. A 10-turtle team, however, seemed just as able to reach the surface as a group of 100.

(Continued on the next page)

The newly-hatched turtles work their way to the surface as a team. The turtles at the top and sides of the nest dig upward while those near the bottom pack down the sand that falls from above.





These young green turtles were hatched in a laboratory, then released among the dunes of a Florida beach. They had never seen the ocean before but found their way directly to it, crossing this channel and steep sand bar along the way.

100 Turtle Eggs (continued)

There are other advantages in the big groups. The turtle teamwork continues during the trip from the nest to the surf. In tests with young hawksbill turtles, we allowed hatchlings to crawl one by one across the beach. They stopped more often than those traveling in groups. The single turtles seemed to lie still longer during stops and to go less surely toward the surf. So single turtles are on the open beach longer and are more likely to be caught, or, if they have come out of their nest during the day, to dry up in the hot sun.

When a nestful of hatchlings comes out all at once or in a few smaller groups, periods of stopping are fewer and shorter because the turtles keep bumping one another. We found some evidence that the path of a big group of hatchlings usually goes more directly toward the sea than that of turtles traveling separately.

These advantages are almost surely part of the reason that sea turtles lay a lot of eggs intsead of only one. There are probably many more reasons.

Why Not More Eggs?

If 100 eggs in a nest are needed to help sea turtles survive, it seems that there would be advantages in producing a great many more eggs. One way to increase the number of eggs would be to make each egg smaller. But then the amount of food stored in the egg for the unhatched turtle would have to be reduced. This would make each hatchling smaller and turn it out into the world less able to scramble, to resist drying up, and to get through its first year in the ocean.

If a turtle produced more eggs of the normal size, it would almost surely be overburdened. Even if the female turtle could carry more eggs to the beach, she would probably have trouble housing the bigger group in a proper nest. A proper nest is one with the right temperature and humidity, and a "roof" thick enough to hide the eggs. These needs probably affect the size of the nest the female digs, which is just right for 100 eggs.

Once you think about it, it seems that almost everything a species of sea turtle does, or that happens to it, is reflected in some way in those 100 eggs or so the female drops into the hole she digs in the sand ■

In the next issue, the author tells what has been learned so far about how the young sea turtles find their way to the sea, and where they go after they disappear in the surf.

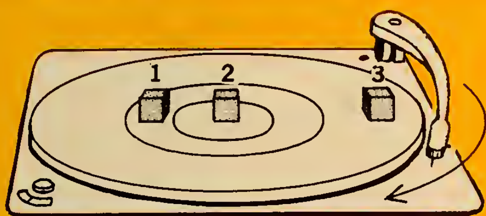
To learn more about the nests of sea turtles, Dr. Carr and his assistants dig into many nests to measure their depth and to count the eggs. Here, Mimi Carr, the author's daughter, and Shefton Martinez B. explore a nest on a Costa Rican beach.

MYSTERY PHOTO
How did the icicle get to the middle of the wire?

BRAIN-BOOSTERS

prepared by **DAVID WEBSTER**

WHAT WOULD HAPPEN IF . . .



. . . the turntable were spun around slowly at first, then faster and faster? In what order would the wood blocks slide off?

CAN YOU DO IT?

Can you "float" a needle in a glass of soapy water?

JUST FOR FUN

Last year we told how to clean dirty pennies by putting them in a mixture of salt and vinegar. Catsup can also be used to brighten pennies. Put some catsup on an old penny and wash it off after a few hours.

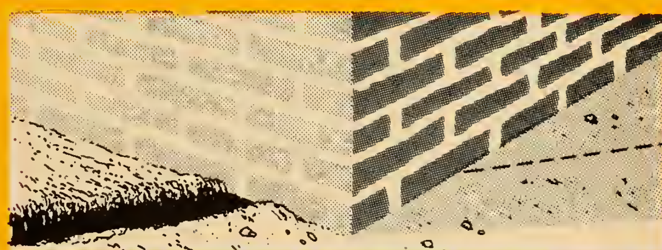
FOR SCIENCE EXPERTS ONLY

A fly is flying around in a moving train. When the train stops, will the fly go backward, forward, or stay where it is in the car?

Submitted by John Mazzarella, Philadelphia, Pennsylvania

FUN WITH NUMBERS AND SHAPES

The solid black line is a ditch that is being dug for a water pipe that will go through the corner of the house and out the other side *in a straight line*. How can the builders draw the broken line, to guide them in digging the rest of the ditch, *without making any measurements?*



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The jar in the photo contains oil, a melting ice cube, and drops of water from the melted ice. Why does the ice float in the oil if the water sinks to the bottom?

What will happen if? The bottle containing the smaller amount of water sounds the higher note when you tap it. Will that same bottle sound the higher note if you blow across the opening of each bottle?

Can you do it? To make a glass of water that contains just one eighth of a drop of milk, first use a straw to place one drop of milk into a full glass of water. Stir the mixture, then dump out half and add more water until the glass is filled again. Do this twice more, and you will have one eighth of a drop of milk in the water. How could you make a glass of water that contained one fifth of a drop of milk?

Fun with numbers and shapes: There are six drawers in the chest.

For science experts only: The pan of oil happened to be placed under the edge of the garage roof, where rain would run into it. Rainwater is denser than oil, so the rainwater sank to the bottom of the pan. As the pan filled with water, the oil floating on the water ran over the top of the pan and onto the ground. When winter came, the water in the pan froze.

LIGHTING the WAY for PLANTS

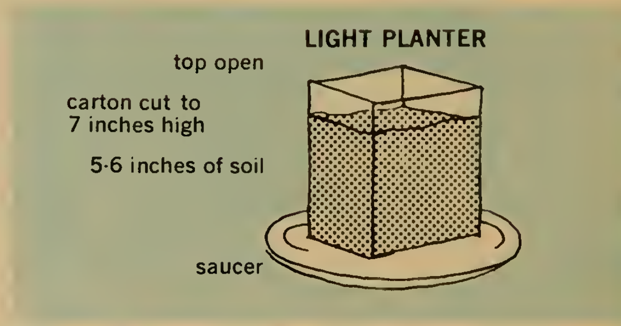
by Nancy M. Thornton

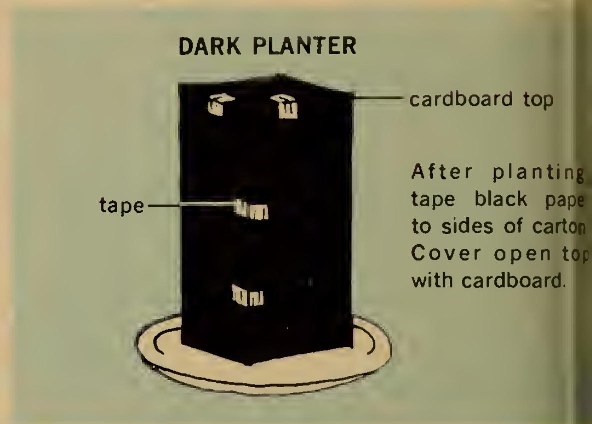
Green plants cannot survive for long without light. Here are some ways for you to find out how much light they need.

■ Peek under a porch, and you'll find very few green plants. Nor can many grow under a thick clump of trees. Green plants seem to need light. But how much light do they need? Does darkness always mean death for them, or does it result in plants that grow in strange ways? In this SCIENCE WORKSHOP, you can investigate the relationship between green plants and light—and you'll be able to eat some of your results!

You will need a packet of radish seeds, some soil, and four empty milk cartons. Half-gallon milk containers are good for growing radishes. Cut or punch several small holes in the bottoms so that excess water can drain away. Also put a layer of facial tissue on the bottom of each carton so that the soil will not drain away with the water. Fill the bottom of each carton with soil about five to six inches deep. Then put 10 radish seeds on top of the soil and cover them with ⅛-inch of soil. Sprinkle water on the soil until it is thoroughly damp. Once the radishes start growing, thin them so there are only three or four in each carton.

The diagrams on this page show what you should do to the cartons to test the effects of different lighting conditions on radish seedlings.





.IGHTING CONDITION IN CARTON:	First observations	Second	Third
Date			
Color and total number of seed leaves			
Color and total number of regular leaves			
Stem color			
Average leaf length			
Other observations			

Put all four cartons in a well-lighted place where the temperature will be about the same for each. Water the plants whenever the soil surface is dry. Put some "plant food," such as Hyponex, in each carton once a week.

Harvesting Your Results

Look at the plants every two or three days to see how they are developing. Do this for about four weeks. Record your observations on four charts (like the one shown) so you can compare growth under the four light conditions.

You'll find that the *seed leaves* are the first two leaves that develop. They're easy to recognize because they are heart-shaped. They contain food that had been stored in the seed, but they also make food like other leaves *(see "Visit to a Plant Factory,"* N&S, *September 30, 1968).*

Does one group of radishes grow more quickly than the others? To find out, figure out the *average leaf lengths* of the four groups from time to time. Do this by measuring the lengths of several leaves in one carton. Add together all the lengths. Then divide by the number of leaves you measured. Your answer is the average leaf length for plants grown in that carton. (Be sure to measure leaves from the same part of the plants each time.) How do the different lighting conditions affect the average leaf length?

What differences show up when you compare the observations you wrote down in the four charts? In what ways do all of the plants seem alike? What conclusions can you make about the importance of light to radish plants?

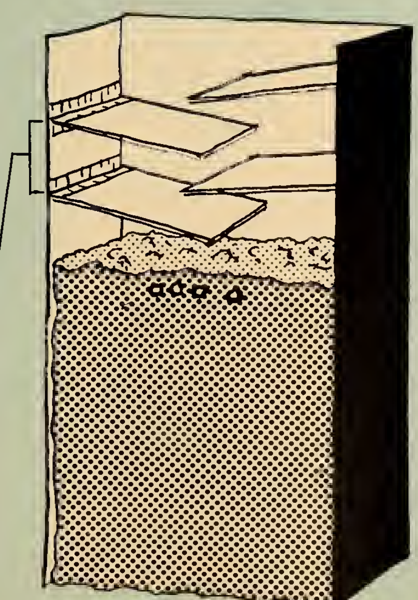
Don't forget to compare the sizes of the radishes themselves, and of the rest of the roots. (When you munch on a radish, you're actually eating a root, but it's a special kind of root that is mainly stored food. Where did this food come from?) ■

INVESTIGATIONS

• Do the growth rates of plants change when the plants' surroundings are changed? Make two planters, one that light can enter and one that is light-tight. Observe and record the growth of the radish plants for one week, then reverse the light conditions of the cartons. (Remove the black paper and tape from the light-tight carton; make the other carton light-tight.) Observe the growth for a second week.

• Change a half-gallon milk container into an "obstacle course" for radishes, like the one shown here. Plant only two or three seeds in the carton and water the plants at least once a week. After three or four weeks, observe how the plants have grown in their efforts to reach the light.

OBSTACLE COURSE FOR RADISHES



ROUND TRIP TO THE MOON

■ For thousands of years men have obs moon, our closest neighbor in space, from age distance of 240,000 miles. In the years or so, telescopes have sharpened of the moon's surface—but only of the si moon that is always facing the earth. In few years spacecraft have carried instrum cameras to the moon and sent close-up p its surface, as well as aerial views of its side, back to earth by radio.

Very soon now, a spacecraft carrying n

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

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

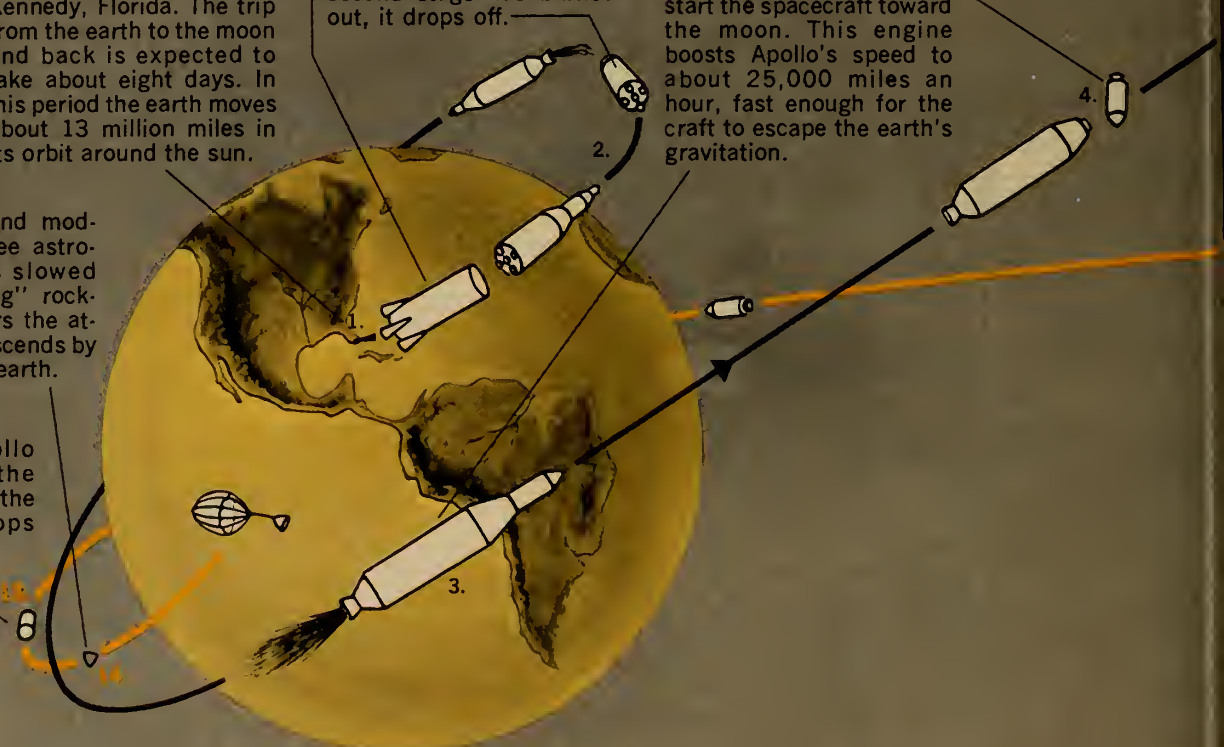
1. The Apollo spacecraft, carrying three astronauts, is launched from Cape Kennedy, Florida. The trip from the earth to the moon and back is expected to take about eight days. In this period the earth moves about 13 million miles in its orbit around the sun.

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

5. The burned-out stage drops away.

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

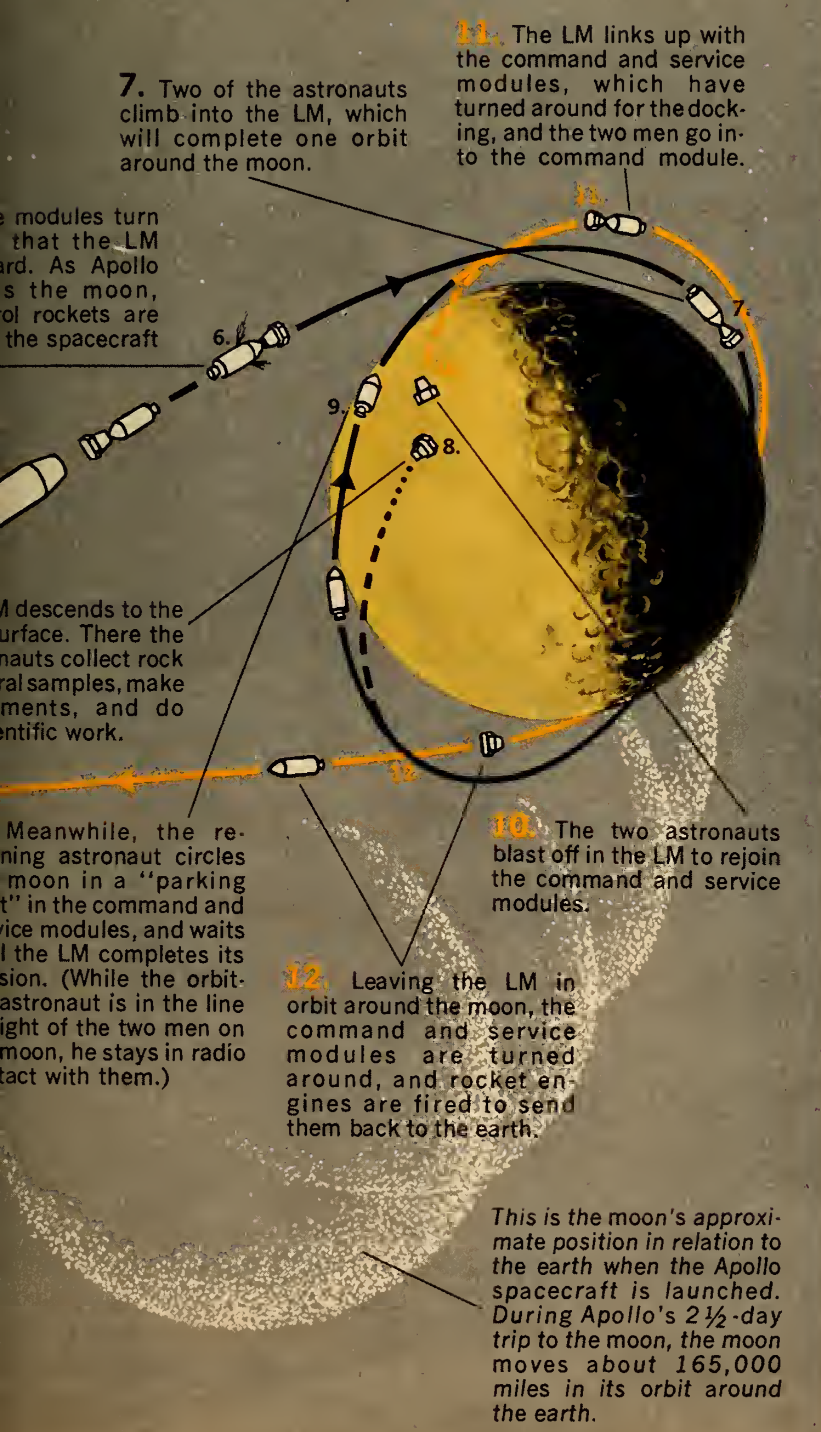
13. Before the Apollo spacecraft enters the earth's atmosphere, the service module drops away.

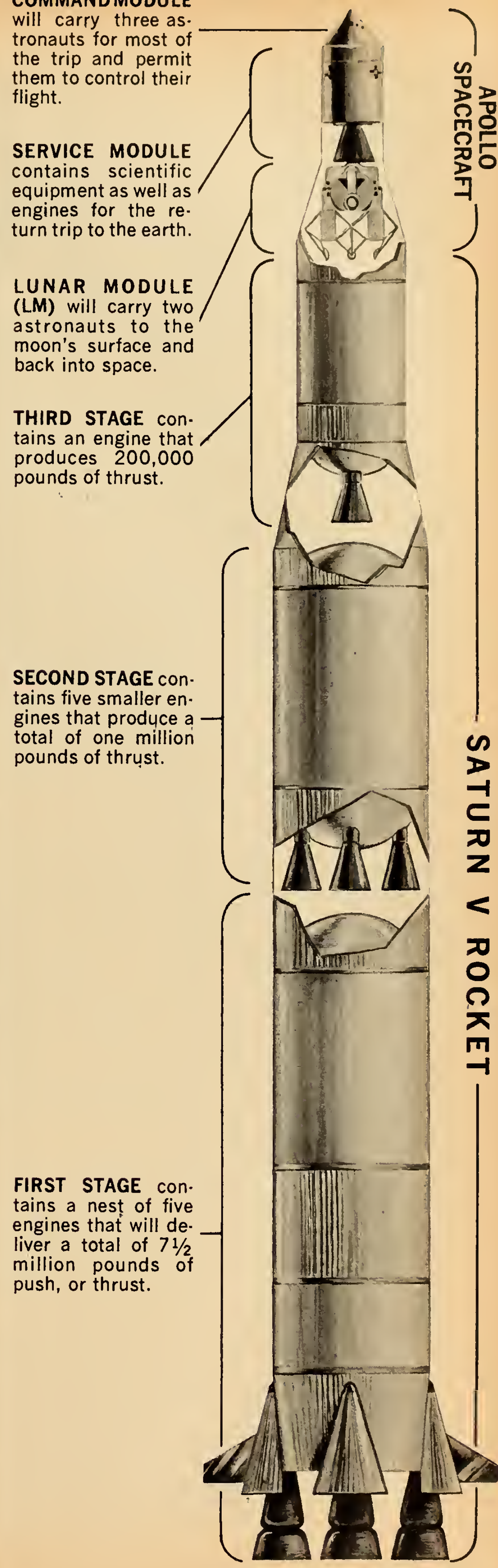


travel to the moon, circle it, and return to earth. And within a year, if all goes well, men may set foot on the moon—the most exciting step of all.

Three astronauts will leave the earth in the three-part Apollo spacecraft, which will be launched into space by a three-stage Saturn V rocket (*see diagram*). The rocket and spacecraft together will stand 364 feet high—as high as a 36-story building—on the launching pad.

This diagram shows the main steps of the trip from the earth to the moon's surface and back ■





EXPLORING RADIO WAVES

■ When was the last time you made some radio waves?

Did you say "Never"? The fact is that every time you switch an electric light on or off you make radio waves.

You can test this with a flashlight cell, some copper wire, and a radio receiving set. A small portable set works best. Scrape the *insulating* material or coating off the ends of a short piece of wire, and tape one end to the flat bottom of the flashlight cell. Turn the receiver on as loud as you can, then tune out the station, so you hear no sound. Then hold the cell close to the set and rub the other end of the wire over the metal "button" on the top of the cell. Do you hear a noise from the radio? If not, try pressing the taped end of the wire tightly against the bottom of the cell as you rub the other end over the button.

The noise you hear, called *static*, is made by radio waves that are *detected*, or picked up, by the receiver's *antenna* and changed into sound waves by other parts of the set. Does your radio *transmitter*, or sender, make waves while electric current is flowing through the wire, or just when the current starts or stops flowing? (In finding out, don't keep the wire connected to both ends of the cell very long; it uses up the cell's electricity too fast.)

Tracking Radio Waves

Turn the receiver in different directions as you make radio waves. Does this make any difference in the *signal*—the sound that you hear? Probably not, if the receiver has a metal rod antenna sticking out of it. But many portable radios have an inside antenna—a fine wire coiled around a flat iron bar. If the back of the set comes off easily, you can probably find this "bar" antenna. Does a bar antenna pick up waves better with its long side or with its short end? How can you tell?

Does the transmitter send out waves in all directions? You can find out by holding the "best" side of the receiver antenna toward the transmitter as you move the receiver around the transmitter. What happens to the signal as you move the transmitter toward and away from the receiver?

By taping two or three cells together in *series*, as shown, you can make a *battery* of cells that produces a stronger current. Will a battery like this make stronger radio waves than a single cell does? How can you tell?

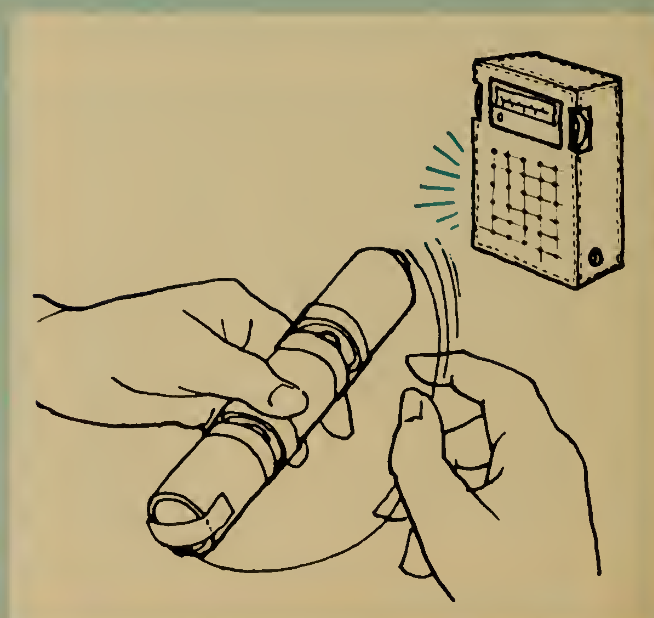
Do you think the radio waves come only from the point where the wire touches the cell's "button," or from the whole wire? Try a longer piece of wire and see if it changes the signal in any way. How about the shape and position of the wire? You might bend it into a loop, or a square, and turn it up-and-down, sideways, and at different angles to the receiver.

What Blocks Radio Waves?

We know that radio waves, like light waves, can travel through a vacuum—a space with nothing in it. Do you think they can travel through materials such as wood, metal, cloth, glass, plastic, and so on? You can find out by placing a piece of such material directly between your transmitter and the radio. When you find a solid material that the waves pass through, get a container made of that material and fill it with sand, soil, water, or other liquids to see whether radio waves pass through them.

Try putting different-sized pieces of the same material between the transmitter and receiver and see whether their size or thickness seems to affect the signal. Also, try placing the same piece of material at different distances between the transmitter and receiver. From your findings, do you think that radio waves travel only in straight lines, or can they "bend" around a small piece of blocking material?

Can you think of other things that might affect the radio waves sent out by your transmitter? How about rain or snow, for example? Or trees? Or a brick wall? Use your portable radio to look for other sources of radio waves. Try an electric razor, a fluorescent lamp. Do they make radio waves while they are "on"? As they are switched on or off? Does lightning make radio waves? ■



These 16-ton statues, toppled from their platform at Akivi about 300 years ago, were lifted back into place in 1960.

The "GIANTS" of Easter Island

A Norwegian scientist may have found out how these mysterious stone statues were carved and set up all over the island by people using tools of stone.

by Carrol Alice Stout

Dots show where statues once stood on platforms around Easter Island

■ When the stonecarvers had "released" the giant *moai* from the rock atop the dead volcano, the workmen laid down their stone picks and returned to their village, about four miles across the small Pacific Ocean island. Then the 12-foot-high moai, or statue, "came to life," walked across the island, and climbed onto a stone platform that had been built for it near the village.

That was the story the people on Easter Island *(see map)* told the Norwegian archeologist, Thor Heyerdahl, 10 years ago when he led an expedition to investigate the mysterious stone statues found there. For more than 200 years, scientists have wondered how the huge statues—some weighing as much as 25 tons—had been carved with primitive tools and moved across the island.

The story didn't make sense, though. Statues don't "come to life." Besides, as you can see in the photograph above, these long-nosed, long-eared, blank-eyed statues with long-fingered hands clasped under their stomachs had no legs!

When the Dutch admiral Jacob Roggeveen "discovered" the island on Easter Sunday in 1722, he saw many of these statues standing on platforms of stone. Fifty-two years later, when the English explorer Captain James Cook visited Easter Island, most of the statues lay face down at the

(Continued on the next page)

base of their platforms. Cook also noticed that the people of the island did not seem as lively and healthy as Roggeveen had reported them to be.

"I Can Make a Statue"

When Heyerdahl's expedition got there, no statues were standing. For months the scientists and helpers in his expedition examined the statues and looked for clues to the past. They found that people had lived on the island much earlier than most scientists had believed. Wood from a statue platform was dated by the carbon-14 method *(see "Dating the Past,"* N&S, *September 16, 1968).* The test showed that the platform had been built sometime between 900 and 1,300 years ago.

Almost 300 years ago, according to legends and to clues that have been found, a war took place on the island. One of the two groups of people who lived on the island was wiped out except for one man. This group was known as the "long ears" because of their custom of lengthening their ear lobes by making holes in them and putting in weights.

Heyerdahl made friends with the island's mayor, Pedro Atán. Atán said that he was descended from the only long-ear to survive the war, a man named Ororoine. Heyerdahl asked Atán if he knew how the statues were carved.

"Yes," he said. "I will carve you a statue. My relatives and I. Only a real long-ear can carve a statue."

Many people in the camp didn't think that the mayor could keep his promise, but Heyerdahl believed him. Late the following night, Heyerdahl sat in his tent with two companions talking about their work. Suddenly they heard a faint humming sound. It was a strange kind of singing. It grew louder. Through the tent opening they could see men, each with a feathery crown, huddled in a circle in the middle of the camp. Each was hitting the ground with something he held—a war club, a paddle, or a stone pick.

Soon two people wearing bird masks could be seen dancing to the low-pitched song of the men and the shrill voice of an old woman. After the ceremony, when Heyerdahl told the mayor how much he had enjoyed it, the mayor said that the ceremony had not been performed to entertain the expedition members. The song was for the blessing of God, *Atua.*

Off to the Quarry

Next day Atán and five of his relatives took a few expedition members to the quarry atop the crater of the dead volcano, called Rano Raraku *(see map).* There, hundreds of partly finished statues had remained for centuries since an unknown day when the stonecutters had laid down their stone picks and never returned *(see photo).*

The long-ears began collecting some of the hundreds of stone picks scattered over the quarry. The picks looked like flat front teeth of some giant animal. The mayor's men

For at least 300 years these finished statues have lain in the stone quarry on the side of Rano Raraku volcano. Others were left standing on the side of the volcano (see cover). The statues were carved out of *tuff*, a soft rock formed of volcanic ash and cinders that became *consolidated*, or stuck together, as rainwater flowed through them over many years.

went right to work. They spread out their picks along the base of the rocky wall. Each man set a gourd of water near him. The mayor, still wearing his fern leaf crown, measured the rock face using his outstretched arms and outspread fingers as a ruler. With a pick he marked the stone.

The mayor gave a signal, and the men lined up in front of the wall and suddenly began singing. They began hitting the wall in rhythm with the song. It was the first time in centuries that the sound of stonecutting had been heard at Raraku. One tall old man became so excited that he danced as he sang and hit the rock. Slowly, the marks grew deeper under the men's picks.

Without breaking the rhythm, a worker would grab his gourd and splash water on the rock to soften it and to keep rock splinters from flying into his eyes.

After they had worked three days, you could see the outlines of the statue. Whenever one of the men threw aside a dull pick, the mayor grabbed it and struck it against another pick on the ground to sharpen it again.

At the end of the third day the stonecutters stopped. They were woodcarvers, and not trained to carve stone for long periods of time. Atán said that it probably would have taken 12 months, with two teams working all day, to finish a statue. An archeologist with the expedition agreed. But Atán had shown how a huge statue could be carved from hard stone using only tools the islanders had used centuries ago.

Can He Raise a Statue?

Heyerdahl asked the mayor if he also knew how the statues were lifted to the platforms. "Of course," said Atán.

Heyerdahl decided to call the man's bluff. He offered to pay Atán $100 on the day that the largest statue lying on its face in the sand at Anakena Bay stood again on its platform. Right away, the mayor accepted the challenge.

To raise a statue, Atán needed 12 men, three poles, and a huge pile of pebbles and boulders. To begin, three men put the ends of their poles under the statue and pushed down on the other ends, using the poles as levers to lift the statue. The figure did not stir. They kept prying. Finally, a tiny space could be seen between the ground and the statue. The mayor, lying on his stomach beside the statue, quickly shoved tiny pebbles under it. Steadily the process went on. Lift, push stones under the statue, rest, and lift again. Now everyone except the lifters was gathering rocks. Larger and larger ones were needed as the huge figure gradually rose.

When men could no longer reach the ends of the poles, they pulled on ropes fastened to them. Men had to climb up the stone pile to place new stones under the statue. One false move and the statue and the stones would topple.

The old woman brought special egg-shaped stones. She and the mayor placed them in a circle, thinking their magic would help.

The mayor passed ropes around the stone head and fastened them to stakes driven into the ground, to hold the statue on the platform.

After 18 days of work, the statue was finally eased into an upright position. The pile of stones was taken apart.

The mayor had done what he said he would do. A statue had been lifted to a platform by men using the same kind of tools Easter Islanders of long ago might have used.

How Did the Statues Move?

Since the mayor had shown that he knew so much about statues, Heyerdahl asked whether he knew how they were

(Continued on the next page)

Scientists are shown rebuilding the base of the platform to which this 22-ton statue was lifted by a giant crane. The "top-knot" of red stone is like ones found near each of the statues that had been toppled off their platforms.

moved from Rano Raraku crater, where they were carved, to different places around the island.

The mayor said, "They walked."

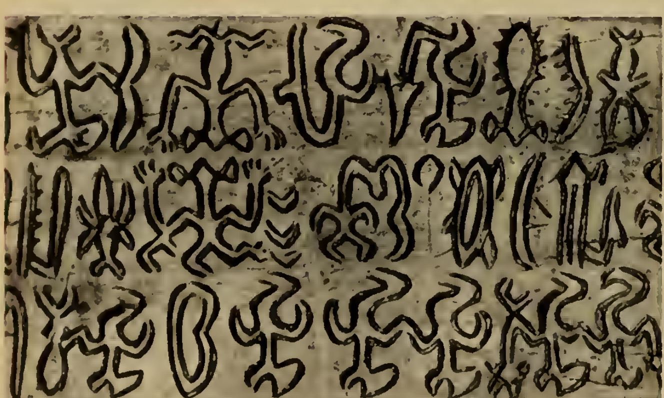
Heyerdahl kept asking and the mayor admitted that possibly a *miro manga erua*—a kind of sledge made out of a forked tree trunk—had been used. He knew they were used to move heavy stones into position on top of the platforms. He knew how to make one, but he did not have enough relatives to move a statue, and other Easter Islanders were not interested in helping.

At the camp two large oxen were killed and barbecued. Everyone on the island was invited. After the people had enjoyed the food and fun of a good picnic, it was not difficult to get nearly 200 of them to help move the statue.

They put the sledge in place under a 12-foot statue that had been left long ago on a road. Carefully they lashed the statue to the sledge with strong ropes, and pulled the giant over the ground.

In this way, scientists got an idea of *how* the giant statues may have been carved, carried across the island, and raised to their platforms. *Why* they were made is another question. Present-day islanders believe that the statues represented ancestors of the people who made them, and that those people thought the statues had "supernatural" powers.

The statues are not the only remains found on the island. There are many elevated tombs, hundreds of stone towers that must have marked land boundaries, caves lined with stones fitted together, rocks with pictures carved into their sides, and the remains of stone houses and farmyards.



Writing like this is carved on wooden tablets found on Easter Island. It might reveal something about the religion of the people who carved the giant stone statues—but so far no one has been able to decipher the writing.

There are also wooden tablets carved with a writing like no other writing known today *(see photo).*

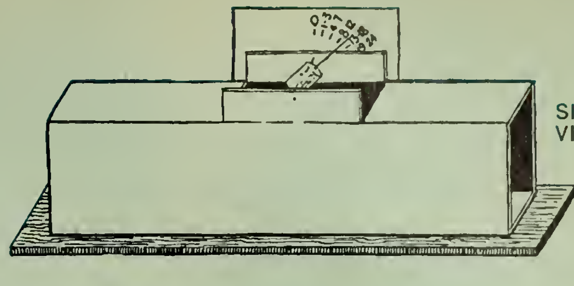
These accomplishments seem astonishing to Dr. William Mulloy, a Professor of Anthropology at the University of Wyoming, at Laramie. (An *anthropologist* is a scientist who studies how man has developed.) Dr. Mulloy has been studying the remains on Easter Island for 13 years, and is now directing efforts to restore many of the giant statues to their platforms.

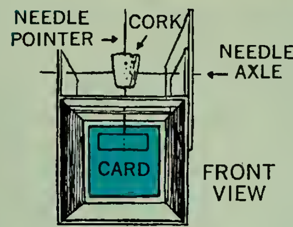
This head of an Easter Island *moai* was displayed in front of the Seagram Building in New York City last month, before being shown in other large cities in a campaign to raise money to restore more of the statues on the island.

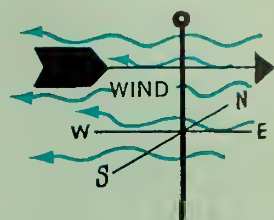
He believes that the small island could never have had more than three or four thousand people living on it. And he doubts that many visitors could have reached the remote island bringing new ideas with them. Yet the island people must have developed a fairly complicated way of living to produce the things they did before war almost wiped them out.

By studying the remains left by these people, scientists may learn more about how they lived, worked, played, and worshiped. But unless someone finds the "key" to the writing on the tablets and learns to read their messages, the mystery of Easter Island may remain at least partly unsolved ■

HOW FAST DOES THE WIND BLOW?

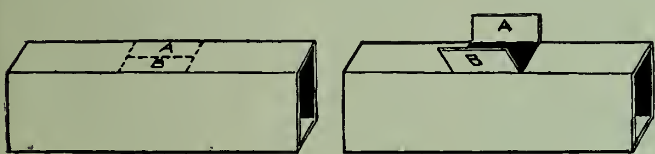






■ When the wind blows so hard that you can barely make headway walking into it, how fast is the air moving? You can measure the speed of the wind on breezy days as well as gusty ones by making a simple *anemometer,* or wind gauge.

To make an anemometer, you will need a milk carton with both ends removed, a long darning needle, two shorter needles, a cork, and a piece of cardboard. The carton should be thumbtacked to a block of wood. Cut the middle section of one side of the carton as shown here, and fold up flaps A and B to make supports for the axle.



Push the long needle through the flaps, placing a cork at the center *(see diagram).* Mount one needle vertically in the cork to serve as a pointer. Cut a square of cardboard to fit inside the carton, attach the third needle to it with tape, and stick the needle into the cork as shown. When the apparatus is set up, the card should move quite easily and smoothly within the box. (You may have to adjust the cork and axle.)

When the wind is blowing, point the apparatus into the wind so that the wind blows through the box. As the wind pushes against the cardboard square, it turns the axle and *deflects* or tilts, the needle pointer.

The distance the needle is tilted indicates how fast the wind is flowing through the carton. To measure this distance, you need a gauge. Fasten a piece of cardboard to the side of the carton and draw a line on it parallel to the indicator needle when it is standing straight up.

You can *calibrate* the gauge, or mark the tilt of the needle at different wind speeds, by using the Beaufort scale on this page.—FRANKLYN M. BRANLEY

BEAUFORT SCALE

WHEN—	WIND SPEED IS—
Smoke rises straight up	0 mph
Smoke drifts in one direction	1-3 mph
Leaves rustle; flags stir	4-7 mph
Leaves and twigs move constantly	8-12 mph
Paper, small branches move; flags flap	13-18 mph
Small trees sway; flags ripple	19-24 mph
Large branches move; flags beat	25-31 mph
Whole trees move; flags are extended	32-38 mph
Twigs break off trees; walking is difficult	39-46 mph

INVESTIGATION

Do the speed and direction of the wind give any clues about changes of weather where you live? You can find out by keeping a record on a chart like the one shown here. Each day at the same time, say about 8 o'clock in the morning, measure the wind speed and direction from which it is coming. About six hours later, note the weather (sunny, cloudy, rainy, snowy, or whatever) and enter it on the chart.

DATE	TIME	WIND SPEED	WIND DIRECTION	TIME	WEATHER

When you have kept the chart for several weeks, study it to see if there is any connection between the speed and direction of the wind and the weather that follows. Keep in mind that your findings would be more reliable if your anemometer were more exact, and if you measured the wind hourly for months, instead of once a day for several weeks. Also, that wind is only one of the things that helps make the weather what it is.

WHAT'S NEW

by
B. J. Menges

Fog over airports is a serious problem to aviation, second only to overcrowding of the skies and runways. Cold-weather fog can be removed by "seeding" it with dry ice, which turns droplets of water into falling snow. But this method doesn't work with the much more common fog that forms at temperatures above freezing—the fog that is blown in from the sea or that rises from warm ground.

A promising solution is a new device called Fog-Sweep. This machine blows two chemicals into the fog through a giant plastic tube. One chemical charges the water droplets in the air with electricity, so they attract each other and combine *(see "The Physics of Fasteners,"* N&S, *December 2, 1968).* The second chemical helps them combine faster, by weakening the elastic "skin" that holds each droplet together *(see "What Makes a Drop?",* N&S, *October 14, 1968).* The combined droplets are heavy enough to fall as rain.

"Dead" volcanoes could erupt in the United States at any time, says the head of the government's Geological Survey, Dr. William T. Pecora. He warns that we shouldn't assume that a volcano is "dead" simply because it hasn't erupted for hundreds or thousands of years. *(See "Kilauea Blows its Cool,"* N&S, *October 28, 1968.)* So-called "dead" volcanoes erupted in Costa Rica and Iran last summer, with great loss of life and property.

Dr. Pecora says that a number of volcanoes in the western states have "eruption potential," including Mount Rainier and Mount St. Helens in Washington, and Mount Lassen and Mount Shasta in California. He urges that a network of detection instruments be set up in these mountains to pick up early signs of volcanic activity. Nearby residents could then be warned of any danger.

If you get chilled and wet playing outdoors while your friend goes to the movies, which one of you is more likely to catch cold? Surprisingly, your friend. Recent experiments at Baylor University in Waco, Texas, tested the don't-get-your-feet-wet theory on a group of healthy men. Some were exposed to cold and dampness, others to viruses that cause colds, still others to both, and some to neither. The result: exposure to cold and dampness didn't increase the number or the severity of colds. Why, then, are colds most common in winter? Because people spend more time indoors, in close contact with each other. Here, cold viruses are spread easily by a cough or a sneeze.

An alligator purse or belt is nothing to be proud of. Alligators are being killed so fast that they are in danger of being wiped out. If an item is made of genuine alligator, not crocodile, the skin probably was obtained illegally. Except for a small species found in Communist China, the only true alligators in the world today occur in the southern United States. In almost every one of these states, alligator hunting is illegal. Yet poachers continue to kill alligators under cover of darkness, even in Everglades National Park. They often earn as much as $700 a night. If caught and found guilty, they receive small fines or short jail terms that they consider "business expenses."

Until recently, large alligators were abundant in the South; now few survive to reach breeding size. Stronger laws and law enforcement are urgently needed to save this awesome animal that has existed since the time of the dinosaurs. Perhaps the answer might be a law forbidding the sale of any alligator goods.

Mysterious radio signals from space have puzzled scientists since their discovery earlier this year. At that time the signals were found to come from one point in space. Their unknown source was called a *pulsar* because the signals came in pulses. Ten more pulsars have since been discovered elsewhere in space.

Some stars and planets are known to send out radio signals; but unlike these signals, pulsar signals are repeated regularly with exactly the same timing. This has led some scientists to wonder whether the signals were coming from intelligent beings in space. Most, though, have thought that the signals were being produced by ancient, burned-out stars called *white dwarfs.* Now Dr. Frank D. Drake of Cornell University, in Ithaca, New York, says the pulsar signal pattern could be produced only by neutron stars. These are stars that have collapsed and become so dense that a one-inch cube taken from one of them would weigh millions of tons on earth. Scientists have talked about neutron stars for 30 years, but have never been able to prove they exist. The pulsar signals may furnish that proof.

An artist's drawing shows how a Deep Submergence Search Vehicle being designed for the United States Navy is expected to look and work. The deep-sea craft being developed by the Lockheed Missiles and Space Company will be able to explore the ocean floor and recover small objects at depths of 20,000 feet.

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

set on the map over "your school." Tune the set to a station whose signal it receives clearly, and be sure to record the call letters of the station for later checking. Then turn the volume down until you can just barely hear the signal.

Have a pupil rotate the set slowly around the spot on the map where it is resting, listening carefully to find the position where the sound is weakest. If the sound is lost altogether, turn the volume up until you can just barely hear it again.

When the signal is least loud, one end of the antenna is pointing toward the transmitter. Draw a straight line through the school mark on the map in the direction in which the ends of the receiver antenna are pointing. The transmitter must be somewhere along that line, but it could be in either direction from the receiver *(see diagram).*

To locate the transmitter, you will have to move the map and receiver to a place at least a few blocks to one side or the other of the line drawn on the map. Mark the new location on the map, place the receiver on it, tune in the same station, and take another "reading." The line you draw on the map through your second location should cross the line drawn through the school marker, and the transmitter should be near the point on the map where the lines cross. You can telephone the radio station to find out exactly where its transmitter is located.

Brain-Boosters

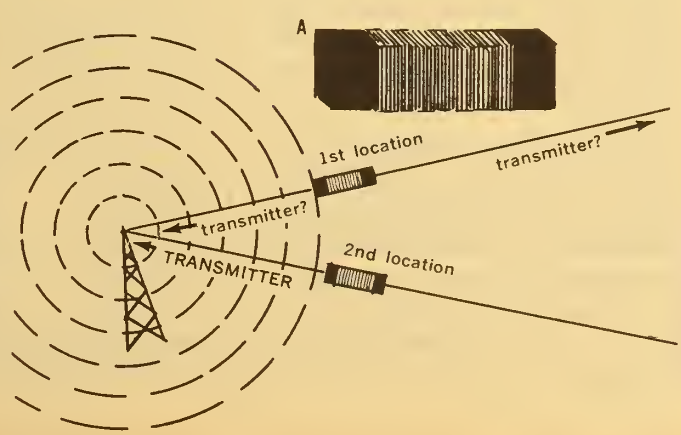
Mystery Photo. The icicle formed under the roof of the house, where the wire is attached. When the weather became warmer, the icicle broke away from the roof and slid down the wire.

You might challenge your pupils to explain how icicles form under the eaves of a house. What often happens is this: Heat from inside the house melts the underside of the layer of snow that has accumulated on the roof. The meltwater trickles down the roof until it reaches the eaves, which are not in contact with the main part of the house, and don't get much of its heat. The air temperature under the eaves may be low enough to freeze the water and make icicles.

What would happen if? Let the pupils try to guess the order in which the blocks will slide off before you make a demonstration (if possible) with a lazy susan or a record player from which the spindle can be removed.

Blocks 1 and 3 will slide off because of the *centrifugal effect* of the turntable's spinning motion. Since block 3 is located farther from the center of the turntable than block 1, it is revolving around the center faster than block 1, so the centrifugal effect on it is greater. Thus, block 3 will slide off first, followed by block 1. If block 2 is precisely over the center of the turntable, then it is *rotating* around its own axis (rather than *revolving* around the center of the turntable), and it will never slide off.

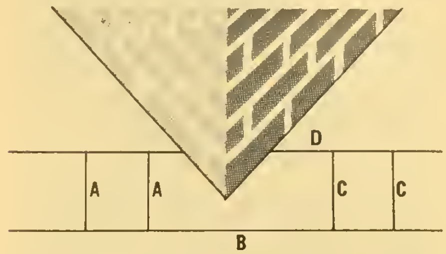
Can you do it? If your pupils tried the investigations and projects in "What's in a Drop?" and "'Surfing' to Safety," *N&S*, Oct. 14, 1968, pages 13-15, they will know that it is impossible to rest a needle on the surface of soapy water, because soap weakens the "skin" effect produced by surface tension. *(See also page 3T of that issue.)*



A bar antenna (A) detects radio waves least well when one of its ends is pointing toward the transmitter. Your pupils can use a bar-antenna receiver at two locations to locate the transmitter on a map (see text).

Fun with numbers and shapes. You might want to let the class try to solve this problem in the schoolyard. All you will need is a piece of chalk and a long, straight stick. First draw a line to represent the part of the ditch that is already dug; then let the children take over.

The diagram shows a way to solve the problem. First draw two equal lines *(A in diagram)* at right angles to the



ditch. Connect the ends of the lines with a long line *(B)* that goes past the corner of the house. Then draw two lines *(C)* that are at right angles to line B and are the same length as lines A. Draw a line *(D)* through the ends of lines C to mark the place where the rest of the ditch should be dug.

The class will probably need some help in finding this solution. Or perhaps they will find another way to help the builders complete the ditch.

For science experts only. The position of the fly in the train car will not change noticeably when the train stops. This is because the fly is "cushioned" by the air, which comes to a gradual stop with the train.

A more massive object, such as a person, tends to move forward in the car as a train slows down, because his greater mass gives him a momentum great enough to overcome the resistance of the air. If a person were swimming in a railroad car full of water, which would offer more resistance to his motion than air offers, his position in the car would not change very much as the train stopped.

Just for fun. Perhaps your pupils might like to find out which does a better job of cleaning pennies—catsup, or a salt-and-vinegar mixture. They could also find out what other common foods can clean pennies. Anything made from tomatoes, for example, will clean pennies (or other copper objects).

Books That Will Help You . . .
(continued from page 1T)

bibliographic references for each experience. Two other features of the book, included in each chapter, are the sections "Other Possible Experiences With ———" and "Introduction to the Experience to Follow."

The appendix includes "A Suggested Order for the Use of the Stories" and "Desert Adaptation of the Materials." The sequence of experiences is: sand, earthworm, robin, cat, tree, woodpecker, spiders, moles and shrews, ants, grass, garden, bees, caterpillars and butterflies, grasshoppers or crickets. Illustrations are included that can be helpful and enjoyable to even the youngest children.

Science for the Elementary School, by Edward Victor (Macmillan Company, 1965, 772 pp., $8.95). Although Part One of this book has some worthwhile chapters on the broad goals of the elementary science program, methods of teaching science, sources of science materials, and evaluation of science learning, it is Part Two, with its science content, learning activities, and bibliography, that will be of particular usefulness to many teachers.

The science content is presented in outline form, simply and clearly, yet with sufficient detail. This format should help teachers by:

1) lending itself to the presentation of concepts in a logical learning sequence;

2) eliminating extraneous material to make key concepts clearly and easily identifiable;

3) making it easier for teachers to select concepts for use at different grade levels;

4) simplifying the wording and making it easier for teachers to bring the vocabulary down to an appropriate level while preserving the accuracy and flavor of the science content;

5) being sufficiently detailed to provide the teacher with ample material for daily lessons and unit plans. (In fact, more science content has been included than is usually taught in grades K-6. The additional material is intended for the fast learner.)

The learning activities that follow the science content in each chapter are not all-inclusive Their purpose is to familiarize teachers with one representative activity that can be used to teach each of the key concepts in the outline. The topics covered in the outline are "The Earth and the Universe," "Living Things," and " Matter and Energy."

nature and science

TEACHER'S EDITION

VOL. 6 NO. 8 / JANUARY 6, 1969 / SECTION 1 OF TWO SECTIONS

◀ N & S REVIEWS ▶

Books That Will Help You Teach Science

by Dulcie I. Blume

This is the last of three reviews of some books published in the past five years that have earned a front-row position on the shelves of elementary school teachers of science. Many were written by people with years of experience in teaching science to children. All of these books will help you to answer questions . . . to develop and direct investigative activities . . . to create classroom situations from which your pupils will be propelled to their own investigations, observations, and books.

Science Equipment in the Elementary School (University of Colorado—Elementary Science Advisory Center, Boulder, Colorado, March 1967, 36 pp., $1). This bulletin contains a long list of materials for teaching elementary school science, along with photographs and suggestions for use. The list is organized into rough categories for convenience, but many items could be put into several categories. The classroom was chosen as the unit for estimating quantities. Some indication of cost is given wherever possible.

There is also a special "junk" category: gear wheels, spools, pastry cutters, bottle caps, bicycle pump, corks, sponges, etc. The one feature these objects have in common is that they cost "nothing," being brought in by the children or teacher. But they are invaluable: a good laboratory, whether in university or elementary school, always has an ample junk box.

The following bulletins come from the National Science Teachers Association of the National Education Association, and may be ordered from NEA Publications Sales Division, 1201 16th St., N.W., Washington, D.C. 20036.

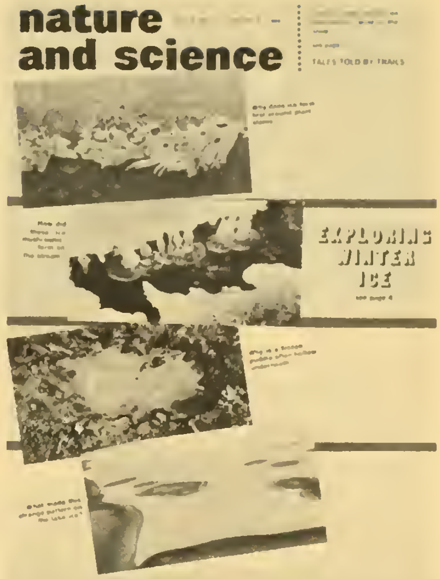
Biological Science — Teaching Tips from TST (1967, 224 pp., $5, Stock Number 471-14526); **Earth-Space Science — Teaching Tips from TST** (1967, 121 pp., $4, Stock Number 471-14350); **Physical Science — Teaching Tips from TST** (1967, 144 pp., $5, Stock Number 471-14348). These three bulletins are compilations of articles from *The Science Teacher.* The articles fall into two categories—those with content information to enrich the teacher's background, and those containing classroom ideas that can help add variety to a science program. The content may be familiar to some, but most of the articles present new information not commonly available to the secondary teacher.

Helping Children Learn Science (1966, 188 pp., $3, Stock Number 471-14498). This bulletin is a compilation of articles from the periodical *Science and Children,* for the elementary school teacher. The compilers had in mind articles that (1) present material that is consistent with accepted philosophy and practices and with the latest trends in science education; (2) provide usable material for classroom teachers, curriculum personnel, and administrators who are not science specialists.

The articles are presented in five categories: objectives for teaching science, background information for the teacher of science, resources for teaching-learning, classroom teaching-learning experiences, and experimental science curriculum studies. Just one excellent example

(Continued on page 4T)

Mrs. Dulcie I. Blume is Coordinator of Curriculum Materials of the Alameda County School Department, Hayward, California.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T-4T.)

Tracing Prehistoric Trade
How archeologists found a way to prove that men's early villages traded with each other.

● **Exploring Winter Ice**
Your pupils can investigate how ice forms and melts on a lake or pond, and test their findings in a refrigerator "laboratory."

● **Tales Told by Trails**
By learning to "read" the tracks of wild mammals, your pupils can study their travels and behavior.

Who Goes There?
This WALL CHART shows how to identify the tracks of common animals.

● **Brain-Boosters**

How Do Turtles Find the Sea?
A biologist tells of his efforts to find out how baby turtles find their way to the ocean and where they go when they get there.

● **A Swinging Experiment**
Your pupils can use a simple pendulum to test the idea that objects of different weight dropped simultaneously from the same height will land at the same time.

IN THE NEXT ISSUE

A special-topic issue: Life in the Arctic: How animals are adapted to survive in the Arctic . . . The Eskimo's world . . . Cycles in animal populations . . . How biologists are studying polar bears . . . Learning to live with permafrost.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Exploring Winter Ice

Here are answers to the questions about photos in the article:

Page 4: A lake freezes and unfreezes first at the shore. When the shoreline is free of ice while the rest of the lake is frozen, the lake must be unfreezing. . . . When water that has collected in a deep crack in a rock is subjected to freezing temperatures, a layer of ice forms at the surface of the water. With more cold weather, the rest of the water may freeze. The expanding ice, trapped between the rock and the ice layer above, pushes against the sides of the crack. In the course of many freezings and meltings it may gradually split the rock.

Page 5: The constant movement of water in the river channel keeps it from freezing. . . . The movement of the birds stirs up the water, so it can't freeze, and the birds continue to flock to this "oasis" in the frozen lake, keeping it unfrozen. . . . Air bubbles were trapped in the block of ice as it froze.

Page 6: Like the soil and rocks on the shore, the wooden pilings take heat from the water on cold days, making it *freeze* around them first. They lose heat to the ice on warm days, making it *melt* there first. The repeated freezing and melting of ice around the pilings prevents a thick layer of ice from building up around them, so the ice around the pilings is always "new," or clear, ice. The ice looks black because you can see through it to the dark water below.

Tales Told by Trails

Most wild mammals are shy or nocturnal, so their behavior is difficult to observe. We can interpret it by following tracks and other signs. Unless children get outdoors and *look,* the study of wild mammals will be largely book lessons.

Have your pupils discuss places in your area where mammal signs are likely to show up. Proceed with the observations on an individual basis. Advise using a portrait attachment for snapshots of small tracks. Encourage pupils to bring in sticks showing toothmarks, nuts and acorns that have been gnawed open, and casts of tracks.

Casts of animal tracks in mud or ice are easily made by pouring a mixture of plaster of Paris and water into the track. If the children practice mixing plaster of Paris in school,they will have no difficulty on the trail. Use quick-setting plaster, available at hardware stores. Add enough plaster to fill the track, a little at a time, to ½ cup of water in a tin can or plastic container. When the mixture looks like pancake batter, pour it into the track *(see diagrams).* A very neat job results from placing a stiff paper collar fastened with a paper clip around the track. The plaster may be lifted off after setting for about 15 minutes. Any mud can be cleaned off with an old toothbrush at home.

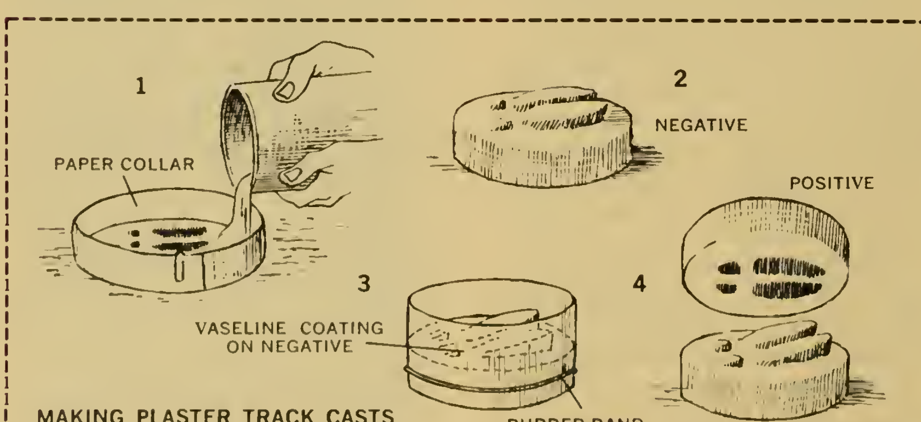
If the air is very cold, casts can be made in snow by spraying the track with water from an atomizer. This will harden the track. As a further precaution against melting, mix some snow into the wet plaster.

This cast will be a "negative" reproduction of the track; that is, the paw marks will protrude. To make a "positive" cast, first coat the negative cast with vaseline, then set it in the paper collar and pour plaster mixture over it until the protruding paw mark is covered. When the plaster has set, you can separate the positive cast of the track from the negative cast. If the negative is removed carefully each time, many positives can be made from it.

A Swinging Experiment

Some of your pupils may "know" that a 100-pound ball and a 1-pound ball dropped simultaneously from the same height will reach the ground at the same time. They will probably say that "Galileo proved it by dropping balls of different weight from the Tower of Pisa." There is no historical evidence that Galileo ever did that experiment, although it was done in Galileo's time at another tower by a Dutch mathematician named Stevinus.

(Continued on page 3T)



MAKING PLASTER TRACK CASTS

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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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Learn to "read" the stories that animals "write" in the snow.

see page 7

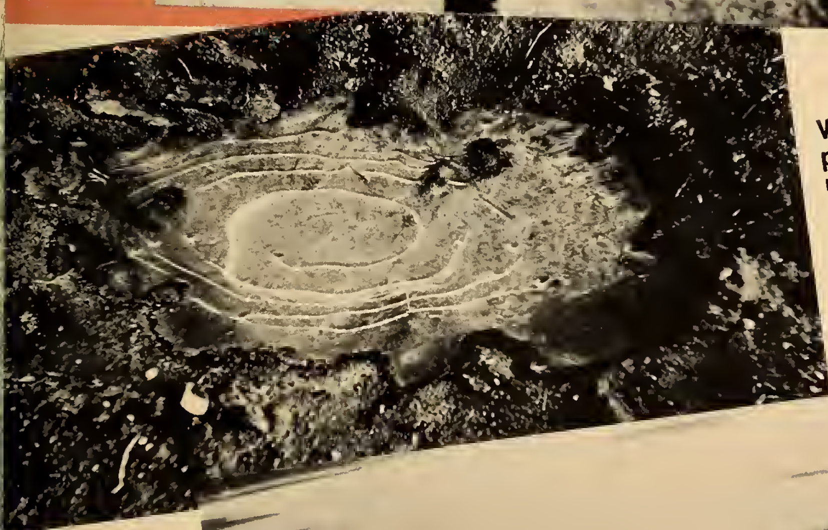
TALES TOLD BY TRAILS

Why does ice form first around plant stems?

How did these "ice ushrooms" form on he stream?

EXPLORING WINTER ICE

see page 4



Why is a frozen puddle often hollow underneath?

What made this ange pattern on the lake ice?

nature and science
VOL. 6 NO. 8 / JANUARY 6, 1969

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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 September, October, December through March, monthly November, April, May, 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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Did the people who first began living together in villages know that other villages existed? Here is how scientists found out by...

Tracin Prehistori Trad

■ The remains of some of the earliest villages formed men have been dug up in recent years by *archeologis* scientists who study how people lived in the past. Th villages were scattered about in the lands around t eastern end of the Mediterranean Sea *(see map)*.

When the remains were "dated" by the carbon- method *(see "Dating the Past,"* N&S, *September 16, 196* they showed that people were living in some of the villag as early as about 10,000 years ago. This was about 3,0 years before writing was invented, so the villagers left written records that might tell how they lived.

At the sites of the villages, however, archeologists fou the remains of simple gardening tools, pieces of grain, a the fossil bones and horns of sheep and goats. Some the goat horns were straight, like those of wild goats, a some were twisted, like those of today's domesticat goats. This showed that the early villagers had begun raise food plants—and perhaps even animals—in additi to getting food from wild plants and animals, as their a cestors had done for thousands of years.

The Question of Trade

Archeologists wondered, though, whether the people these ancient villages traded goods with each other whether they even knew that other villages existed. Af all, the villages were hundreds of miles apart, and ma were separated by mountains or water.

At the sites of the ancient villages, archeologists fou the remains of clay pots and of cutting tools made of c sidian, a hard volcanic glass that can be chipped li

This map shows the sites (•) of ancient villages in the Near East which scientists believe were trading with each other as early as about 10,000 years ago. The signs (◆ ◇ ● ○) under a village name show which types of obsidian were found in tools dug up there. The larger signs (◆ ◇ ● ○) show where each type of obsidian is found on or near the surface of the earth. The obsidian used in some villages must have come from at least 400 miles away.

int to sharpen an edge. The pottery and the tools found the different villages had all been made in much the ıme way, but that didn't prove that the people of the llages were in contact with each other. They might have ıade these simple objects the same way by chance.

It seemed likely that there was some trading between llages, though, because some of the villages were hun-eds of miles from places where obsidian is found, around ɔlcanoes. Three British archeologists decided to try to ıd a way to tell where the obsidian found in each village ıme from. They described their investigation in an article ıblished recently in *Scientific American* magazine.

ne Obsidian Test

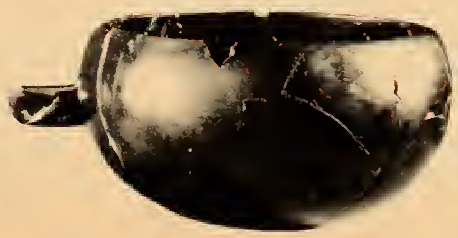
The scientists analyzed samples of obsidian taken from fferent volcanic areas. They found that obsidian from e same place contained the same amounts of the ele-ents barium and zirconium, while obsidian from different sources had different amounts of these elements.

Next they located places of volcanic activity nearest to the early villages, where the people could have found obsidian. They measured the amounts of barium and zirconium in the obsidian from each of those places and in the obsidian tools found at the village sites. This made it possible for them to figure out where the obsidian found at each site had come from originally. By matching the obsidian sources and the villages where the obsidian tools were found, the scientists found that obsidian had been carried across mountains, deserts, and water to the early settlements *(see map)*.

Now the scientists had proof that the ancient village-dwellers had traded with each other. But that's not all. Their discovery of a way to trace obsidian found in one place to the place where it was formed may help archeologists find answers to other questions about the travels of prehistoric men ■

Obsidian splits along curved surfaces *(see photo)*, so it is easily chipped to form a hard, sharp cutting edge.

This highly polished bowl carved of obsidian was dug up at the site of the village of Tepe Gawra *(see map)*.



Exploring Winter Ice

by David Webster

The ice that forms on a pond or lake keeps changing until it disappears. You can observe some of these changes and use a refrigerator to investigate how they take place.

Is the lake now freezing over, or unfreezing?

■ One of the strangest changes in nature is the freezing and thawing of a pond. In just a few days the blue water silently changes into a hard sheet of ice. In the spring, usually with equal suddenness, the water in the pond reappears. You can learn more about ice by watching a pond and by investigating what happens as water freezes.

The water in a pond reaches its warmest temperatures in late summer. The pond then begins to cool because of the colder autumn air. As water at the surface of a pond cools, it becomes more *dense* and sinks to the bottom of the pond. *(See "How Dense Are You?",* N&S, *September 30, 1968.)* To get an idea of how this happens, float an ice cube in a glass of warm water. Drop a little ink or food coloring liquid on top of the ice and watch how the cold, colored water moves in the warmer water.

From Water to Ice

In a pond, warm water from the bottom is pushed up to the surface by the colder water as it sinks. This natural circulation of the water is known as *pond turnover*. Animals that spend the winter sealed beneath the ice depend upon the air that is dissolved in the surface water that sinks to the bottom.

Water, like other liquids, "shrinks" and becomes more dense as it is cooled. But when it reaches a temperature of 39° F., a strange thing happens. The water begins to *expand,* and become less dense, when cooled below this temperature. Since ice forms when water is cooled to 32°, ice is less dense than water, and floats in it.

Look at an ice cube floating in a glass of water. How much of the ice is under water? Do you think that water is a lot denser than ice, or just a little bit? Salt water is more dense than fresh water. Does an ice cube float a lot higher in salt water than in fresh water? Make some salty water and find out. Can you find any liquids in which an ice cube will not float? Try milk, kerosene, alcohol, salad oil, and orange juice.

Have you ever noticed how ice cubes frozen in a metal tray have a little bump on the top? The bump forms be-

How might ice have helped to split this rock?

cause the middle of an ice cube freezes last. So the extra volume of the expanding ice is pushed up in the center. The force exerted by freezing ice is tremendous. It can break car radiators, water pipes, rocks, and even the concrete walls of a swimming pool.

Fill a bottle with water, cap it tightly, and put it outside on a cold night. Place the bottle inside a tall, empty fruit juice can or milk carton, because the expanding ice will probably break the bottle. Does it shatter into many little pieces, or just along one crack? Will a bottle of water break if it is left uncapped or if it is only partially filled? What happens to an unopened can of fruit juice, a water balloon, or an open bucket of water when the liquid freezes?

Study a Pond, Make a Lake

If there is a pond or lake near where you live or go to school, watch it as the weather becomes colder. You will probably see that the ice forms first next to the shore. One reason is that when the sun goes down, the soil and rocks along the shore lose their heat to the cooler air even faster than the water loses its heat to the air. This makes the water lose heat to the soil and rocks faster than it loses heat to the air.

Also, the water is shallow near the shore, so there is less water to cool there than at the middle of the pond. (Which cools faster, a bathtub full of water, or a glassful of water at the same temperature?)

In the early stage of freezing, a pond becomes rimmed by a paper-thin layer of ice. This usually occurs at night, during the first "cold snap." Should a strong wind develop the next day, the fragile ice might be broken up by waves and blown to the shore. Otherwise, the pond will freeze over completely if the cold weather continues. Why doesn't

If you get to a lake before it is completely frozen over, you will see that the ice forms first along the shore.

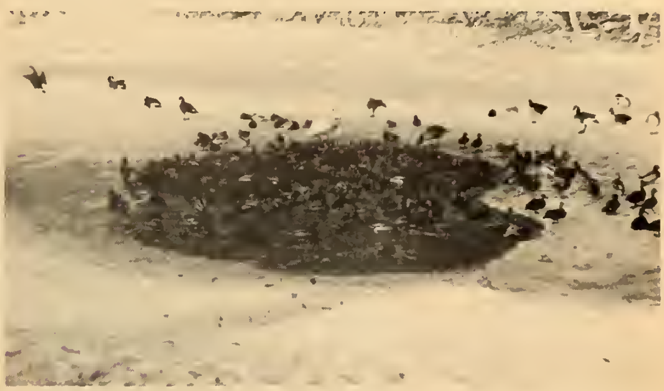
a bump form in the middle of the pond, as it does in an ice cube?

You can watch ice formation by making miniature lakes. Cover the bottom of a jar with water, then put it in the freezer and peek at it every 15 minutes. Where does the ice form first? Which freezes last, the water in the middle, or along the bottom? Why does the jar of water freeze in a different manner than a pond?

Will a large amount of water freeze as fast as a smaller amount? Try it and see. Large lakes usually require much longer to freeze than small ones. In the same town, you should be able to find open stretches of water in large bodies of water long after the smaller lakes and ponds are completely frozen over.

At what spots does the pond you are observing freeze last? One way to locate the deeper places in a pond or lake is to notice where the water freezes last. Ice formation is also slowed down by moving water; sometimes the water at a lake's inlet never freezes at all. As long as ducks continue swimming in the same place, the water around them will remain free from ice for a long time.

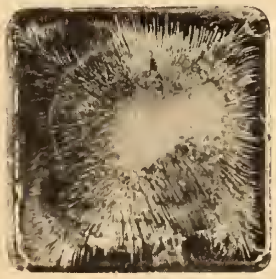
Why hasn't the water frozen in this river channel?



Are the birds gathered here because the water is unfrozen, or is the water unfrozen because the birds are gathered here? Or both?

Clear Ice, "Black" Ice, White Ice

The first ice that forms on a lake is usually clear. The ice may look black, though, because you can see through it to the dark water below. After a few weeks, clear ice on a lake usually turns into the more familiar white ice. How long does the clear ice remain on the lake you are watching? The milky color of white ice comes from tiny air bubbles that get frozen into it. The surface of the ice can become wet when some of the ice melts during a warm day.



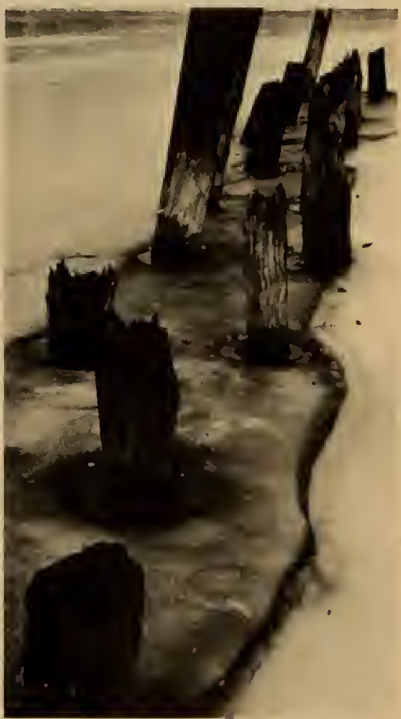
What made the pattern in this block of ice?

Then the meltwater turns into white ice when it is refrozen at night. Often snow that falls on the ice is later turned into slush by the sun and warm air. Also, decaying plants at the bottom of the lake give off gas bubbles that rise and become trapped under the ice. *(Continued on the next page)*

Look at an ice cube. What part of the ice contains most of the white air bubbles? As the water freezes from the outside, the air that it contains is forced into the middle. The air bubbles in the last water to freeze make the ice white. Can you make an ice cube that is completely clear? Probably not. (The clear ice served at restaurants is made in a can whose sides are cooled by a liquid at 10° F. Compressed air pumped through the center of the can bottom bubbles up through the water and out at the top. This keeps the water circulating past the sides of the can, where it gradually freezes. The core of white ice is removed from the cylinder of ice before it is cut up into clear cubes.)

The Ice Thickens

Unless snow falls on the ice, it grows thicker only from the bottom. The air temperature may rise above freezing during the day, warming the ice, and perhaps even melting the top layer. But as the air temperature drops below freezing during the night—say to 10°—the ice will gradually cool to 10°, and more water will freeze along the bottom of the ice.



Can you guess why the ice looks black around the pilings?

You might think that if the air temperature stayed below freezing long enough, the lake would freeze solid. But as the ice gets thicker, it takes longer for the ice at the bottom to reach the same temperature as the air. In time, the ice gets thick enough so that the cold air is never able to cool the bottom surface of the ice below 32°, and no more ice can form.

You can use a thermometer to measure the temperature of water as it becomes ice. Put a thermometer in a jar of water in your freezer. Record the temperature every 15 minutes. What do you notice about the temperature of the water once the ice begins to form? Does the ice ever reach the same temperature as the air in the freezer?

How thick does the ice get on lakes? Chop holes into the ice with an axe or hatchet. Is the ice thicker near the shore or in the middle? When you cut through the ice, how far does the water rise in the hole? *(Be sure to check with your parents before walking out on any ice, though, and always have an adult with you.)*

From Ice to Water

As the weather begins to warm up in the spring, the ice on a pond starts to melt quite rapidly. Most of the melting takes place at the bottom of the ice. Even though the water under the ice is just a few degrees warmer than the freezing point, it melts the ice more than the warm air above does.

Will an ice cube melt faster in cold water or in warm air? Get two ice cubes of the same size. Put one of them in a glass of cold water and the other one in an empty glass at room temperature. How long do you think it will take for each ice cube to melt? Watch and see. What would happen if the investigation were repeated in the refrigerator?

When the weather gets warm, the air bubbles in pond ice spread out in all directions, until the ice becomes completely honeycombed. The ice disappears first where it froze first—along the shore. (Can you guess why?) Soon all of the ice left becomes so weak that it begins to break up. Once this happens, the ice disappears as suddenly as it came. Ice that was once solid enough for walking on can disappear completely in a week ■

Does a crushed ice cube melt faster than a whole ice cube? Get two glasses of water and two ice cubes of the same size. Crush one ice cube by wrapping it in a cloth and hitting it with a hammer. Put the cracked ice in one glass and the whole ice cube in the other. Does the broken-up ice melt much faster? Why do you think ice cubes are sometimes made with a hole through them?

ANSWERS TO QUESTIONS ON THE COVER

- A plant stem loses its heat to the cold air faster than water loses its heat to the air. This makes the water lose heat to the plant stem faster than it loses heat to the air, so the water freezes first around the stem.
- The moving water melted the bottom layer of the ice on the stream. Then icicles grew down from the remaining ice, until they touched the stream. The stream water then refroze around the icicles.
- After a puddle has frozen over, the water remaining beneath the ice often sinks into the ground.
- A light snow fell on the lake ice. Then the snow melted around breaks in the ice where water could touch the snow.

Tales Told by Trails

by Dave Mech

Whether you live in the city or the country, you can study the lives of wild animals by following their tracks.

■ The best way to learn an animal's ways is to watch the creature. But that often is impossible. Many animals are active only after dark, and those that are active during daylight are usually too wary to let you near. This shouldn't stop you, though. Simply look for clues that might reveal their habits.

The most useful kind of clues are tracks. These show up best in mud, sand, dusty roads, and snow. You don't need to venture into the deep wilderness to find the tracks of wild animals. Within the limits of most big cities, you can discover tracks of such mammals as rabbits, squirrels, mice, opossums, raccoons, and skunks.

Look at Your Own Tracks

You already know at least one track—your own. First chance you get, take a look at your bare-foot print. How does it differ from the tracks of other animals? Right away you will notice that it is larger than almost any other track you will find. So you know that *size* can help you tell one kind of track from another.

Now compare your track with the track of a dog. You'll find at least three more important differences: (1) Your track is long, whereas a dog's is round. (2) The toes are all at the front of your track, but a dog's toes are on the front and side of the track. (3) A dog has only four toes. Remember differences in *shape,* for they will help you tell the tracks of one animal from those of another.

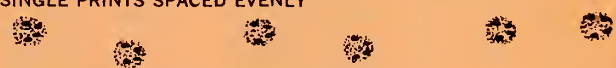
Before you can learn much more about tracks, you need some experience with different kinds. Winter is the best time to get this experience if you live in the northern states. (In areas without snow, you will have a harder time, but you can still study tracks in wet or dusty areas.) A day or two after a snowfall, go looking for fresh trails. Be sure to arm yourself with a ruler or tape measure, a notebook, a pencil, and perhaps a camera.

How To Study Tracks

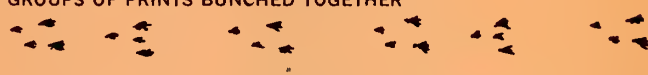
Fields, woods, vacant lots, and even your own backyard are good places to find tracks. Look around bushes, logs, trees, brush piles, and along fences or hedges. When you find a track, examine a single print. How long is it? How wide? How many toes does it have? Make a drawing of the print and jot down the measurements.

Then measure and sketch the spacing of the tracks. Is each print spaced evenly in a trail? Or are there two, three,

SINGLE PRINTS SPACED EVENLY



GROUPS OF PRINTS BUNCHED TOGETHER



or four tracks bunched together? How far apart are the groups? If you have a camera, put your ruler near the tracks and take a picture of them. Jot down a note about where and when you photographed them.

Make the same sketches, measurements, pictures, and notes for each different kind of track you find. Then you can compare them with the drawings on pages 8 and 9, or with tracks shown in books (*see listing at the end of this article*). You can best identify large tracks by looking at individual footprints. Smaller tracks can most easily be told by the pattern of their groupings.

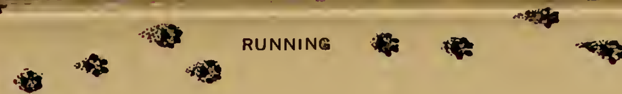
When you recognize most of the tracks in your area, your detective work has just begun—and so has the fun.

(Continued on page 10)

ON THE TRAIL OF A WOOZLE

Do you remember the story of how Winnie-the-Pooh and Piglet tracked the mysterious Woozle? As they walked around and around a clump of trees, they found more and more Woozle tracks ahead of them. What was the Woozle?

Four toes on all feet. Prints are 1½ to 2½ inches long. In walking, prints are in straight line, 12 to 18 inches apart. Sets of prints are 2 to 3 feet apart when running. Red fox has small toe pads; gray fox has larger, wider pads. Foxes have much hair on their feet, so toe pads may not leave marks.



Four toes on all feet; no claw marks showing. Prints are about one inch long. In walking, prints are 5 to 8 inches apart. Sets of prints are about 30 inches apart when running. The wild bobcat has prints about twice the size of a house cat.

Prints are about one inch long. Sparrows hop, leaving paired prints. Some other birds, such as crows, starlings, and pheasants, walk with prints in single file. Sparrows are perching birds; their side toes are not spread wide from the front toe.

Four-toed front prints are about ¼ inch long. Five-toed hind prints are about ½ inch long. Sets of prints are 3 to 6 inches apart when running. Tail sometimes leaves drag mark between prints.

STRIPED SKUNK

Five toes on all feet. Front prints are 1 to 2 inches long and show claws clearly. Hind prints are 1½ to 2½ inches long and seldom show claws. Sets of prints are 6 to 12 inches apart when running.

DOG

Four toes on all feet; claw marks showing. Prints vary greatly in size, depending on the kind of dog. Cocker spaniel prints are about 2 inches long; Alaskan husky prints, 4 inches long. Distance between prints when walking and running also depends on dog's size.

PIGEON

Prints are about 2 inches long. The side toes are spread wide from the front toe, since pigeons do more walking than perching. Wing marks are sometimes left on snow when a bird flies from the ground.

MEADOW MOUSE

Four-toed front prints are about ½ inch long. Five-toed hind prints are about ⅝ inch long. Sets of prints are about 3 to 9 inches apart when running. Meadow mice often tunnel under snow.

LONG-TAILED WEASEL

Weasels have five toes on all feet but the fifth toe seldom shows in prints. Front prints are about an inch long. Hind prints are about 1½ inches long. Sets of prints are 12 to 22 inches apart when running, and hind prints often land in front footprints. Tail sometimes leaves drag mark.

WHITE-TAILED DEER

Pointed prints are about 2¾ inches long. In walking, hind feet are often placed on top of front footprints. Deer can leap from 10 to 22 feet. Dewclaws, which are small unused "claws" behind the hoofs, sometimes show when foot sinks deeply into snow or mud.

GRAY SQUIRREL

Four-toed front prints are about one inch long. Five-toed hind prints are 2 to 2½ inches long. Sets of prints are 20 to 24 inches apart when running.

COTTONTAIL RABBIT

Claws and toe pads seldom show because of hairy feet. Front prints are about one inch long. Hind prints are 4 to 5 inches long. Sets of prints are 1 to 7 feet apart when running.

WHO GOES THERE?

A GUIDE TO ANIMAL TRACKS

RACCOON

Five toes on all feet. Front prints resemble hands and are 2 to 3 inches long. Hind prints are 3 to 4 inches long. In walking, sets of prints are 12 to 30 inches apart. Sets of prints are 2 to 3 feet apart when running.

■ The drawings on these pages show the tracks and trails of 16 animals that are common throughout most of the United States. When you find an animal's track, take notes on its size, shape, the number of toes, and the pattern of footprints in the animal's trail. Then compare your observations with these drawings.

Remember that the size, shape, and clearness of tracks vary with snow or ground conditions. Tracks are distorted when snow thaws, and tracks made in fluffy snow or loose sand are not as clear as those shown here. The diagrams show both front and hind prints if they differ very much. Otherwise, just one print is shown. The captions tell the distances between footprints, or between sets (groups of all four prints) when the animal is walking or running ■

GULL

Prints are about 3 inches long, and about 4 inches apart when walking. Webbed feet (for swimming) are similar to those of ducks, geese, and swans.

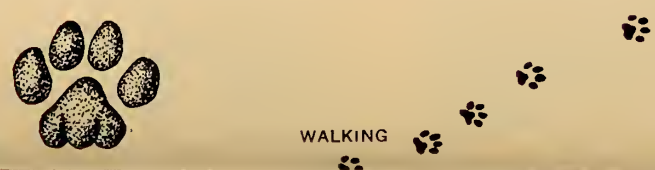
RAT

Front prints are like four-fingered hands. Five-toed hind prints are about 1½ inches long and have long heels. Tail sometimes leaves a drag mark between prints. In walking, sets of prints are 3 to 4 inches apart. Sets of prints are 7 to 12 inches apart when running.

GRAY FOX

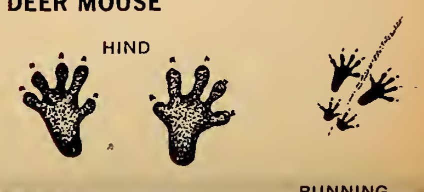
RED FOX

HOUSE CAT



SPARROW

DEER MOUSE



Tales Told by Trails (continued from page 7)

The next step is to follow a set of tracks. That is the way you learn about how an animal lives—how it gets its food, what it eats, where it lives, how far it travels, and so on.

One very important rule to keep in mind when tracking is never to step on the tracks. You may have to examine them again. I learned this from a cottontail rabbit I once followed. After I had tracked it for several minutes, the track suddenly ended. I had almost decided that the rabbit had sprouted wings when I thought of another answer. Perhaps it had turned around and gone backwards on its own track.

Upon looking at the rabbit's trail, I found it all scuffed out by mine. I couldn't tell whether or not it had back-tracked. But by watching carefully along both our trails, I found where the rabbit had taken a long leap off to one side. Then it had continued on its way. As I kept on the trail, the rabbit did the same thing six times. But I had learned, and was able to figure it out each time.

After you track an animal a little way, you may notice that its pace changed. Try to figure out what the animal was doing. A good way to get clues about its pace is to study your own tracks again. First walk for several feet. Then hop. Then run at different speeds. Notice how different your tracks look each time. To imitate a rabbit or squirrel track, lean forward and put your hands into the snow. Then hop, using your hands for leverage and bringing your feet around in front of them. Remember how the track looks, for it will help you tell which way a rabbit or squirrel track is headed. Usually their hind footprints are ahead of their front footprints.

A RABBIT'S HIND FEET LAND AHEAD OF ITS FRONT FEET

When you are tracking an animal, take notes on how far it travels, what kind of living place, or *habitat,* it uses (fields, woods, swamps), and what it eats. If you can follow it a long way, draw a map of its travels. Try to figure out why it goes where it does. If you find its den, note whether it is a hole in the ground, a hollow log, a tree, or what. Keep notes on where it is so you can come back and track the animal again.

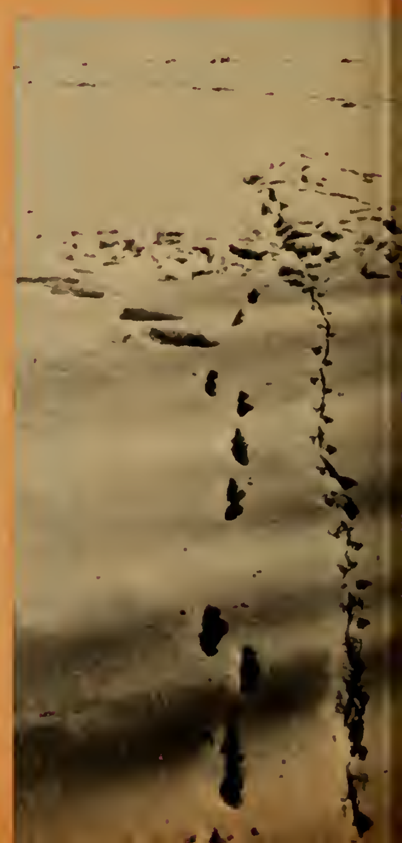
This is exactly the method that scientists sometimes use to study the lives of animals. For instance, some biologists in Michigan followed over 2,000 miles of fox trails. They kept track of everything the foxes ate. Their findings surprised those people who thought that foxes eat mostly game animals, such as pheasants and rabbits. In one study, the foxes were trailed for 577 miles and killed only three pheasants in that distance. In another area, they killed only five rabbits, two quail, and one hare in over 1,000 miles. Both studies showed that the foxes' main food was mice, shrews, and *carrion* (dead animals).

Solving a "Whodunnit"

Probably the peak of your tracking career will come when you figure out a "Whodunnit"—a group of tracks where one animal chased, caught, and killed another. I saw such a set of tracks last spring (*see photo*). A fox had come upon a fresh muskrat track and followed it. Where the fox caught up to the muskrat there was blood and sign of a scuffle. Only one track left the area—the fox's.

There is much more to learn about tracking. With experience you will learn to tell an old track from a fresh one. You can learn to predict where certain animals will cross roads, streams, and valleys. But these things take experience, and there's only one way to get that. Put on some warm clothes and go look for some tracks. And don't forget your notebook and pencil ■

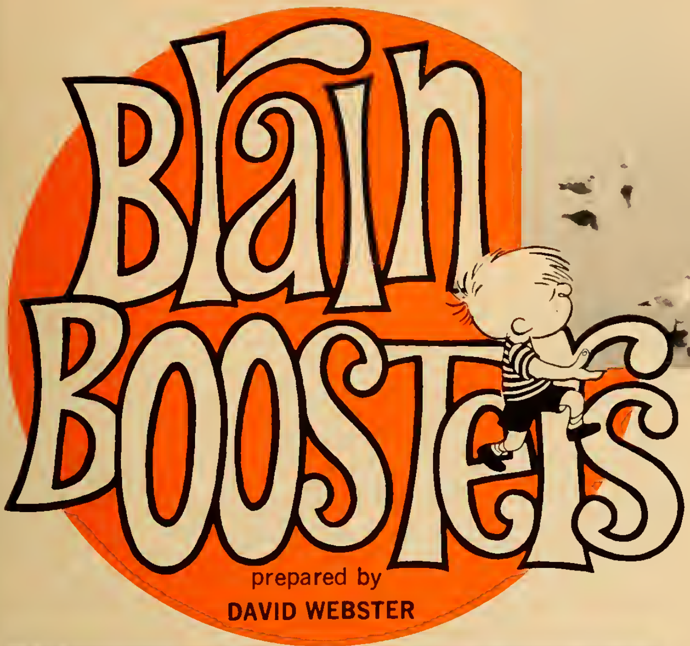
Look in a book store or library for these books on animal tracks: The most complete book on tracks and other animal signs is **A Field Guide to Animal Tracks,** by Olaus Murie, Houghton Mifflin Co., Boston, 1954, $4.50; a mammal identification guide that includes track information is **A Field Guide to the Mammals,** by William H. Burt, Houghton Mifflin Co., Boston, 1952, $4.50; also look for **Animal Tracks and Hunter Signs,** by E. T. Seton, Doubleday & Co., Inc., New York, 1958, $3.95; **Animal Tracks,** by George F. Mason, William Morrow and Co., New York, 1943, $2.75; **Field Guide to Animal Tracks,** The Stackpole Co., Harrisburg, Pa., 1958, $1.50.



The tracks on the left side of this photo are those of a fox, running parallel to the trail of a muskrat. Between the muskrat's footprints is a mark left by the animal's dragging tail. The muskrat's trail ends in the maze of tracks at the top of the photo. (The large footprints crossing the photo were made by the author.)

MYSTERY PHOTO

How can sea gulls stand on water?



WHAT WILL HAPPEN IF . . .

. . . you freeze a jar of water that has an ice cube floating in it? Can you see the ice cube after all the water has turned into ice? *Submitted by Darlene Critchfield, Arlington, Virginia*

CAN YOU DO IT?

Put 5 teaspoons of cornstarch into a cup. Into another cup, put 4 teaspoons of cornstarch and 1 teaspoon of baking soda. Now have someone shuffle the cups around so you don't know which is which. Can you make a test to tell which cup contains the baking soda? (You probably won't be able to taste any difference.)

FUN WITH NUMBERS AND SHAPES

Each of these three shapes measures the same length around the outside. Do all three shapes have the same amount of space inside them?

FOR SCIENCE EXPERTS ONLY

When I put my hand under cool running water from a faucet, the water feels cold. But when I drink the same water, it feels much warmer. How can this be?

Submitted by Skip Williams, Pittsburgh, Pennsylvania

JUST FOR FUN

Pour a little vinegar into a jar and drop in a number of different materials. Try a rock, a penny, a piece of chalk, a seashell, and some salt. The vinegar should be shallow enough not to cover up the materials completely. Look into the jar each day and see what changes occur.

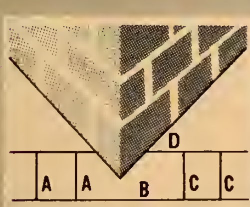
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The icicle formed under the roof of the house, where the wire is attached. When the weather became warmer, the icicle broke away from the roof and slid down the wire.

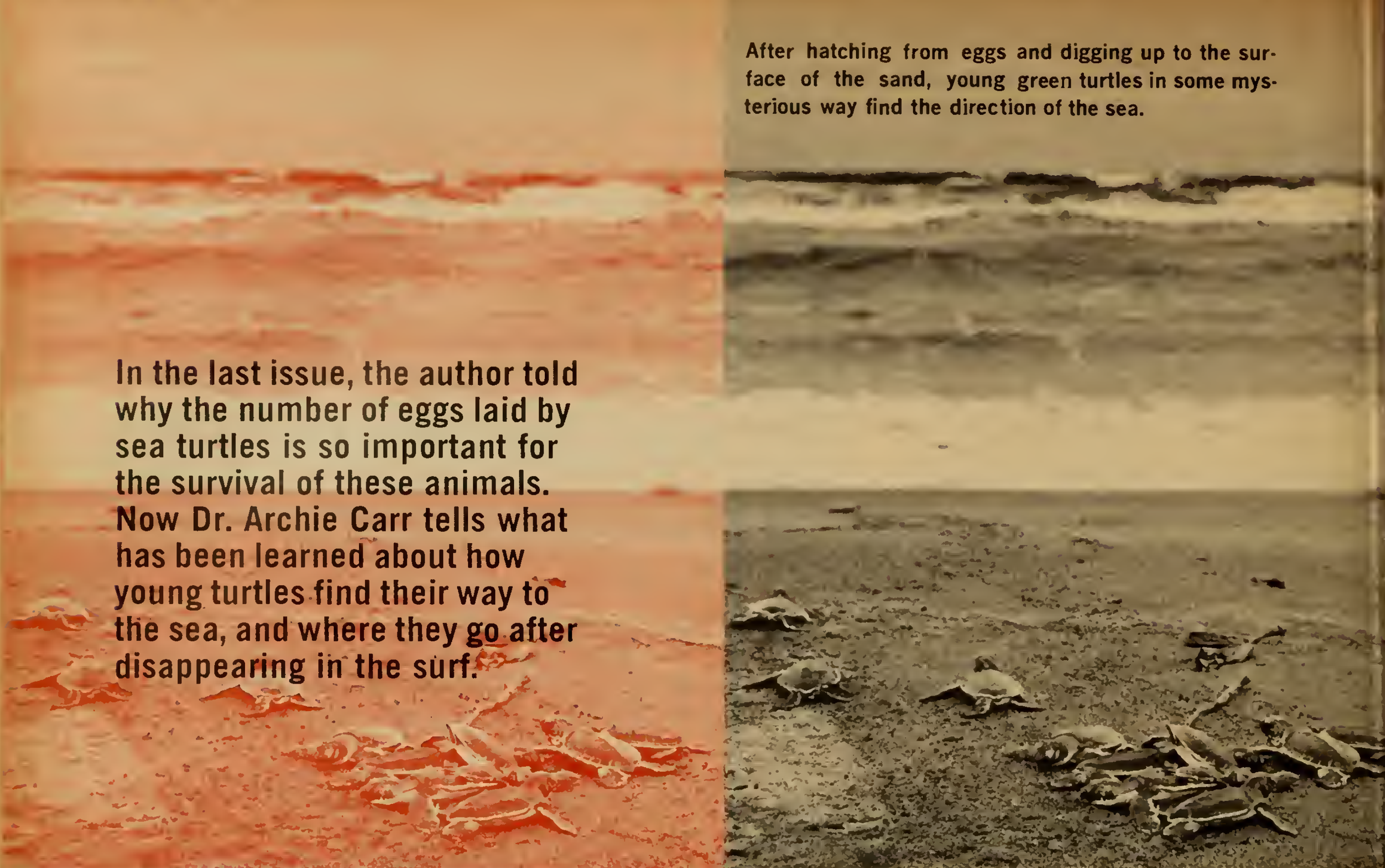
What would happen if? Block 3 would slide off the turntable first, followed by block 1. If block 2 were in the exact center of the turntable, it would never slide off. What would happen if marbles were used instead of blocks?

Can you do it? It is impossible to "float" a needle on soapy water. Soap weakens the surface tension of water so that it will not support a needle *(see " 'Surfing' to Safety,"* N&S, *October 14, 1968).*

Fun with numbers and shapes: The diagram shows a way to draw the broken line without making any measurements. First draw two equal lines *(A in diagram)* at right angles to the ditch. Connect the ends of the lines with a long line (*B*) that goes past the corner of the house. Then draw two lines (*C*) that are at right angles to line *B* and are the same length as lines *A*. Draw a line (*D*) through the ends of lines *C* to mark the place where the rest of the ditch should be dug.



For science experts only: The position of the fly in the train car will not change as the train stops. The fly is "cushioned" by the air in the car as the air gradually comes to a stop with the train.



After hatching from eggs and digging up to the surface of the sand, young green turtles in some mysterious way find the direction of the sea.

In the last issue, the author told why the number of eggs laid by sea turtles is so important for the survival of these animals. Now Dr. Archie Carr tells what has been learned about how young turtles find their way to the sea, and where they go after disappearing in the surf.

HOW DO TURTLES FIND THE SEA?

BY ARCHIE CARR

■ Two mysteries about green sea turtles are how the newly-hatched turtles find the sea, and where they go after they enter the surf. The trip to the water begins when the turtles break out of the nest buried in sand on the beach. The nest may be in full view of the sea. More likely, however, the nest is located so that the baby turtles, or *hatchlings*, see nothing but sand and sky.

The little turtles have to find the water, and unless they are eaten they nearly always do. They come out of the nest and, almost at once, begin to crawl in the general direction of the sea. They move around, through, or over obstacles. They go up or down hills, sure of whatever sign it is that marks the ocean for them. They can find the ocean by daylight or at night, in all weather except heavy rain, with the sun or moon hidden or shining brightly in any part of the sky. Their main guiding sign is still a mystery.

Clues Along the Beach

Although sea-finding seems to involve light, it is not a simple urge to move toward light. Otherwise the hatchlings would go toward the sun or moon, which they only rarely do. Sometimes they do get led astray by an arti-

This article is adapted in part from the book, So Excellent a Fishe, *by Archie Carr, published by The Natural History Press, Garden City, N.Y.*

ficial light, or by some strong patch of natural light such as from a hole in the clouds. Most often, however, they move surely toward the water, no matter what the condition of the sky may be.

After they leave the soft sand behind and reach the hard beach, there are other signs to guide them, such as the white foam of waves breaking on the beach. At night a lantern set beside the direct path to the water often draws a train of hatchlings toward it. By day a shiny or white object may do the same.

The hardness and smoothness of the ground may cause the turtles to move faster for a moment. If a log blocks the way they move along it to the end, and then turn to the sea again. No normal feature of a beach keeps the turtles from following the main sea-finding signal, whatever it may be.

Several zoologists at the University of Florida, at Gainesville, set out to discover how the turtles find the sea. We learned that when hatchlings were blindfolded, they could not find the water. This seemed to prove that the turtles needed their eyes for finding the sea. In another test, we took some hatchlings just before they came out of a nest on an island in the Caribbean Sea. We flew them to the Pacific shore. There we allowed them to come out of an artificial nest back in the dunes. They went directly to the strange ocean, even though it was completely hidden from their sight.

More tests were needed to find out what turtles see on beaches, and what kinds of light they need to help them find the sea. Dr. David Ehrenfeld, now Assistant Professor of Zoology at Barnard College in New York, began a series of experiments in which he put eye glasses with changeable lenses on adult turtles *(see photo).*

The lenses for the glasses were colored to let through light of one of the colors that make up white light. A lens that let in only green light seemed to make no difference at all in the ability of the turtles to find the water. Lenses that let in only blue light caused a little trouble, but those that let in only red light seemed to make it very hard for the turtles to find the water. It seems that there is something about green and blue light that tells a turtle the direction of the sea. Or, maybe turtles just see better in green and blue light.

By Land or by Sky?

Later, Dr. Ehrenfeld wanted to find out whether turtles were using certain colors of light from the sky, or the outline of the land, to guide them to the sea. He made a round testing area 42 feet across, surrounded by a wall 18 inches high. The wall and some palm trees planted in the area hid details of the surroundings from turtles inside the circle, without blocking the light from the sky.

At different times of the day and night Dr. Ehrenfeld used a device called a *spectrophotometer* to measure the amounts of red, blue, and green light coming from the sky over the sea and land. Then he released hatchlings in the center of the testing area and watched to see the directions they chose. The spectrophotometer showed no differences between the light in the sky over the sea and that over the land.

The turtles in the walled area had trouble finding the right way to the sea. Some of them headed inland. Many did not bother to move at all. Later the wall and trees were removed. When other young turtles were put into the testing area, most of them headed directly for the sea, even though it was not visible. *(Continued on the next page)*

By putting special eyeglasses on sea turtles, Dr. David Ehrenfeld tried to discover if some color of light helps the turtles to find the direction of the sea.

Young green turtles are colored dark above and light below. This coloration may protect them from enemies as they drift and feed near the surface of the ocean.

How Do Turtles Find the Sea? (continued)

So it seems that whatever sign guides turtles to the sea, it is not located high in the sky, but low over the horizon. We still don't know for sure whether it is the color of light, or the outline of the land, or something else that guides them. Only further study may solve this mystery.

Where Have All the Turtles Gone?

Another puzzle is the disappearance of young sea turtles for their first year of life. At most of the known nesting grounds, the water in front of the beach is an unfit living place for the hatchlings. I haven't been able to find them there at any time after the hatching season. They must move farther out to sea.

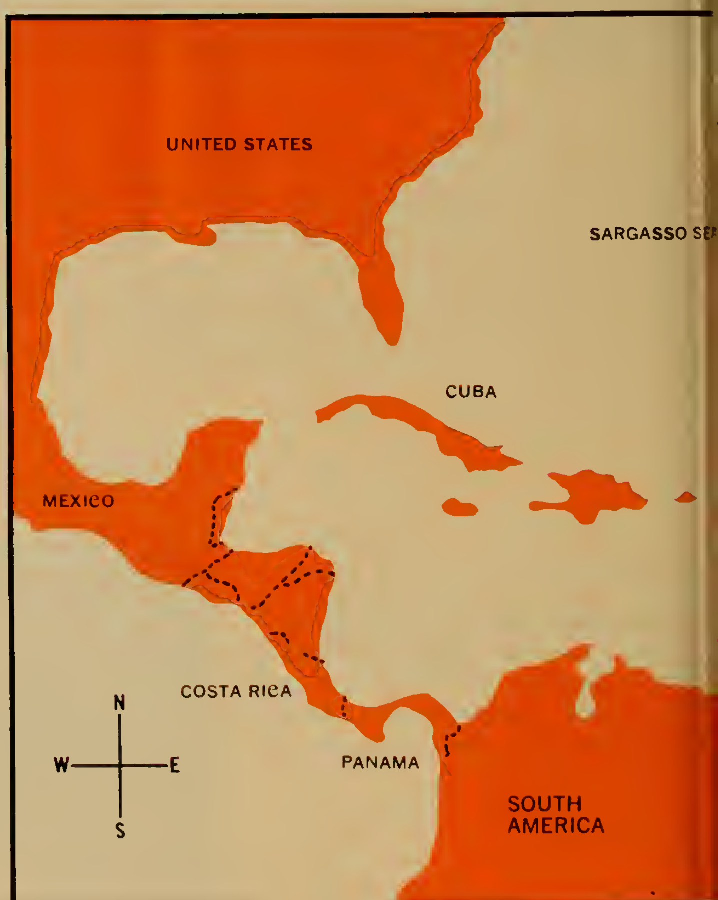
Other facts agree with that idea. The coloring of the young green turtle is like that of fish that live in the open ocean: dark above and white below *(see photo)*. The white underparts make the turtle less visible to an enemy seeing it from below against the sky, while the dark back mixes with the dark depths of the water to hide the turtle from birds overhead.

The most likely idea to account for the disappearance of the little turtles seems to be that they drift in the open sea for a time. If this is so, the turtles must be picked up by currents along the shore and carried wherever the currents go. The trouble with this idea is that nobody knows where the currents go.

The search for the hatchling turtles goes on. The smallness and weakness of young turtles' jaws must keep them in places where they can find plenty of small, soft-bodied animals for food. In tanks no more than two or three feet deep, they feed equally well at the bottom or at the surface. In deeper water, however, they have trouble finding and working with food on the bottom. Perhaps the young turtles live at the surface in some part of the sea where there is a sure supply of floating food.

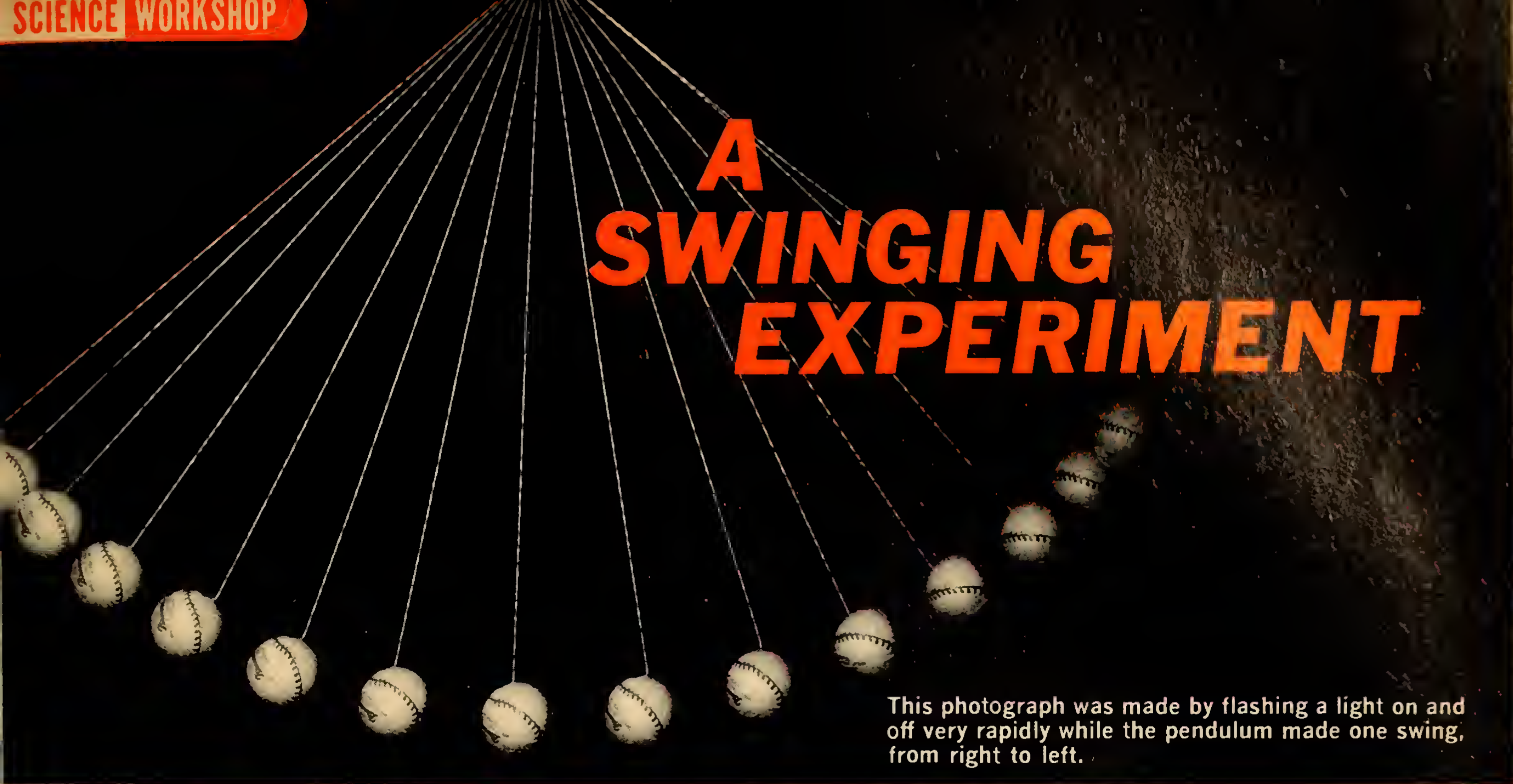
There is only one place I can think of where, at the surface of the open ocean, there might be food that baby turtles could find and eat. That place is in the North Atlantic in the Sargasso Sea *(see map)*, which is filled with sargasso weed, a type of brown algae. It is estimated that 10 million tons of sargasso weed float in that part of the ocean. Many animals live among the weeds and perhaps young sea turtles find their food among them.

But I have never been able to find a place, or anybody who knew of a place, where young sea turtles could be caught. Wherever it is that hatchlings seem to lose themselves, they cannot really be lost. They are just in some place that hasn't been thought of by zoologists. Until that place is found, there will be another big mystery in our understanding of the lives of sea turtles ■



The young turtles disappear after they enter the sea along the eastern coast of Central and South America. They move far out into the ocean, perhaps to the Sargasso Sea.

A SWINGING EXPERIMENT



This photograph was made by flashing a light on and off very rapidly while the pendulum made one swing, from right to left.

■ If a 100-pound ball and a 1-pound ball are dropped from the same height at the same time, will one hit the ground before the other?

Some scholars of ancient times said that the heavier object would be pulled to the earth faster than the light object. There is no evidence that any of these scholars tried dropping weights to see what happens. Some said that objects fall too fast for the eye to follow them. Do you think this is so? Try it and see.

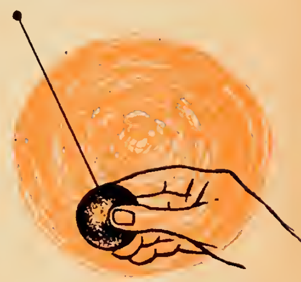
Centuries later, in the 1600s, the Italian scientist Galileo thought of another way to investigate falling objects. One story is that he got the idea as he watched a hanging lamp swing back and forth on its chain, after someone had pulled the lamp to one side to light the candles.

As you might expect, the distance the lamp moved from one side to the other got shorter with each swing. But Galileo noticed that it took the same length of time for the lamp to swing from one side to the other, no matter how far it traveled during each swing. He also saw that during the downward part of each swing the lamp was falling, even though the chain kept it from dropping straight downward, as an unattached object falls.

Galileo reasoned that if a heavy object falls faster than a light object, as the ancients said, then a heavy lamp should swing faster than one of lighter weight. You can test this idea, as Galileo did, by making a *pendulum*.

Swinging Your Weight

Tie or tape an object about as heavy as a golf ball to one end of a string about three feet long. Tie the other end of the string to a wall hook or floor lamp so the weight can swing back and forth freely. Make the knot at the bottom of the hook and tie it tightly, so the string won't turn around the hook as the pendulum swings.



Keep the string stretched straight as you lift the weight part-way up *(see diagram)*. Then let go and watch until the pendulum stops swinging. You can see that each swing is shorter in distance than the swing before it. Does a short swing seem to take any less time than a long swing?

Use a watch with a second hand to measure how many seconds it takes your pendulum to make 10 full swings. (A full swing is from one side to the other and back again.) With this measurement, how can you figure out how many seconds it takes for just one full swing?

Now attach a heavier weight to the string and time 10 full swings. Also try a lighter weight. Do you think the weight of a pendulum makes it swing any faster or slower?

What do you suppose Galileo decided about the falling speed of heavy objects and light objects? ■

INVESTIGATION

Before Galileo died he designed a way to use a pendulum to regulate a clock. The pendulum took one second for each full swing. Can you think of a way to change your pendulum so that it makes one full swing each second? Two full swings? Try it and see.

WHAT'S NEW

by
B. J. Menges

20 million gray squirrels went on the move last fall, deserting their homes in North Carolina, Tennessee, Georgia, and Missouri. Apparently it all started the previous fall, when there were plenty of nuts and acorns for the squirrels to store for winter. As a result, more squirrels than usual survived the cold weather. Last spring they produced a very large number of young.

That same spring, frost struck nut-bearing trees, killing many flowers that would have developed into nuts and acorns. Last fall, when the squirrels started to gather nuts again, they discovered there would not be enough food to last through winter. Searching for food they could store, the squirrels moved farther and farther from their nesting areas, and many thousands of them died as they tried to cross highways, rivers, and lakes.

Get out of town! This is the warning some physicians are giving to residents of Los Angeles, where smog has become a major health hazard. The smog forms when sunlight shines on smoke, gases, and other pollutants produced mainly by automobiles and industry (*see "What's New?"*, N&S, *September 16, 1968*). Cars alone pour over 12,000 tons of pollution into the air over Los Angeles each day. Once formed, smog often blankets the city for days at a time, trapped between sea breezes from the west and mountains to the east. The smog irritates the sensitive linings of people's noses, throats, and lungs, and also damages plant life over a wide area.

To reduce smog, Los Angeles forbids industry to use certain fuels, regulates the burning of rubbish, and requires that late-model cars be equipped with pollution control devices. Even so, there is still about as much smog as there was 10 years ago. If pollution controls had not kept up with the increasing amounts of pollution produced by the city's rising population, it might now be impossible to live in "The City of Angels."

Painless injections are helping in the worldwide fight against smallpox, malaria, and other diseases that spread rapidly. The injections aren't given with hypodermic needles. Instead, vaccine is injected with a new type of spring-powered "gun." When the spring of the gun is compressed and then released, it shoots the vaccine through a tiny hole in the gun at a speed of 700 miles an hour. The stream of liquid pierces a person's skin so fast that he feels no pain at all.

Since the injections are painless, people are less fearful of being inoculated. And because the device works quickly and economically, millions of people throughout the world can be protected at low cost.

The world's tallest tree has been saved. This 385-foot redwood, recently discovered in California's Redwood Creek Valley, seemed destined for the lumberman's saw. But conservationists have now won a long, hard battle to create Redwood National Park in northern California. The second, third, fourth, and seventh tallest trees so far discovered are in the same forest.

Lumber companies have already leveled many redwood forests. Only 250,000 acres of unspoiled redwoods are left where there were once two million acres of the trees. Even though the new national park includes 32,500 acres of redwoods in its 58,000-acre area, many more trees should be saved. If the present rate of lumbering continues in the remaining redwood forests, the trees that took many centuries to reach their majestic heights will be gone within 20 years.

One of the strangest families in the animal kingdom has been discovered in Israel. This is the family of a species of hornet called *Vespa orientalis.* At the first stage in their development, these insects come out of their eggs as grubs, or soft, plump, wormlike *larvae.* They eat insects and other animal food brought to the nest by the adult hornets. As the grubs chew this food, saliva drips from their mouths. The adult hornets sip the saliva.

The adults themselves cannot digest the foods they bring to the nest, according to Israeli scientists. But the saliva of the grubs changes these foods into a form that the adults *can* digest. Without the grubs, the adults would starve. This seems to be the only known case in the animal kingdom where the lives of the adults depend on the young.

If skis always came off the instant a skier fell, there might be 20,000 fewer skiing injuries each year, according to Dr. Lawrence D. Sher, an Assistant Professor of Biomedical Engineering at the University of Pennsylvania, in Philadelphia. Skis that remain fastened when a skier falls often get tangled and act as levers, pushing or twisting his legs. Many skiers fasten skis to their boots with a spring binding that is supposed to unfasten when the pressure from the boot suddenly changes, as in a fall. But this doesn't always work, often because the skier has tightened the binding too much, in fear of losing his skis on a downhill run.

Dr. Sher has enlisted a group of volunteers to ski this winter with electronic devices on their boots that will measure the forces the boots exert on their bindings during skiing maneuvers. With that information, Dr. Sher believes, an "ideal" ski binding can be designed—one that simply fastens or unfastens, so it can't be overtightened, and always unfastens immediately in a fall.

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

Whether it proved anything is another question.

Suggestions for Classroom Use

After your pupils have offered their answers to the question beginning the article, have them drop two objects of different weight at the same time from the same height, and try to discover by sight or sound whether both land at the same instant. Try light and heavy books, a book and a pencil, a basketball and a golf ball, and a golf ball and a ping-pong ball, for example. Have them drop the objects while standing on the floor, standing on a chair or table, and standing at the top of a stairwell.

Sometimes the objects may seem to land at the same time; other times they may not. Could some force other than the pull of the earth's gravity be affecting the fall of one object more than the fall of another? Your pupils will probably suggest that a basketball is pushed upward more than a golf ball is by the air they fall through *(see "Discovering an 'Ocean' from the Bottom,"* N&S, *Nov. 11, 1968).* They can test this idea by dropping two sheets of paper, one flat, the other wadded into a ball. Both are the same weight, and the air pushes against each square inch of each object with equal force; but the flat sheet has more square inches of area for the air to push upward against.

A golf ball and a ping-pong ball are nearly equal in area. So when they are falling at the same speed the air pushes upward on both with nearly equal force. But the golf ball's greater *mass* (the amount of material making it up) makes it resist the air's upward push more than the ping-pong ball resists it.

By this point, your pupils will probably be anxious to try Galileo's pendulum experiment, which can easily be done at home or in school. They will probably find, as Galileo did, that neither the weight of a pendulum nor the distance it swings changes its *period*—the period of time it takes to swing from one side to the other and back again.

Topics for Class Discussion

- *Why does a pendulum fall in a curved path instead of straight down?* The earth's gravity is pulling the unattached end of the pendulum downward, and the hook is pulling the pendulum toward the hook. (Have your pupils try to draw a straight line from the top to the bottom of a sheet of paper while someone pulls the sheet sideways.) The pull of the hook doesn't slow the fall until the pendulum is directly below the hook.
- *Does a pendulum move at constant speed throughout its swing?* It starts falling from a dead stop, moves fastest at the bottom of its swing, then slows gradually until it stops rising and begins to fall back down again. So your pupils can probably guess that it moves faster and faster as long as it is falling.
- *How does a pendulum complete a long swing in the same time it completes a short swing?* The longer the pendulum falls, the faster it is moving at mid-swing, and the farther it will go in the same time it took to make a shorter swing.
- *What makes an object fall?* For convenience, we usually say it is the force of the earth's gravity pulling the object toward the earth's *center of mass (see "Balancing Point,"* N&S, *Nov. 13, 1967, page 2T).* Actually, though, the earth and the object are *attracted,* or pulled, toward each other by a force called *gravitational attraction.* This force exists between any two objects, and the closer they are, the stronger the attraction between them. (This is why an object moves faster and faster the longer it falls toward the earth.)

The greater the mass of two objects, the stronger the gravitational attraction between them. It is stronger between the earth and a heavy object than between the earth and a lighter object. However, the greater the mass of an object, the more resistance it offers to a force that tends to change its motion, and this resistance cancels the extra attraction between the earth and a heavy object. Dropped simultaneously from the same height, a light and a heavy object will accelerate at the same rate and will land at the same instant unless one is slowed up more than the other by air pressure.

Brain-Boosters

Mystery Photo. Sea gulls, of course, cannot stand on water. The birds in the photograph are standing on smooth ice. At the upper-right-hand corner of the photo, near the retaining wall, you can see where the ice has been broken.

What will happen if? After your pupils have tried to guess what will happen when you freeze a glass of water that has an ice cube in it, encourage them to try it at home and see. The ice cube will still be visible in the glass of frozen water.

Can you do it? Your pupils can obtain the materials necessary for this problem at home, or you can provide small amounts of cornstarch and a cornstarch-and-baking soda mixture in plastic bags. See how many pupils can make the correct identifications and explain to their classmates how they did it.

The best way to find out which cup has the baking soda is to add some vinegar to both cups. Vinegar makes baking soda give off carbon dioxide, and you will be able to see the gas bubbling through the vinegar in the cup that contains baking soda.

You might challenge your pupils to determine which of two cups of cornstarch contains other "mystery powders," such as powdered milk, confectioner's sugar, plaster of Paris, salt, or flour. In many cases the presence of the mystery powder can be ascertained by taste, smell, color, or feel. *(Caution the children against tasting any "mystery mixtures" of their own concoction without first asking an adult.)*

Fun with numbers and shapes. A circle always encloses a greater area than any other *plane,* or two-dimensional, geometric figure of the same length around (perimeter). Similarly, among *solid,* or three-dimensional figures, a sphere encloses a greater volume than any other figure of the same surface area.

For science experts only. Different parts of the body vary in their sensitivity to heat. Water usually feels

(Continued on page 4T)

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

warmer to the mouth than to the hand.

It is possible to change temporarily the heat sensitivity of parts of the body. An easy way to demonstrate this is to set up a pan of cold water and a pan of moderately hot water, with a pan of lukewarm water in between. Place one hand into the cold water and the other into the hot water, and keep them there for a minute or two. Then transfer both hands to the lukewarm water simultaneously. The lukewarm water will feel relatively warm to the hand that has been in the cold water, and cool to the hand that has been in the hot water.

Just for fun. Vinegar releases carbon dioxide from lime (calcium carbonate) just as it does from baking soda (sodium bicarbonate). Chalk, a seashell, and a limestone rock all contain lime, so a bubbling reaction will be seen if they are placed in vinegar. Let your pupils drop other materials into the vinegar and see whether they can find another substance that probably contains lime.

Books That Will Help You . . .
(continued from page 1T)

of the wealth of material contained in this bulletin is found on page 8—"Clue Words," a categorizing of 98 verbs describing activity connected with science learning.

Ideas for Science Investigations, by Victor M. Showalter and Irwin L. Slesnick (1966, 58 pp., $2.25, Stock Number 471-14500). Although this booklet was designed primarily for use by high school students, it can be of invaluable help to teachers, too. Part One presents suggestions for use of the book. Part Two shows how three high school students developed individual investigations into the same natural phenomenon, the rise of sap in plants. Part Three contains suggestions and sample questions for another kind of investigation. Part Four is a guide to references that can be of help in conducting any science investigation. The entries have been limited to those that are known to be of value.

Investigating Science with Children Series (set of six volumes, 1964, $13.50, Stock Number 478-14280). Vol. 1, Living Things; Vol. 2, The Earth; Vol. 3, Atoms and Molecules; Vol. 4, Motion; Vol. 5, Energy in Waves; Vol. 6, Space. These handbooks have the distinguished sponsorship of two leading groups concerned with the improvement of science teaching: NSTA and NASA (the National Aeronautics and Space Administration). Each book in the series is concerned with a single area of science and moves from simple concepts to more complex ones within each chapter, so any teacher, at any grade level, should find that all of the books contain usable material.

The question-discovery approach is used, and although the activities and learnings are purposely not graded, they are designated for difficulty by an *x*, *y*, or *z*. All six volumes are filled with helpful illustrations, and each chapter concludes with a summary of the main ideas that have been developed. Throughout each book, cross-references are made to activities and science content found in the other books in the series.

To ensure accuracy, leading scientists were asked to read and review the content concerning their respective fields during the preparation of the manuscripts. But there are no final answers in these books. Let the series be thought of as a challenge to further learning.

nature and science
TEACHER'S EDITION
VOL. 6 NO. 9 / JANUARY 20, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Life at the Top of the World

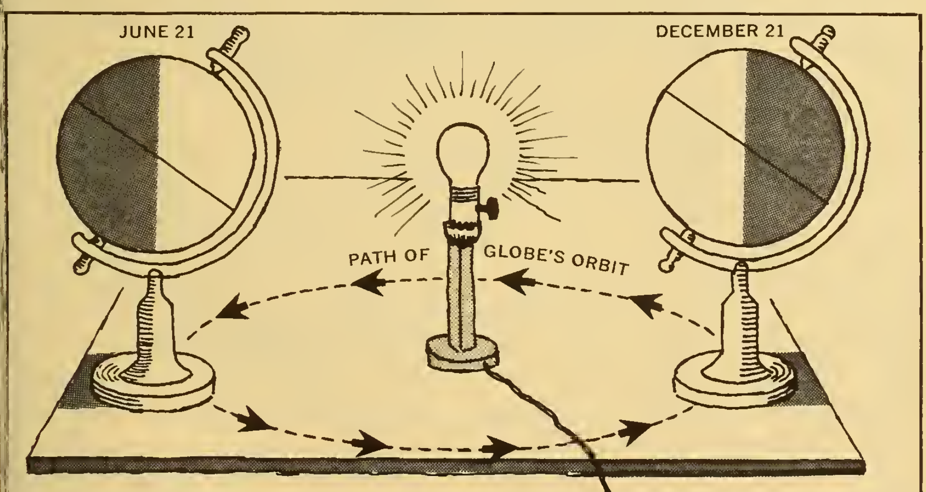
This special-topic issue deals with a *biome*—a large area of land having a particular combination of climate and plant and animal life. The prairie and the tropical rain forest are examples of biomes. (The October 30, 1967 issue of *N&S* was devoted to the desert biome.) The *tundra,* subject of this issue, is the northernmost biome in the world.

The word tundra comes from a Finnish word meaning "treeless plain." Tundra is dotted with lakes and bogs, and has low temperatures, a short growing season, and little precipitation. It is a land of low-growing plants, such as mosses, lichens, and rushes.

A second kind of tundra, called *alpine* tundra, can sometimes be found on high mountains where the climate is similar to that in the far north. But it is in the Arctic where the true tundra stretches for thousands of miles. Technically, the whole Arctic region is not a biome, since it consists of both tundra and ocean. But parts of the Arctic Ocean might be considered an extension of the tundra biome, since some tundra animals roam far out on the ocean ice in search of food.

This article briefly describes some of the characteristics of Arctic life. If time permits, you might discuss with your class some other features of the Arctic, including the "midnight sun" *(see box),* and an important group of

(Continued on page 2T)



You can demonstrate the "midnight sun" of the Arctic by moving a globe around a lighted bulb as shown in the diagram. (Keep the axis pointed in the same direction throughout.) With the globe at "June 21" position, rotate it once, showing that the North Polar region is in daylight for 24 hours. At the "December 21" position, it is in darkness for 24 hours.

IN THIS ISSUE

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

IN THE NEXT ISSUE

An astronomer tells of the trials and tribulations of lifting a telescope high in the atmosphere with a balloon . . . A visit to Flatland—a two-dimensional world . . . A WALL CHART shows how optical telescopes work .

plants common to the tundra, the lichens (*ly*-kens). One of the most abundant kinds of lichens is called reindeer moss (though it is not a moss). As the name implies, this lichen is an important food for reindeer and caribou. A lichen consists of two kinds of plants, algae and fungi. Both kinds benefit from living together: the fungi obtain food from the algae; the algae obtain protection and water from the fungi. Neither could exist alone. This "partnership" is called *mutualism.*

Survival in the Arctic

This article offers several examples of ways in which Arctic animals have become adapted through evolution to survive in the far north. An *adaptation* can be defined as *any aspect of an organism that promotes its welfare, or the welfare of the species to which it belongs, in the organism's normal environment.*

Adaptations can be lumped into these categories:

1) *Morphological* adaptations include the shape, size, structure, and color of an animal, and of its parts, such as feet, teeth, and beaks. The long fur of Arctic mammals is one example; the white fur of the Arctic fox and the white feathers of the snowy owl are others.

2) *Physiological* adaptations refer to processes within the animal's body; for example, the ways in which Arctic mammals are able to maintain different temperatures in two different parts of their bodies (*see text of article*).

3) *Behavioral* adaptations include the undersnow burrowing of small Arctic mammals and the ability of the polar bear to find, stalk, and kill seals.

It usually takes many generations for a species of animal to become adapted in such ways. However, an individual animal may have the ability to adjust to a change of environment during its lifetime (*see "Getting Used to the Cold," page 6*). This ability is called *adaptability*, and it is inherited, just like white feathers or thick fur. So adaptability is also an adaptation, which varies in degree from species to species.

Topics for Class Discussion

• *Why is small size a disadvantage in cold climates?* The diagrams on page 4 show how a large object is better able to keep heat than a smaller one. Arctic mammals tend to be larger than closely related mammals in warmer climates (though there are exceptions to this rule).

• *Why don't Arctic mammals avoid the winter cold by hibernating?* When an animal hibernates, its body temperature drops to near freezing and all of its body processes slow down. In this way the animal sleeps for most of the winter, hidden in a den where the air temperature stays above freezing. If the temperature drops too low, however, the animal usually wakens. It then must find a warmer den, or it will die. Because of the Arctic permafrost, there are very few burrows where animals can find above-freezing temperatures, so the ability to hibernate has not evolved.

• *Of what advantage are small ears in the Arctic?* There is a generalization, called Allen's rule, that states: *Within any one species, protruding parts such as tails, ears, or bills tend to be shorter in colder climates than in warmer climates.* Having relatively small extremities helps reduce heat loss in an animal (because less surface area is exposed to the air).

This generalization is illustrated by the diagram of fox ears on page 6. Your pupils can find other examples of this phenomenon by looking at illustrations in mammal field guides. Have them look particularly at the tail length of rodents, such as mice, and the ear size of rabbits and hares.

• *Why must mammals and birds rid their bodies of excess heat?* These two groups of animals are warm-blooded, maintaining a high, steady temperature by processes within their bodies. Your pupils may already know that human body cells (especially those in the brain) can be damaged if the body temperature rises just a few degrees above normal. Most extra heat in humans is given off through the process of perspiration. Your pupils have probably seen dogs panting on a hot day; dogs "sweat" through their mouths.

For Your Reading

Animals of the North, by William O. Pruitt, Jr., Harper & Row, New York, 1967, $5.95, is a collection of essays that reveals a great deal about the lives of such animals as wolves, hares, moose, and caribou.

Snow, Sixty Below, Eskimo

The Arctic has been the home of the Eskimo for 5,000 years. Today about 55,000 Eskimos survive. Their lives are rapidly changing as the Arctic becomes more "civilized."

Arctic explorers and scientists have learned a great deal about survival by observing the cultural adaptations of the Eskimos. Long ago, the Eskimos discovered that two layers of lightweight clothing are much warmer than one thick garment. Each layer of clothing traps some air that is warmed by body heat and protects the person from cold. The inner layer of clothes (which are usually made of animal skins) often has the furry part facing inside. The animal hairs also trap air. When an Eskimo is active, however, air circulates freely in the layers of lightweight clothes, carrying away excess heat.

After your pupils have studied the WALL CHART, you might explain further the principle on which both the parka and the buildings of the Eskimos are based: warm air rises and cold air sinks. *(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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. 6 NO. 9 / JANUARY 20, 1969

SPECIAL-TOPIC ISSUE

LIFE IN THE ARCTIC

nature and science

VOL. 6 NO. 9 / JANUARY 20, 1969

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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 EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

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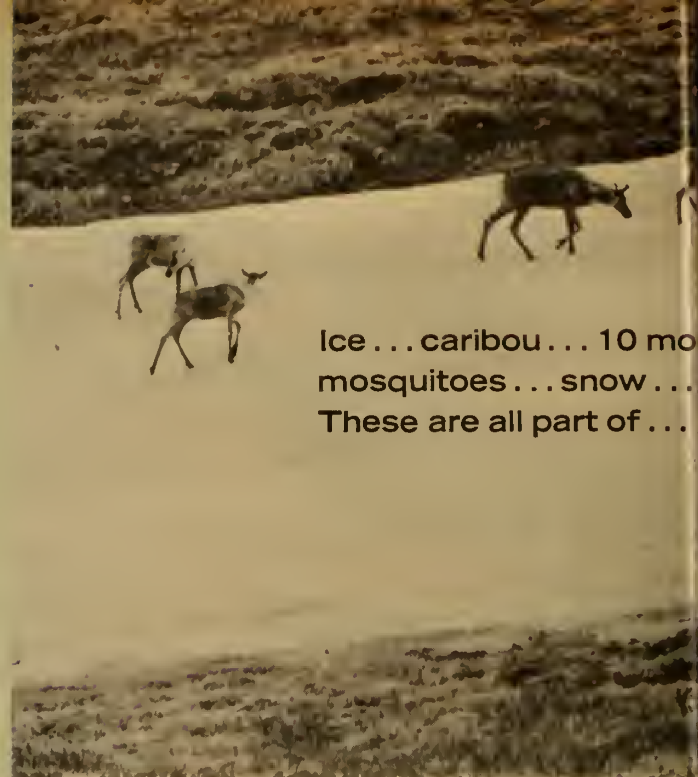


Ice . . . caribou . . . 10 mo
mosquitoes . . . snow . . .
These are all part of . . .

The Arctic is made up of treeless land called *tundra* (sho in green) and ice (shown in white). The deep-frozen grou called *permafrost* lies north of the dashed line.

Life at the top of the world

■ Take an imaginary airplane trip to the North Pole. As the plane streaks north over Canada, you notice fewer cities, towns, and highways. Lakes and evergreen forests stretch as far as you can see. Then the trees begin to thin out. They seem small and stunted, and grow in scattered clumps. Soon there are no more trees. Now you are over *tundra*—a land of bogs and ponds and nearly level ground covered with low plants such as mosses and lichens.

North of the tundra lies the Arctic Ocean. And in the ocean, at an unmarked point somewhere below the drifting ice, is the North Pole *(see map).*

From there, the Arctic stretches south in all directions. It ends at the southern edge of the tundra, called the *tree line* (although scientists don't always agree on the exact boundaries). Trees can't survive in the tundra because of the short growing season and because the Arctic is really a sort of desert. Not much snow or rain falls there, and most of the year the moisture is frozen so that plants can't use it.

Opposite Ends of the Earth

Whether you live in Florida or Minnesota, the weather is affected by cold winds from the distant Arctic. Winds from the Antarctic affect the southern half of the world in the same way.

Antarctica and the Arctic differ in some important ways. The Arctic is made up of tundra and ocean. The ocean waters store heat in the summer and this helps lessen the cold of winter. The Antarctic, however, is a continent. It is much colder than the Arctic and is covered with about eight times as much ice.

Most of the year, the Arctic seems barren and lifeless. Then for about eight weeks in the summer the temperatures rise above freezing and the days become quite warm. The arrival of summer triggers great changes in the Arctic plant and animal life. In those few weeks of warmth, plants flower and produce seeds; insects hatch from eggs, develop into adults, and then lay eggs for next summer's generation; birds arrive from the south, build nests, and raise young that will fly back south with their parents before winter cold arrives.

Only a few kinds of Arctic animals remain active all year long *(see pages 4 and 12).* Scientists like to study the plant and animal communities of the Arctic because life there is simple compared with that in warmer parts of the world. This simplicity of life may help cause the mysterious changes in the populations of many Arctic animals *(see page 10).*

Eskimos have managed to live in the Arctic for thousands of years *(see page 8).* In the future, man will turn to the Arctic more and more, trying to find new sources of fuels, minerals, and food for the rapidly growing numbers of humans on earth. If man is to live comfortably in this land of bitter cold and deep-frozen ground *(see page 15),* he can learn a great deal from the Eskimos and other living things for whom the Arctic is home.—LAURENCE PRINGLE

■ Look in your library or bookstore for these books about the Arctic and its life: **The Poles,** by Willy Ley, LIFE Nature Library, Time Inc., New York, 1962, $3.95; **Land of the Hibernating Rivers,** by T. A. Cheney, Harcourt, Brace & World, Inc., New York, 1968, $2.95; **Explorers of the Arctic and Antarctic,** by Edward Dolan, Crowell Collier, New York, 1968, $3.95.

SURVIVAL IN THE ARCTIC

Some animals live year round in the Arctic. Scientists have discovered some of the ways in which animals such as sled dogs and caribou survive in this cold, barren world.

by Penny Parnell

■ Going barefoot in the snow is something that would not appeal to many people. But mammals living in the Arctic run on their bare paws over ice and snow at temperatures of 50 degrees below zero, Fahrenheit.

Scientists at the University of Alaska's Institute of Arctic Biology, in Fairbanks, are studying how mammals are able to survive in the frigid temperatures of an Arctic winter. "Life in the Arctic proceeds at the same pace as in other parts of the world," says Dr. Laurence Irving, a Professor of Zoology at the Institute. "The animals here have the same needs as animals in other climates."

Most Arctic mammals remain active all year long. Only a few go into the deep sleep called *hibernation*. Because mammals are *warm-blooded* (they have a high, steady body temperature), they must actively seek food each day. Most of their food is used to produce body heat.

Somehow, the Arctic mammals survive. Over millions of years, they have slowly changed *(evolved)* in ways that help keep them alive and well through the long Arctic winters. Dr. Irving has been studying Arctic mammals for over 20 years. To find out how the mammals can survive in such a cold climate, he has spent months living on the Arctic coast and traveling overland by dogsled.

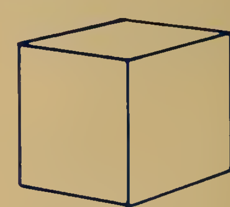
Sometimes it is so cold that batteries used in the scientists' equipment freeze unless they are carried inside the men's clothes. However, the scientists are able to measure the temperatures of many wild mammals, as well as the temperatures of the sled dogs they use.

Asleep in the Snow at 30 Below

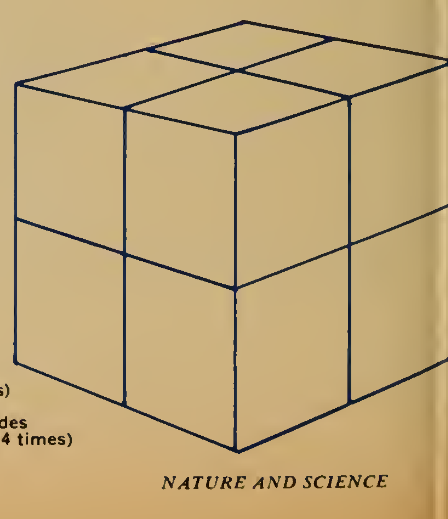
The scientists have found that the thick fur of the land mammals keeps their bodies from losing much heat to the air. (Sea mammals, such as seals, have thick layers of fat that help keep heat in their bodies.) Most Arctic mammals have an inside body temperature of 99°F. The skin temperature of sled dogs resting in the snow was 91°, while just a few inches away from their skin, the snow in contact with the fur might be 60 or perhaps even 100 degrees colder.

"We noticed that the sled dogs would curl up in the snow to sleep at 30 degrees below zero," said Dr. Irving. "The

As a block gets bigger, its bulk *(volume)* increases faster than its surface area. In the same way, as an animal gets bigger, its heat-producing bulk increases faster than the surface area of its skin. Since an animal loses body heat through its skin, a big mammal is better able to keep body heat than a small one.



VOLUME = 1 block
SURFACE AREA = 6 block-sides



VOLUME = 8 blocks (increased 8 times)
SURFACE AREA = 24 block-sides (increased 4 times)

wind would cover them with blowing snow, yet it did not melt on their fur. When they got up, the hollow place where they had lain would not be melted."

The small Arctic mammals, such as mice, lemmings, and shrews, have a special problem. Because of their small size they lose heat more rapidly than bigger animals *(see diagram)*. The small mammals could not carry enough fur to protect them from the cold. Instead, they spend most of the winter underneath the snow, digging tunnels in search of food and staying in nests made of grasses and moss. The temperature may be 15° in the nest while it is -40° or -50° at the surface of the snow.

Turned on by the Cold

Changes *within* their bodies also help to keep Arctic mammals warm. A drop in the air temperature may cause a change in an animal's *metabolism*—the chemical processes within the body. Metabolism includes the "burning" of food and fat that produces heat. Warm-blooded animals have a certain level of metabolism (called *basal metabolism*) which keeps the body temperature normal while the animal is at rest.

If there is a sudden drop in the temperature of the air around an animal, its body adjusts by speeding up the metabolic processes. Food is burned faster to produce extra heat. The air temperature that starts this speed-up is called the *critical temperature*.

The critical temperature for some Arctic mammals is amazingly low. Scientists have found that the winter critical temperature for the Arctic fox *(see photo)* is about 40 degrees below zero. This means that the fox's metabolism doesn't usually speed up until the air temperature drops lower than -40°. In contrast, the critical temperature for most humans is about 80 degrees *above zero*.

Arctic mammals (and some birds) are able to save heat by having *two* body temperatures—one for the main body and a much lower temperature for the legs and feet. Dr. Irving measured the skin temperature at different places on the body of a resting sled dog. While the air temperature was 22°F., the temperature of the skin on the dog's toe was 46° and on its heel 32°. The skin temperature under the thick fur of the dog's flank, however, was 92°.

An Arctic animal can keep cool temperatures on its legs and feet without lowering the temperature of its heart, kidneys, and other vital organs. Inside the body, the arteries carrying warm blood toward the legs are close to the veins carrying cold blood back to the heart. The warm blood moving toward the legs loses heat to the cold blood rising from the legs. This helps keep heat in the animal's body.

SNUG IN THE SNOW?

Is it as cold underneath of the snow as it is on top? To find out, get two thermometers. Check to see that both show the same temperature. Leave one on the surface of the snow. Then, with your hand, make a small tunnel in the snow (at least a foot deep) so that you can put the other thermometer close to the ground. Fill in the hole you made, marking it with a stick so that you can get the thermometer out later. After 10 minutes or so, compare the temperatures of the two thermometers. Does snow seem to keep cold air from reaching the ground? See if it is warmer under snow that is even deeper.

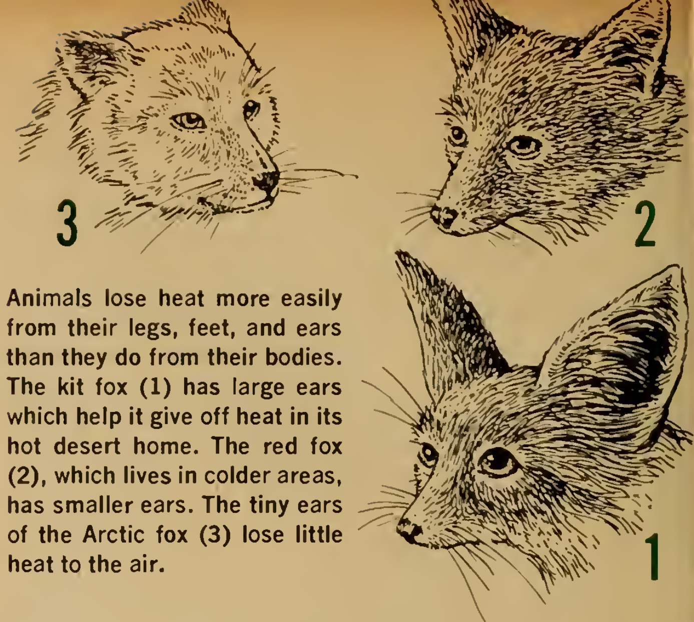
Mr. Gordon Hooten of the Institute of Arctic Biology prepares to take the body temperature of an Arctic fox. By studying mammals such as foxes, scientists at the Institute are learning how mammals survive the Arctic cold.

Too Much Heat in the Arctic?

Strange as it may seem, overheating can be a serious

(Continued on the next page)

problem in the Arctic. "If a man wears enough clothing to be comfortable while resting at 40 below, he will quickly become overheated if he starts running behind his dog team," explained Dr. Irving. "He has to be able to unzip



When warm-blooded animals exercise, their bodies produce a great deal of heat. The extra heat must be given off so that the animals' body temperature can stay normal. These racing sled dogs lose heat from their open, panting mouths.

Animals lose heat more easily from their legs, feet, and ears than they do from their bodies. The kit fox (1) has large ears which help it give off heat in its hot desert home. The red fox (2), which lives in colder areas, has smaller ears. The tiny ears of the Arctic fox (3) lose little heat to the air.

his jacket, or to remove layers of clothing, to avoid overheating. If he perspires so much that his clothes get wet, they lose their protective value. He may actually freeze to death because of overheating!

"Dogs and caribou can't take off layers of clothing," Dr. Irving continued, "but we have noticed that they seldom become overheated." One reason that Arctic mammals seldom get too hot is that their fur lets cool air reach the skin when the animal is moving. They also lose heat wherever the fur is thin—on their stomachs, ears, and legs. They have long, moist tongues that hang from their mouths when they run *(see photo)*. A lot of excess heat is lost from their open, panting mouths.

Many questions are still unanswered in these studies of animals living in the frozen Arctic. Someday we may be able to understand all of the ways in which animals such as the little Arctic fox survive on the lonely ice floes of the Arctic Ocean. As the fox races across the sparkling ice, its body is perfectly adapted to the frigid climate. From mammals such as the Arctic fox, man may learn how to live more comfortably in the cold corners of the earth ■

GETTING USED TO THE COLD

Polar bears and other cold-climate animals are able to live comfortably in the Arctic because they have become adapted to the cold over many generations. Men and other animals can adjust to a cold climate in a small way, or *acclimatize*, in a few weeks or months.

Scientists at the Institute of Arctic Biology discovered that wild brown rats, raised in cold temperatures in a laboratory, could produce heat faster and faster as the temperature of the air dropped to —40°. Below that temperature, they could no longer keep warm. Then the same sort of test was given to a group of white rats that were not used to the cold. The temperature had only dropped to 10° when their bodies failed to produce enough heat to keep them warm.

Humans can also become acclimatized to the cold. When the weather warms in the spring, people who are used to the winter's cold may feel comfortable at 30° or 40°F., and don't need to wear mittens, hats, or scarves. In the fall, however, when their bodies are not yet used to the cold, the same temperatures will numb their fingers and ears. Then they feel warm only when protected by extra clothing.

Brain Boosters

prepared by **DAVID WEBSTER**

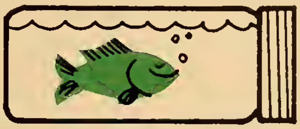
MYSTERY PHOTO

The glass of water appears milky at the top because of air bubbles. How did the bubbles get into the water?

Submitted by Jon Gallant, Bronxville, New York

WHAT WILL HAPPEN IF . . .

. . . you put a fish into a jar of water, then cover the jar and turn it upside down? Will the fish swim upside down for a while?



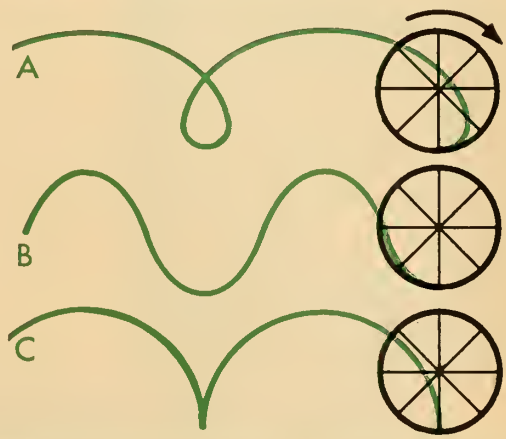
A girl was born in the summer, but now her birthday is in the winter. How could this happen?

CAN YOU DO IT?

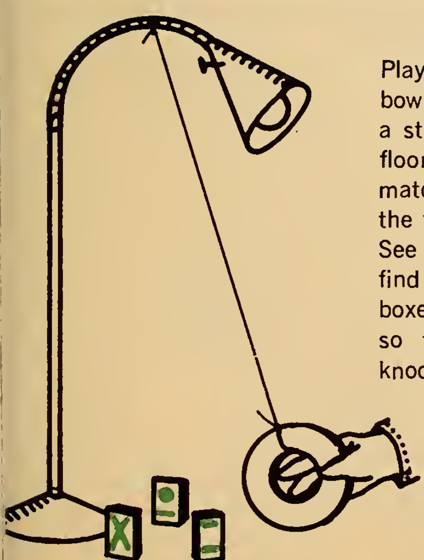
Can you break a round toothpick held between three fingers as shown, without using your other hand?

FUN WITH NUMBERS AND SHAPES

Which path is the one that would be made by a pebble stuck in the tread of a bicycle tire?



JUST FOR FUN



Play a game of pendulum bowling. Hang a weight from a string so it just clears the floor. Set up some small matchboxes or dominoes on the floor near the pendulum. See how many ways you can find to arrange the matchboxes or swing the pendulum so that all the boxes get knocked over. If you don't change the way the pendulum is swinging, can it ever knock down a matchbox that it misses on the first full swing?

ANSWERS TO BRAIN·BOOSTERS IN THE LAST ISSUE

Mystery Photo: Sea gulls cannot stand on water. The birds in the photograph are standing on smooth ice.

What will happen if? When the water is completely frozen, it is still possible to see the ice cube.

Can you do it? The best way to find out which cup has the baking soda is to add some vinegar to both cups. Vinegar makes baking soda give off carbon dioxide gas, which will form bubbles.

Fun with numbers and shapes: The circle has more space inside it than the square or triangle that are the same length around. Does a pound of clay fill the least space when it is shaped into a cube, a pancake, or a ball?

For science experts only: Not all parts of the body are sensitive to hot and cold in the same way. Water of the same temperature can feel cool to your hand and warm inside your mouth.

nature and science | WALL CHART

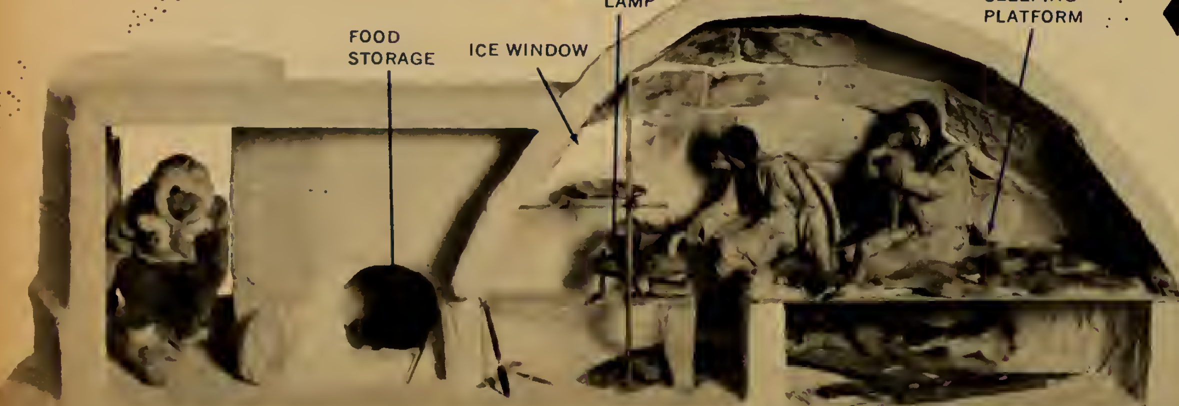
SNOW, SIXTY BELOW, AND THE ESKIMO

The air-tight, loose Eskimo jacket, or *parka,* is usually made from fur of caribou or seals. The hood and the weight of the jacket keep air that has been warmed by the body from escaping at the top. Because warm air rises, it won't escape from the bottom. To keep from overheating, and to keep moisture from collecting inside his clothes, an Eskimo can pull the throat of his jacket forward, letting the warm air and moisture rise up and away.

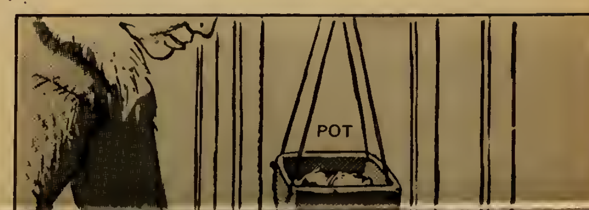
■ Minus sixty degrees Fahrenheit. That's a common winter temperature in Greenland, northern Canada, and eastern Siberia—the lands of the Eskimos.

The Eskimos survive there in spite of the cold. They survive in spite of a short growing season for plants, which creates food problems and a wood shortage. They survive in spite of their winter world of snow and ice that makes finding food and keeping warm difficult.

As they make their living in the Arctic today, Eskimos use rifles, refrigerators, radios, and other modern devices. For thousands of years, however, the Eskimos made their tools, clothing, and homes from the limited materials at hand. This WALL CHART shows some of the ways in which Eskimos survive in the harsh world of the Arctic.—SUSAN J. WERNERT



◀ Most Eskimos have never lived in *igloos.* These snow-houses are used most by Eskimos in the Canadian Arctic. Although some other Eskimos use igloos while traveling, their permanent homes are made of stones and sod. Both kinds of homes have low entrances that tend to keep warm air in and cold air out. The photo shows a cutaway view of a model igloo, on display at The American Museum of Natural History. The diagrams show how to make an igloo.



STARTING BLOCK

EACH LAYER LEANS

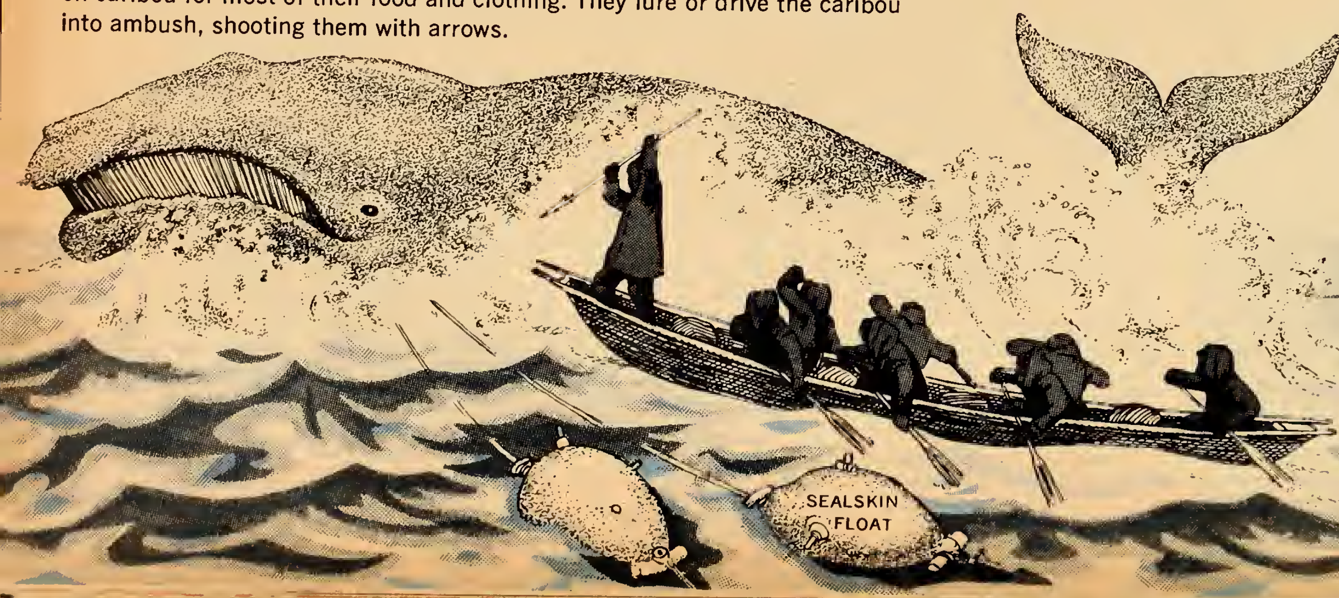
"KING"

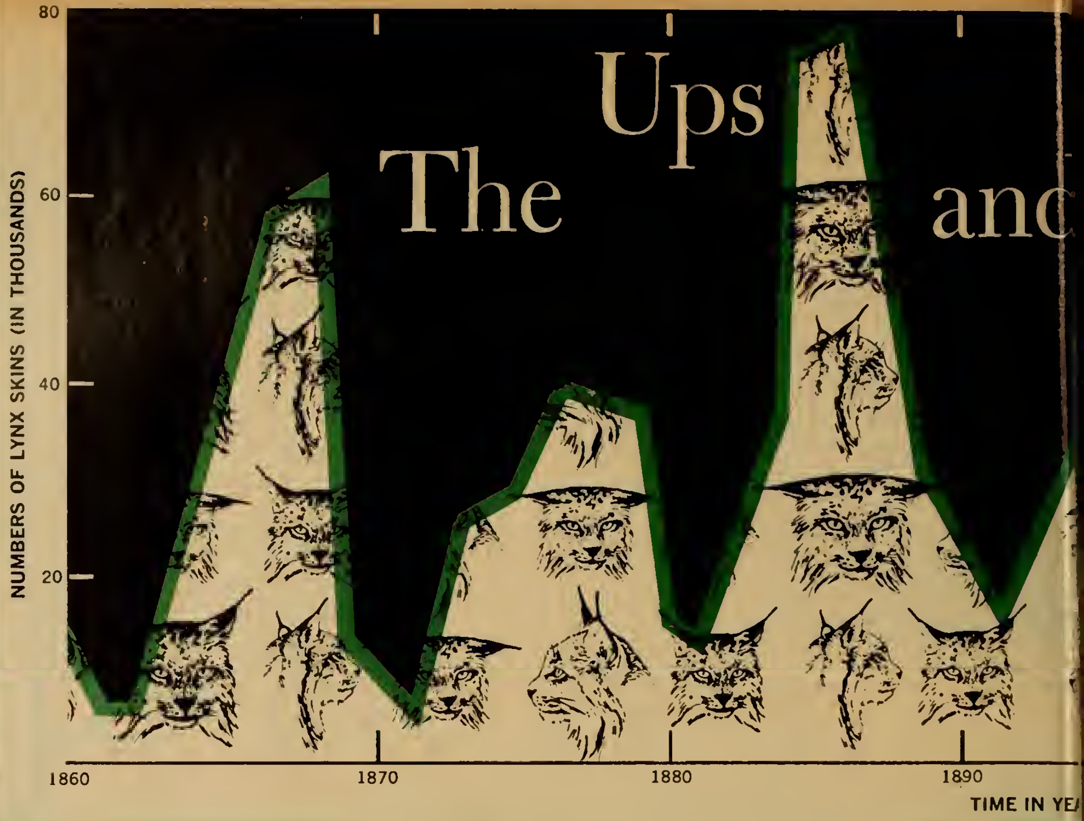
"Eskimo" comes from an American Indian word meaning "eater of raw flesh." But meat is cooked most of the time, in spite of a shortage of wood. Eskimos use lamps like the one above as sources of heat and light. The lamps burn a kind of fat called *blubber*, taken from sea mammals such as whales and walruses. The wicks of the lamps are made of mosses.

Sleds pulled by dogs are used by most Eskimos for land transportation in the winter. The sled runners are covered with mud and then glazed with ice to help them slide easily over the snow and ice. An Eskimo may spend half of his hunting time getting food for his dog team. The dogs are fed even when people go hungry. A healthy dog team, strong enough to go on long hunting trips, is insurance against starvation for all.

In the winter, ice covers most of the Eskimos' food supply —seals and other ocean mammals. Like all mammals, however, seals must get oxygen from the air. They do this through holes in the ice, which are often covered by snow. The Eskimos use dogs to find the holes. Then they put a small piece of bone into the hole in such a way that a seal must touch the bone when it comes up to breathe. When the waiting hunter sees the bone move, he quickly thrusts a spear into the hole.

During the warmer months, skin boats for one man *(kayaks)* or for several men *(umiaks)* make hunting easier. The objects at the side of this umiak are air-filled sealskin floats. Attached to harpoons that are thrown at a whale, they help tire the whale and keep it from escaping. Inland, Eskimos depend on caribou for most of their food and clothing. They lure or drive the caribou into ambush, shooting them with arrows.





The Ups and

In northern lands, the populations of many animals change greatly in the span of just a few years. Scientists are trying to solve the puzzle of . . .

by Dave Mech

■ Scientists, like everyone else, enjoy good mysteries. Scientists called *ecologists,* who study the ways that living things fit into their surroundings, have long been interested in the mystery of *population cycles.*

In most animal populations, numbers stay about the same from one year to the next. The story is different, however, in the northern United States and Canada, especially in the Arctic region. There, the numbers of certain animals do change greatly from year to year. First, numbers go up for a few years, then they suddenly go way down. Then they begin to build again. Because these changes keep repeating, they are called *cycles.*

Population cycles in North America come in two main lengths, one of about four years, the other of about 10. The 10-year cycle can be seen best in the yearly numbers of the Canada lynx *(see photo),* a wildcat weighing about 25 pounds.

Ecologists first noticed lynx cycles when they looked at the records of the numbers of animal pelts taken by trappers. Arctic trappers usually sell their furs to the Hudson's Bay Company, which has kept records for more than 100 years. During that time, the lynx catch has tended to go up and then down about every 10 years *(see graph).* When the catches were highest, trappers brought in up to 80,000 pelts. When they were lowest, only a few thousand of the animals were trapped.

Other animals whose populations seem to have 10-year cycles are snowshoe hares, ruffed grouse, red foxes, muskrats, mink, and fishers (fox-sized mammals related to weasels and mink). It also appears that other species are cyclic in certain parts of the Arctic or at certain times. In fact, some scientists believe they have found population cycles in everything from chinch bugs to tent caterpillars.

The four-year cycles are most easily seen in the numbers of Arctic lemmings—mouse-like mammals that live in the far north. According to some people, these animals rush to the sea every three or four years and kill themselves. The story does have a bit of truth to it, for lemming numbers do get very large about every three or four years, and masses of the animals seem to go "mad" and move long distances. At times, some of them even drown in the sea.

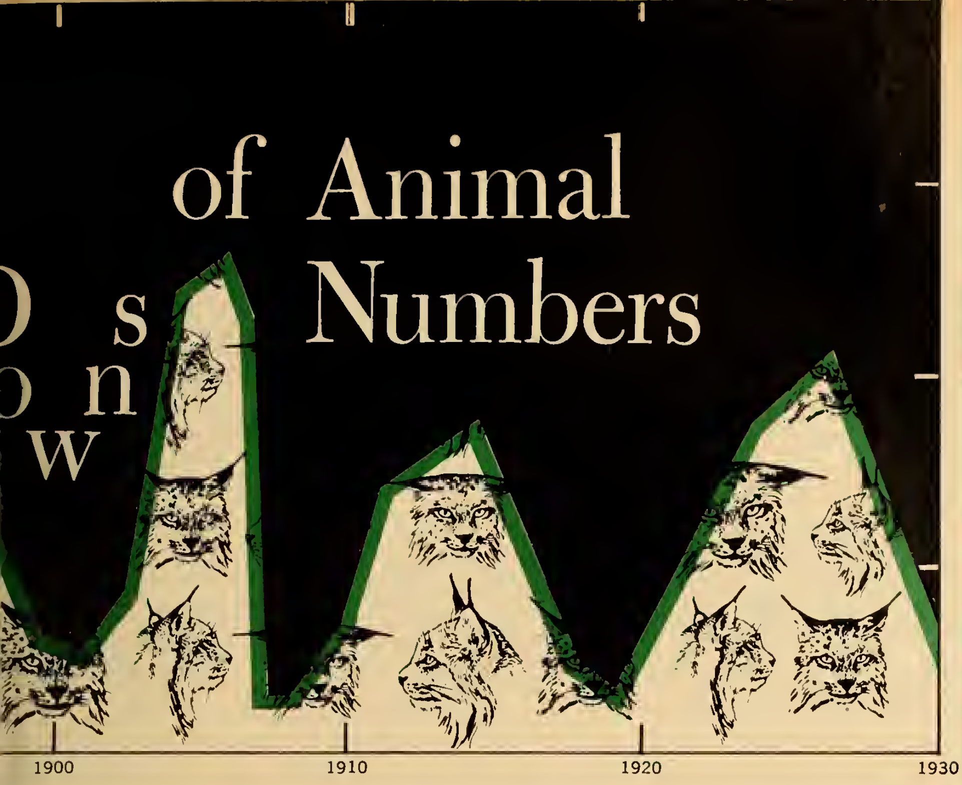
What Causes Cycles?

Few scientists have the same views on Arctic population cycles. Some don't even believe there are cycles—they think there is something wrong with the figures. Most ecologists agree that the cycles exist. That, however, is about all they agree on.

Some think a three-to-four-year cycle is the basic one. According to their idea, every third high point in the cycle is the highest. This shows up as the peak of a 10-year cycle. These ecologists think that all the Arctic cycles are related. A few suggest that some unknown "outside" force causes the cycles. Such things as spots on the sun, moonlight, and amounts of a certain gas in the air have all been blamed for highs and lows of animal populations.

Some scientists claim that cycles come about just by

# of Animal Numbers



This graph shows the number of lynx skins bought from trappers by a fur company from 1860 to 1930. Notice how the numbers reach a peak about every 10 years. These ups and downs seem to be related to changes in the numbers of snow-shoe hares, which the lynx depend upon for food. No one knows why the hare numbers go up and down.

hance. That is, in any string of numbers picked by chance by throwing dice, for example), the same number will ome up every so often. These scientists believe that nance explains why animal populations reach a peak very so often. By chance, they think, factors favoring igh animal populations might show up about every eight 11 years. With smaller mammals like lemmings, they ight occur sooner, causing three-to-four-year cycles.

Most ecologists believe there is a cause—or causes— r the population cycles other than chance. For example: ould cycles in the numbers of predators, such as lynx, be used by cycles in the populations of the animals that e predators eat? This idea has possibilities. Communi- s of plants and animals in the Arctic are simple com- red to those of most of the world. Arctic animals tend to pend on only one or a few other animals or plants for od. Thus a change in the numbers of one plant or ani- al may cause great changes in the numbers of another. r example, lynx depend on snowshoe hares for food. hen the numbers of snowshoe hares drop, the numbers lynx also drop. But this fact still doesn't explain why owshoe hare numbers have ups and downs.

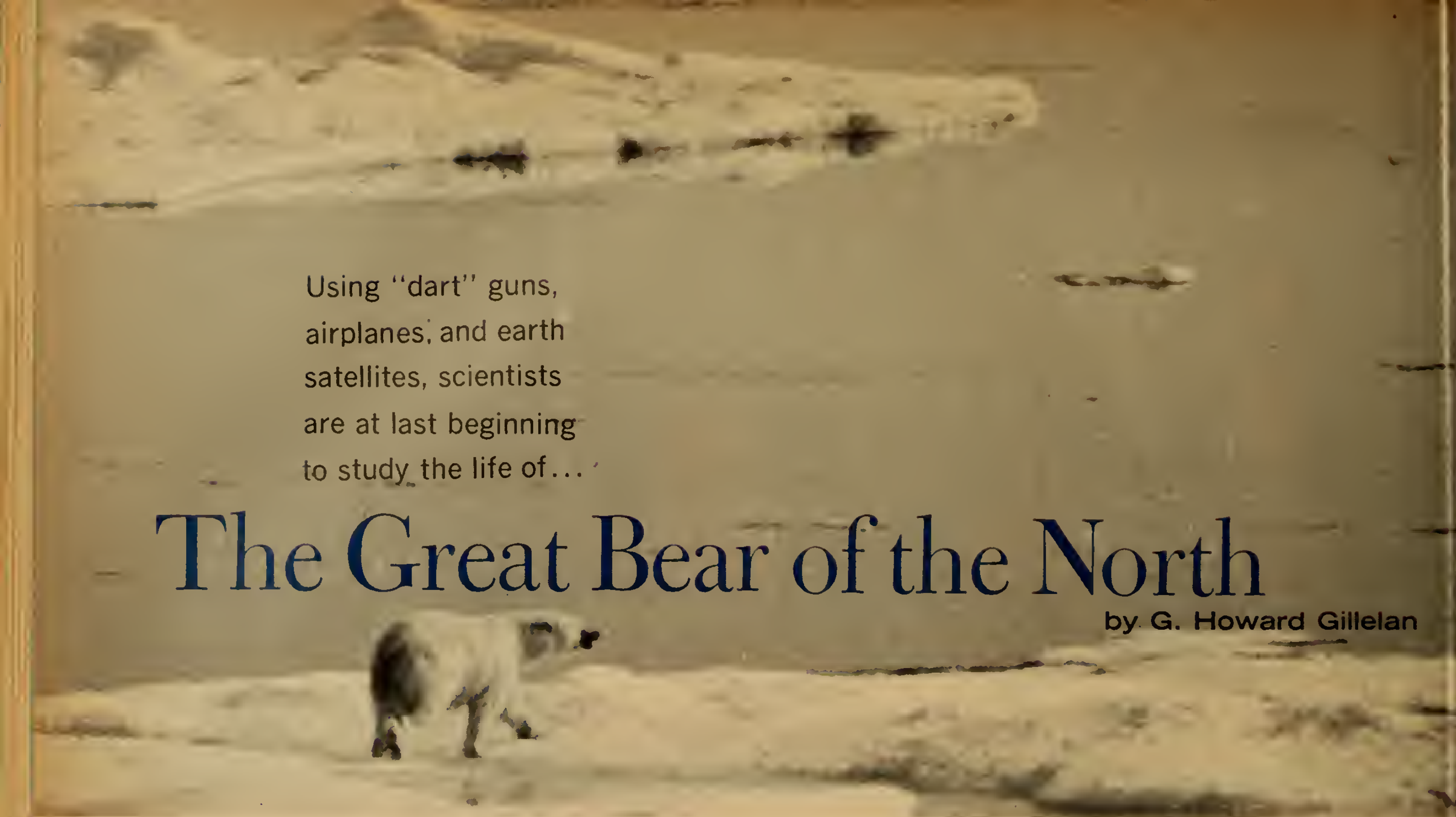
A few ecologists believe that cycles of snowshoe hares pend on the animals' food supply, the plants. Accord- to this idea, when hare numbers are low, few plants eaten, so vegetation grows thickly. Then as hares in- ease, their numbers reach a point at which they destroy st of the plants. Many of the hares starve. This gives plants a chance to grow again, and the cycle starts over. The trouble with this notion is that it doesn't fit the facts—scientists seldom find large numbers of plants destroyed, no matter how many hares there are.

When Stress Builds Up

Another theory is based on something called *stress.* When animals are crowded together in cages, they suffer from stress, a kind of "nervousness" that makes them less healthy. The same is probably true in the wild. As animal numbers in the wild get larger, there is more and more stress. When numbers build too high, the animals have to hunt far and wide for food, and begin to fight. Then a sudden cold snap or blizzard may cause most of them to die suddenly.

It is true that when snowshoe hare numbers "crash" (drop suddenly), scientists find animals dying from *shock,* the result of great stress. Also, Dr. Kai Curry-Lindahl, an expert on lemmings, believes that stress could account for the strange actions he has noticed in lemmings at the high point of their four-year cycle. But other scientists say that the stress theory doesn't explain why populations crash about the same time all over the Arctic.

Scientists have worked on this mystery for over 30 years without coming up with a definite answer. Instead they are still asking questions. Do population cycles really exist? If so, are they related to one another? Are they caused by some "outside" force, or do they result from an "inside" force like stress? Population cycles are still a fascinating science mystery ■



Using "dart" guns, airplanes, and earth satellites, scientists are at last beginning to study the life of...

The Great Bear of the North

by G. Howard Gillelan

■ Biologists have learned a great deal about the lives of many wild creatures, but have only recently begun to study the polar bear. This great white ghost roams more than five million square miles surrounding the North Pole. The cold temperatures and dangers on the drifting ice make it difficult for men to study the polar bear.

Another problem for scientists is that polar bears seldom come to land. They spend most of their lives on the ice of the Arctic Ocean, north of the territories of the United States, Canada, Denmark, Norway, and the Soviet Union *(see map on page 2)*. Recently, biologists from these five countries have held meetings to plan studies of polar bears.

One of the goals of the biologists is simply to find out how many polar bears there are. Estimates of the world's polar bear population run from 5,000 to 20,000. No one knows the total for sure, and no one knows whether polar bears are increasing or decreasing in numbers. Some biologists believe that the bears may be in danger of dying out (becoming *extinct*).

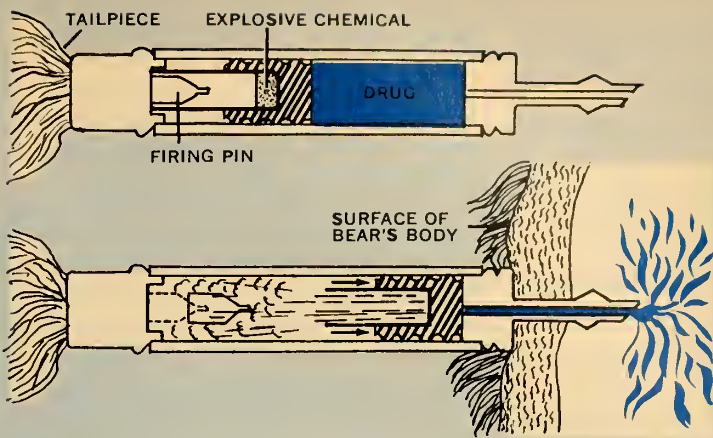
Scientists do know that polar bears feed almost entirely on seals. Sometimes a bear travels hundreds of miles in search of food. One mystery is whether a bear roams at random or travels in a particular direction. There is even some question about whether a bear could keep moving in the same direction if it wanted to. A polar bear's vision is apparently not strong enough so that the animal could guide itself by the stars. Also, there are few landmarks, such as hills or rivers, on the tundra and ice. The ice itself drifts about three miles a day. If a polar bear can find its way under these conditions, its "guidance system" is worth learning about!

"Shooting" Bears for Science

One of the most important tools used by biologists in their studies of polar bears is a *"dart" gun (see photo and diagram on next page)*. Instead of a bullet, this weapon shoots a *hypodermic syringe* (a device for pushing liquids into an animal's body). When the syringe strikes a bear, usually in the shoulder or hip, a drug is injected into the animal. The drug takes effect almost immediately, and the animal loses control of its muscles. It can still hear, see, and smell, however.

The bear stays this way for about a half hour or less. But a scientist working quickly has time to measure the bear, clip a numbered tag to one of its ears, and take a blood sample. Sometimes the biologist uses a tattooing needle to mark permanent numbers on the inside of the bear's upper lip. He may also mark the bear with a large splotch of long-lasting, brightly-colored dye *(see photo, right)*, so the animal can be easily seen from a plane.

The biologists keep notes on each bear they mark. They record the date and location of the capture, the bear's sex and measurements, the numbers of the animal's tag and tattoo. If a bear is recaptured by scientists or shot by hunters months or even years later, the animal can be identified from the records. Then something may be



After the syringe is loaded with a drug *(above, right)*, it is put into a special gun *(above)* and shot at a bear. When the syringe strikes the bear, a firing pin is driven forward and causes a chemical to explode, forcing the drug into the animal. The brightly-colored tailpiece on the syringe enables scientists to see where it strikes the bear.

learned about the animal's growth and travels.

To get within shooting range of a polar bear, the biologists often use two airplanes that have skis for landing gear. When a bear is sighted from the sky, one plane lands at a point about two miles ahead of the bear. The pilot and one of the scientists then lie in wait behind a ridge of ice while the second plane "herds" the bear toward them. Since the range of the dart gun is limited, the scientist cannot shoot until the bear is dangerously close. The pilot stands by with a hunting rifle in case something goes wrong.

Search for the Perfect Drug

One of the pioneers in polar bear research is Dr. Vagn Flyger of the Natural Resources Institute at the University of Maryland, in College Park. Working with Dr. Flyger were Dr. Martin Schein of West Virginia University, in Morgantown, and Dr. Albert Erickson of the University of Minnesota, in Minneapolis. James Brooks of the United States Fish and Wildlife Service and Jack Lentfer of the Alaska Game Department are continuing to study polar bears in Alaska.

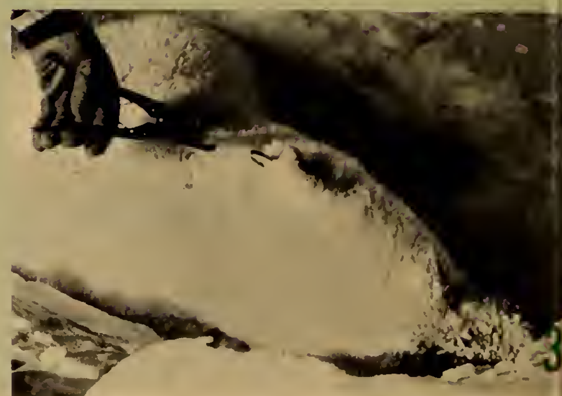
Several years ago, Dr. Flyger used dart guns while studying deer. When the "weapon" was being considered as an aid in polar bear studies, he became interested in this new challenge.

Dr. Flyger and the other biologists had some problems when they first began using the dart gun in the Arctic. In warmer climates, the gun worked well for distances up to 70 yards. In the Arctic, however, the cold temperatures affected the gun so that it had a range of only 40 yards.

(Continued on the next page)

When the drug takes effect, the polar bear cannot move for about 30 minutes. This photo shows Dr. Vagn Flyger marking a bear with a brightly-colored dye so that the animal can later be identified from an airplane.

During the half hour when the bear cannot move, biologists take measurements of its body (1), and clip a numbered tag to one of its ears (3). Photo 2 shows a bear fitted with a collar that contains a dummy radio transmitter, similar to the transmitters that will enable scientists to study the travels of polar bears.



The Great Bear of the North (continued)

The drug presented some problems too. The biologists needed to find a drug that would work quickly and still wear off fairly soon. They also needed a drug that would not harm the bears in any way. Although the perfect drug has not yet been developed, the scientists have found two that work fairly well. The drugs must be used with great care, though. An amount that would be correct for a large bear could kill a smaller one. So the scientists first estimate the size of a bear from the airplane, then load the syringe with the proper amount of the drug.

Besides studying bears in Alaska, Dr. Flyger has hunted and tagged bears from a ship near the Svalbard Islands, north of Norway. Earlier, near the same islands, Dr. Martin Schein and a photographer took underwater motion pictures of a polar bear swimming. The pictures showed that the bear used only its front legs for swimming; its hind legs seemed to act as rudders, or steering devices.

From Bear to Nimbus to Computer

The biologists hope to trace the travels of polar bears by attaching radio transmitters to the animals. The transmitters would send signals that could be used to find an animal's location. Such animals as deer, raccoons, and grizzly bears have been tracked by radio.

So far no polar bear has actually been fitted with a radio transmitter. The biologists first had to make sure that a dummy transmitter, about the size and weight of a real one, could be held on a bear's neck in a special collar *(see Photo 2)*. Now they must find a battery that will power the transmitter in the low temperatures of the Arctic. The transmitter must also be waterproof, since polar bears often swim long distances.

Some time this year, the National Aeronautics and Space Administration (NASA) may launch a satellite called Nimbus that could help track polar bears. The main job of the instruments aboard Nimbus will be to gather information about the weather. But Nimbus could also receive radio signals from polar bears. The satellite's instruments would store the information it receives. Later the information would be sent to ground stations, where computers would figure out the location of a bear several times each day.

Polar bears might also be fitted with devices that would record the animals' heartbeat and rate of breathing. This information could also be sent to Nimbus, and eventually to computers on earth, by radio. Using methods like this, man may finally be able to understand the mysterious ways of the great bear of the north ■

The Land That Keeps Its Cool

Living on the frozen earth is no problem —until it begins to melt!

by Margaret E. Bailey

■ The Arctic region has kept its cool for so long that scientists call the frozen earth there by a special name—*permafrost*. Permafrost is a layer of earth that stays frozen all year long, year after year. The layer begins a few feet below the surface of the earth and extends downward 100 to as much as 2,000 feet in some places. It covers about five million square miles of the Arctic and surrounding areas *(see map on page 2)*.

Only the top few feet of this super-cool land ever "defrost." Scientists call this the *active layer*, and it is so "active" that it causes a lot of trouble for people who live in the Arctic.

Each summer the sun's heat melts the ice in the active layer, which softens into a thick, molasses-like mud called "slud," or "muskeg." Animals and vehicles get stuck in this slud, and roads and even airplane landing strips sink down into it. The icy permafrost under the slud acts like a sliding board, and the slud slithers and slips around on top of it. Anything caught in the slud slides along with it—including whole sections of highways, plants, animals, trucks, and houses.

World's Biggest Deep-Freeze

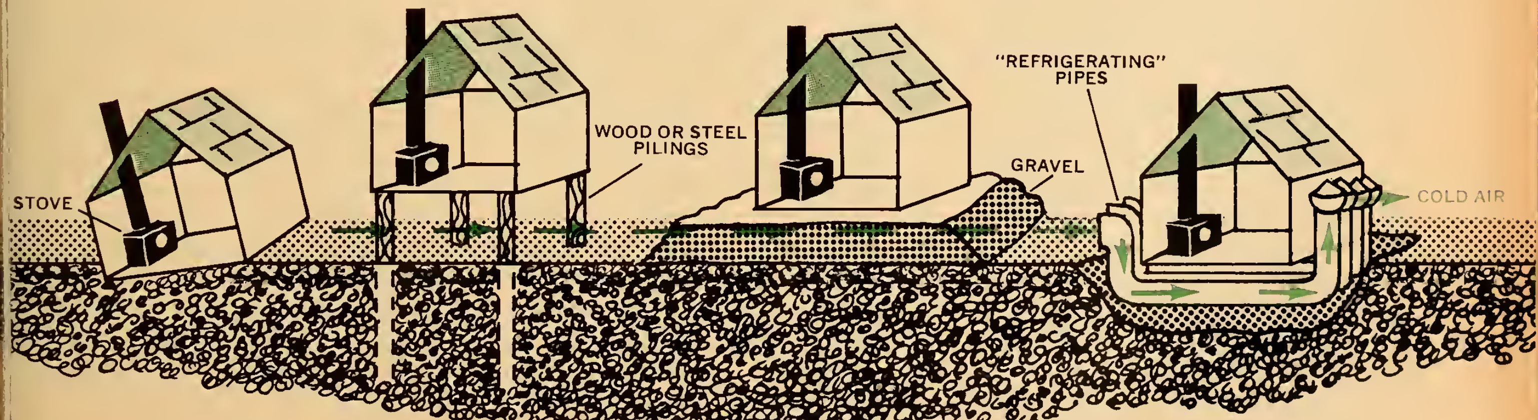
When the active layer freezes in the fall, even more serious trouble begins. After the summer thaw, the active layer is full of meltwater. When the temperature goes down below freezing once more, the active layer starts to refreeze, from the top downward.

As the water at the top of the active layer refreezes, it traps the unfrozen water between it and the permafrost. The trapped water has some air in it, and as the surface layer freezes, it expands and pushes the air into a smaller and smaller space. The air in turn pushes on the trapped water. If there is a weak place in the upper frozen layer, say a spot where a house stove has thawed the ice, the water may burst out through the ice. The water can fill a whole house, and when it freezes and expands, the ice may "explode" the house. Water freezing in the active layer also cracks highways and building walls as it expands and pushes them upward.

Houses that tilt or slump are common sights in the Arctic. This is because the heat from a building can thaw the permafrost during the winter, and the softened ground under the building may sink or shift. Engineers have found that the only way to prevent this is to keep permafrost frozen. One way to do this is to support a building on steel columns above the ground. The layer of air between the building and the ground reduces the amount of heat that passes from the building to the ground *(see diagram)*.

Another way—much cheaper—is to put a layer of gravel between the building and the ground *(see diagram)*.

(Continued on the next page)



A heated building sinks into the earth unless it is built so moving air can carry the heat away before it thaws the frozen soil.

The gravel also keeps heat from the building from reaching the permafrost. The gravel may be carried away gradually by wind or water, though, and have to be replaced.

Sometimes a refrigerating system is needed to make sure that the permafrost under a building keeps its cool. Pipes can be put into the ground under the building with their tops exposed to the cold air outside. As air blows through the pipes, it keeps the ground under the building frozen. In the summer the pipes can be stopped up to keep warm air out.

How Plants Survive in Permafrost Country

There is little rain in permafrost country, but the meltwater in the active layer provides enough moisture for plants to sprout in the spring thaw. Trees grow in southern permafrost regions, but their roots can't go very deep. The trees often tilt in all directions as expanding ice pushes them up during the fall freeze. In the Arctic tundra (see *page 2*) there are no trees because water remains frozen nearly all year. In winter the dry wind evaporates any available moisture, but some small plants escape its effects by dying down to their roots in the soil each winter and sending up new sprouts during each summer thaw. Other plants that can survive with little moisture also keep the tundra from being a total desert.

What a Way To Go

Getting where you want to go can be a real problem in permafrost country, especially if you travel by road. When the soil and plants are removed from the active layer to build a road, the permafrost gets more heat from the sun.

Trees are often tilted in different directions by *frost boils*—pools of meltwater that collect at the bottom of the active layer and push the layer upward as the water freezes and expands.

If the sun melts the permafrost, the road may cave in. Roads built on permafrost must be repaired constantly and often have to be abandoned.

If a driver does manage to keep his car or truck out of the summer slud, he may not be so lucky in the fall freeze. The active layer does not all refreeze at the same time, and car wheels often break through a thin crust of new ice. If the wheels sink too far into the holes, the car may become stranded on the ice in the center of the road. In the late spring, summer, and fall, the best way to travel over permafrost is to fly above it.

Scientists believe that most of the permafrost formed when the climate was colder than it is at present. Within the past century, the earth's climate has been slowly warming up. The Arctic permafrost appears to be melting back at its southern edges, and perhaps along its bottom surface. But it will be a long time in the future before men can stop seeking new ways to live and get around on this immense, deep-frozen land ■

PERMAFROST DOES A MAMMOTH JOB

The large, ancient kinds of elephants called *mammoths* died out thousands of years ago. But it is not unusual to find the body of a mammoth with flesh, fat, hide, and hair still on it buried in permafrost. For many years no one could explain how the mammoths got buried in the permafrost that preserved their bodies.

A possible explanation has been suggested by scientists who study how permafrost forms. Almost all of the mammoth remains have been found in frozen mud and clay from river floods or mud flows. It seems likely that old or weak mammoths may have sought protection from their enemies in shallow river beds and swamps, then died there. When floods came during the spring thaw, the mammoth bodies would be partly covered with clay and mud, which would help preserve them. Some mammoths apparently got stuck and died in slud, and that also protected their bodies.

The remains of summer plants have been found in the preserved animals' stomachs, so the mammoths probably died in the late summer. The bodies would not have decayed much before the winter freeze set in. The following spring, flood waters would have covered the bodies with even more mud and clay. As this material gradually piled up higher and higher, it blocked the sun's heat from the deeper layers, which gradually became permafrost in the cold Arctic climate.

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

In the igloos and sod-and-stone houses, entrance passages are usually lower than the level of the floor inside. (Sometimes a sunken entry can't be built because the snow is not deep enough. Then the Eskimos add an entry hall like the one shown in the model on page 8.) The low entry is out of the wind. Cold air that enters the igloo is gradually warmed by heat from blubber lamps and by body heat given off from the Eskimos. As the air warms, it rises toward the top of the igloo. The air at the level of the raised sleeping platform (*see photo on page 8*) may be 60° F. or warmer.

Topics for Class Discussion

- *Why do your hands sometimes become numb and clumsy when exposed to the cold?* One of the body's automatic responses to cold is to decrease the flow of blood to extremities such as the fingers. This reduces the amount of heat lost from the body. It also affects the muscles and nerves, so that the fingers don't move easily. The circulation in an Eskimo's fingers picks up again very quickly after exposure to cold.

You might emphasize to your pupils that this characteristic of Eskimos is a physiological adaptation to the Arctic. (The WALL CHART illustrates several *cultural* adaptations.) Scientists believe that the body shape of Eskimos represents a *morphological* adaptation. Eskimos have shorter arms, legs, fingers, and toes than people living in warmer climates. Because of this they have less skin surface area to give off body heat. Eskimos also have an extra-heavy layer of body fat. (This might be considered both a physiological and morphological adaptation.) Some scientists think that the shape of the Eskimo face—flattened, padded with fat, and having a small nose—also has evolved through the years to withstand the cold better.

Further Reading

- *People of the Noatak*, by Claire Fejes, Alfred A. Knopf, New York, 1966, $6.95. Written for adults, this book tells of life in Eskimo villages where the old hunting life is still practiced.

Two good books for children are:

- *Arctic Hunters and Trappers*, by Sonia Bleeker, Wm. Morrow & Co., New York, 1959, $2.95.
- *People of the Snow*, by Wanda Tolboom, Coward-McCann, Inc., New York, 1957, $3.25.

Animal Numbers

If your pupils are unfamiliar with graphs, you may have to explain the ups and downs of the lynx skin numbers shown on pages 10 and 11.

Emphasize that cycles are most common in simple communities, such as those in the Arctic and on isolated islands. The more plants and animals of different kinds a community has, the less subject to drastic change it will be. The most stable plant and animal communities seem to be in the tropics, which has the greatest variety of life.

To promote stability, and thus avoid outbreaks of pests and the disappearance of useful plants and animals, man should be trying to keep life on earth as varied as possible. However, exactly the opposite is happening. Man is speeding up the extinction of many species and simplifying communities by reducing the variety of life in them. Scientists are concerned that this will result in increasingly frequent eruptions of crop diseases and pests.

Brain-Boosters

Mystery Photo. The cloudiness of the water is due to the presence of air bubbles. When water is under pressure in a plumbing system, the air in the water is completely dissolved. Once the water leaves the faucet, however, it is no longer under pressure, so the air comes out of solution and forms bubbles in the water. As the air bubbles rise to the surface of the water and break, the water becomes clear again.

The fizzing of soda pop is due to escaping carbon dioxide. The carbon dioxide will bubble out of solution least quickly when the soda pop is kept in a closed container in a cold place. Reducing the downward pressure of the gas above the soda pop (by opening the bottle), warming the liquid, or disturbing it (by shaking or pouring), will cause the carbon dioxide to bubble out faster.

What will happen if? If you can obtain a large jar (with cover) and a small fish, you can demonstrate that when the jar is turned upside down, the fish will remain upright. This is because merely turning the jar upside down will not disturb the water surrounding the fish very much. (Don't keep the fish in the covered jar longer than a half hour or so.)

If the fish *were* turned upside down by moving water, it would right itself immediately. You and your class can see how a fish reacts to moving water by rolling the closed jar along a tabletop. This will set the water in motion. Another way to observe the effect of motion on a fish is to place the fish in a shallow bowl of water over the center of a phonograph turntable. (If the center spindle can't be removed, use a few wooden blocks to raise the bowl above the spindle.) How does the fish react when the turntable begins moving, or when it reaches a steady speed? (Make sure to center the bowl on the turntable, or it may fly off when the table turns.)

Can you do it? Probably no one will be able to break a *round* toothpick held as shown in the diagram merely by squeezing it between the extended fingers. It can be broken, however, by slapping the hand down hard on a desk or table. When the second and fourth fingers meet the desktop, they are stopped; the raised middle finger tends to keep moving downward. The extra force this motion gives to the middle finger should be sufficient to break the toothpick. Ask your pupils why running at a stuck door may sometimes help to open it when pushing alone doesn't work.

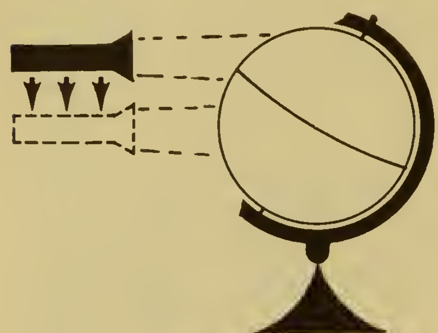
Fun with numbers and shapes. Path C would be the one made by a pebble caught in the tread of a bicycle tire. You can demonstrate this by making a large disc out of cardboard, cutting a hole near the edge where a piece of chalk can stick through, and rolling the disc along the chalk tray so the chalk can draw its path on the board.

(Continued on page 4T)

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

For science experts only. The girl was born in the southern hemisphere in December, January, or February. In the southern hemisphere these are summer months. She now lives in the northern hemisphere, where winter occurs during these months.

With a flashlight and a classroom globe, you can demonstrate how the earth's tilt in relation to the sun helps cause seasonal variations in temperature. In a darkened room, shine the flashlight at the globe as shown in the diagram. See whether any of the



pupils are able to observe that when the flashlight shines obliquely on a portion of the globe ("winter"), the light is distributed through a greater volume of air, and over a greater land area, than when the flashlight shines more directly on a portion of the globe ("summer"). Absorption of the sun's heat by greater masses of land, water, and air helps to account for the lower winter temperatures.

Just for fun. Pendulum bowling is fun. If your pupils investigated pendulums as suggested in "A Swinging Experiment" (N&S, *Jan. 6, 1968*), they are likely to begin by dropping the pendulum so it swings back and forth through the same arc. If the box "pins" are far enough apart and not in a straight line, the pendulum won't knock any more down after the first swing. Your pupils may discover, however, that giving the weight a sideways push as it is released will make the pendulum swing in ever-changing paths, so a box that is missed on the first swing may be knocked down in a later swing.

nature and science
TEACHER'S EDITION
VOL. 6 NO. 10 / FEBRUARY 3, 1969 / SECTION 1 OF TWO SECTIONS

◄ N & S REVIEWS ►

Recent Physical Science Books for Your Pupils

by Fred C. Hess

Questions About the Oceans, by Harold W. Dubach and Robert W. Taber (U.S. Naval Oceanographic Office Publications G-13, Superintendent of Documents, Government Printing Office, 121 pp., 55 cents). One hundred questions about oceanography are answered. The questions were raised by pupils and teachers visiting a science fair and are typical of many that would arise in your classroom. The answers are clear and direct, brief and to the point. While no attempt has been made to organize the questions by topic, both individually and collectively the answers to them make fascinating reading. Even the questions are useful. Oceanography is a new and exciting field of knowledge, and this little paperback provides a good introduction to it.

When Nature Runs Wild, by Thomas P. Johnson (Creative Education Press, 120 pp., $4.95), is a beautiful book dealing with the worst of man's natural enemies: earthquakes, volcanoes, landslides, avalanches, floods, tsunamis, hurricanes, tornadoes, drought, forest fires, radiation, and pollution. It vividly describes them and then explains what man can do about them. A section of experiments and projects dealing with these topics is included. A glossary, a bibliography of books and films, and an index round out a professional presentation that includes 150 well-selected photographs and diagrams. Available also in paperback form at $3.95, this should be a most useful reference work in your earth science library.

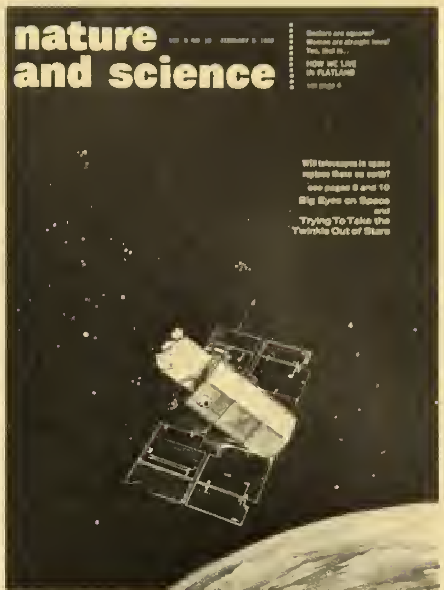
Dr. Fred C. Hess is a Professor of Physical Sciences at State University of New York Maritime College, Fort Schuyler, New York.

The King's Astronomer: William Herschel, by Deborah Crawford (Julian Messner, 192 pp., $3.50), is a lively biography of the "father of modern astronomy." Miss Crawford deftly draws the reader into the Herschel household to relive with Sir William and the talented members of his family his 83 years of achievement. His early career in music, his abiding interest in astronomy, his solar system discoveries, his relationships with other astronomers, his conception of the "island universe" are all vividly presented. Both the scientist and his science are humanized. Many will like it simply because it is an interesting story well told.

Famous Astronomers, by James S. Pickering (Dodd, Mead & Company, 128 pp., $3.50). The stories of 10 astronomers are used to chart the development of astronomy from its infancy up to, but not including, the modern era. These biographies present the astronomical ideas of the Greek philosophers Aristotle, Eratosthenes, and Hipparchus. Next, Ptolemy and his *Almagest* bring astronomy to its apparent death in 150 A.D. The rebirth of the science in the 16th century is portrayed through the stories of Copernicus, Tycho, and Kepler. Advancement into the 19th century is represented by biographical sketches of Galileo, Newton, and Herschel. All of these biographies are quite pleasant and would serve well to warm up and amplify those typically cold textbook biographical notes.

UFOs and IFOs: A Factual Report on Flying Saucers, by Gardner Soule (G. P. Putnam's Sons, 192 pp., $3.49), is a rea-

(Continued on page 3T)



IN THIS ISSUE

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

● **Which Way is Down?**
By varying the positions of sprouting seeds, your pupils can discover whether plant roots always grow down.

● **How We Live in Flatland**
Have your pupils try to see this imaginary two-dimensional world from a Flatlander's point of view.

● **Big Eyes on Space**
This WALL CHART shows how different kinds of telescopes work and tells why a telescope "sees" objects in space more clearly than your eye can.

Trying to Take the Twinkle Out of Stars
An astronomer tells about his adventures and frustrations in sending balloon-borne telescopes into the stratosphere.

Tale of the Torrey Canyon
A detergent "cure" for oil on troubled waters made the Torrey Canyon shipwreck a threat to life in the sea.

● **Brain-Boosters**

IN THE NEXT ISSUE

How a biologist explores life on a tiny Pacific isle... Winners in the Brain-Booster Mystery Object Contest... A WALL CHART showing how plants and animals are adapted for the renewal of life in springtime.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Which Way Is Down?

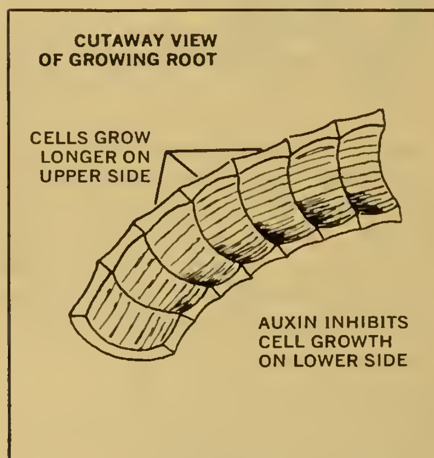
This SCIENCE WORKSHOP investigates the growth movements of plants, called *tropisms.* These movements can be either positive or negative; a plant or plant part may grow toward or away from the stimulus. For example, stems and leaves are positively *phototropic* (growing toward light) and negatively *geotropic* (growing away from the pull of gravity). Roots are negatively phototropic (growing away from light) and positively geotropic (growing toward the pull of gravity).

These movements are controlled by hormones called *auxins.* The hormones may stimulate or inhibit growth, depending on their concentration and the part of the plant they are acting upon. As a root grows, auxin is concentrated most in the cells that are in its lower surface *(see diagram).* The auxin slows the growth of these cells, so root cells on the upper side grow comparatively longer. This causes the root tip to curve downward toward the center of the earth.

For further investigations into plant tropisms, including phototropism and hydro- (water) tropism, see the book: *Discovering Plants,* by Richard M. and Deana T. Klein, Natural History Press, Garden City, New York, 1968, $4.50.

Activity

Set up three jar lids with soaked (imbibed) seeds as described in the text of the article. Leave one as a control with which to compare the others. Every three or four hours, rotate the other lids, turning one halfway around, the other about a quarter-turn. Measure the growth of the root and stem of each sprout in all three lids. Do the control beans grow any faster than the rotated ones?



Life in Flatland

This unusual and amusing article will surely stretch the imaginations of your pupils. It offers more than entertainment. Hopefully, your pupils will come away with an appreciation of the meaning of three-dimensional space and, perhaps, a respect for the limitations of their particular view of the world.

Topics for Class Discussion

- *How does the fog in Flatland help the inhabitants recognize one another?* It is their only way of perceiving depth. Can your pupils think of paintings in which the artist created the illusion of distance by making mountains or trees in the background hazy?

- *What would happen if the atmosphere in Flatland were to clear up?* The far edges of figures would appear as close as the near edges, giving everything the appearance of a straight line. Can perspective, which is another way artists depict space on a two-dimensional surface, be employed in Flatland? No, because the edges seen in Flatland have no thickness that can be diminished.

- *Does everyone in "Spaceland" see things from the same point of view?* Would an ant's view of the world be the same as that of a ten-year-old boy or girl? How might the world look to a baby in a playpen, or to a flagpole sitter? Can your pupils conceive of what it would be like to be blind?

Activities

- To further demonstrate the peculiarities of a world without height, have your pupils look at a photograph in a book. What happens to the image as they bring the edge of the book up to eye level? At what point does the picture become unrecognizable? Would living in Flatland be anything like looking at a room through the crack under the door?

- Have your pupils try to imagine a world without weight, or time, or death, or taste, and so forth. For instance, in a world without light, would we still have artists, or writers, or be able to drive cars? How would we have to change our ways of doing things? With such a discussion as a starting point, encourage your students to write a fantasy of their own.

Big Eyes on Space

You might have each pupil look through a small telescope (or one side of a binocular) at an object across the room; then, when the object is in focus, open the other eye and compare how the object appears with and without the help of the telescope. They can see that the object appears brighter and "sharper," as well as larger, through the telescope.

Some may suggest that perhaps the telescope eyepiece "magnifies" the brightness of the object as well as its size. This possibility can be investigated by holding a small magnifying glass over part of a shiny object, such as a spoon. Does the enlarged image seen through the lens appear as bright

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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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Women are straight lines?
Yes, that is...

HOW WE LIVE IN FLATLAND

see page 4

Will telescopes in space replace those on earth?

see pages 8 and 10

Big Eyes on Space
and
Trying To Take the Twinkle Out of Stars

nature and science

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PICTURE CREDITS: Cover, photo courtesy of Grumman Aircraft Engineering Corp., drawing by Joseph M. Sedacca; pp. 2-6, 8-9, 15-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 7, Lerner Marine Biological Laboratory; pp. 8-9, top: Yerkes Observatory photo, other photos from the Mount Wilson and Palomar Observatories; p. 10, NASA; p. 11, Project Stratoscope of Princeton University sponsored by NSF, ONR, and NASA; pp. 12-13, Barbara Schwarzschild; p. 14, United Press International; p. 15, photos by N. A. Holme; p. 16, photo by David Webster.

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

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■ You plant a seed in soil and a few days later new leav are reaching toward the sky. Below ground, out of sigh you know that roots are growing deep into the soil.

Do you suppose you could "fool" a seed into sendi roots up, instead of down? Does the position of a sprou ing seed affect the direction its roots and leaves grow?

You can find answers to these questions by setting up simple investigation using Red Kidney, Pinto, or anoth kind of garden bean (available at garden or hardwa stores). You can also use dried seeds that are used fo baking beans. These can be found at any grocery stor

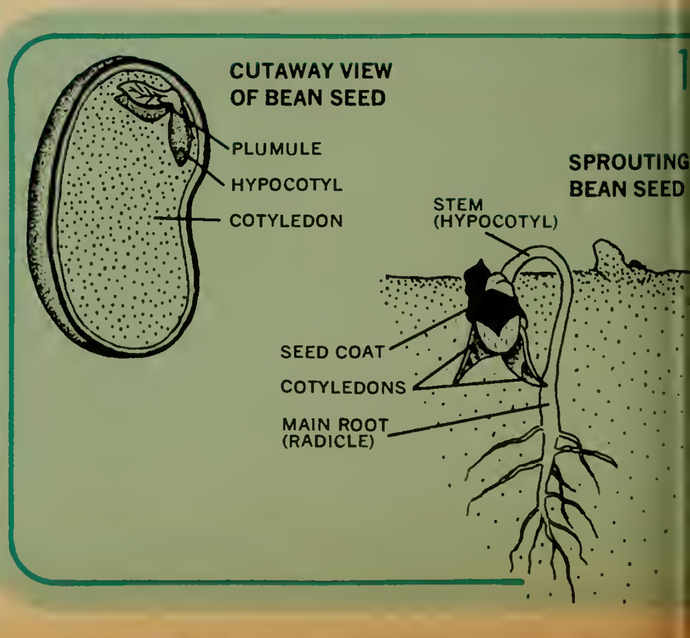
Soak Some Seeds

Soak several dozen beans in warm (not hot) wate They should be covered with two inches of water for a least four hours and for no longer than 12 hours.

Notice how much the seeds swell. Seeds also do th when they are planted in soil. Of course, if the ground i very dry, it takes longer for this swelling to take plac This process of soaking up water is called *imbibitio* Farmers sometimes speed the start of seedlings by soakin seeds before planting them.

After imbibition has taken place, peel off the outer coa of one seed to see what is inside. The outer coat may hav already split off. The two fat halves are called *cotyledon* *(see Diagram 1)*. They provide stored food for the plan until it is able to make its own food by the process calle *photosynthesis*. This process goes on in a plant's leaves. I requires energy from the sun, so it cannot begin until sun light reaches the leaves. If there were no stored food in th cotyledons, the young plant would die before it coul reach the ground's surface.

Between the cotyledons you will see a small pointe object at one end of the bean. This is called the *hypocoty* *(see Diagram 1)*. The tip of the hypocotyl (called th *radicle*) eventually forms the main root of the bean plant.



Using some bean seeds, jar lids, and cotton, you can find out if a sprouting seed always "knows" . . .

Which way is down?

; your seeds grow, be sure to watch the direction of dicle growth.

The tiny object inside the cotyledon, which looks like o tiny, folded yellow leaves, is the *plumule*. When the tyledons emerge from the ground, the plumule grows ge and turns green. The plumule is the beginning of the ves, stems, and buds of the bean plant.

You might wonder what a seed looks like before imbibi-n. Use a dull knife to split a dried seed. How does it mpare with a seed after imbibition?

ce the Light

The seeds will start to sprout soon after they soak up ne water. Take a cotton wad the size of a large marsh-mallow and wet it so that it is very damp, but not drippy. Flatten it and put it inside of a lid from a wide-mouthed jar. Place two seeds, facing the same way, on the cotton. Wrap some clear plastic (such as Saran Wrap) over the open side of the lid. The cotton should be thick enough to hold both seeds firmly against the plastic. Stretch the plastic tightly in back of the lid so that it is flat across the front and tape it firmly in place *(see Diagram 2)*. With a sharp pencil, punch four or five small holes in the plastic around the seeds (to let air in).

Diagram 3 shows how to put the seeds inside of several different lids. Maybe you can think of other ways to place your seeds.

Now prop the lids against a wall or window so that they are upright, facing the light. Beans grow best if they are in plentiful light and are at a temperature between 70° and 85° Fahrenheit. Don't put the lids against a window if the weather is unusually hot or cold.

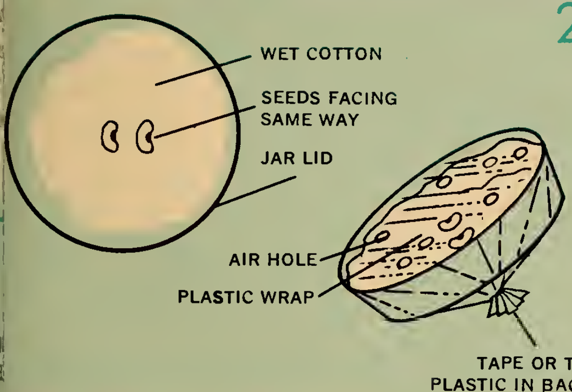
Start watching for hypocotyls and radicles to sprout from the beans. Which direction do they grow? Do they all grow in the same direction?

Perhaps you would like to try the same sort of investigation with other kinds of seeds. Smaller kinds of seeds should not be soaked as long. You might also try the same thing with "eyes" of potatoes. Cut each "eye" so that there is an attached piece of potato, about the size of a marble.

Do you think that farmers must worry about how they place their seeds in the ground when they plant them?

—NANCY M. THORNTON

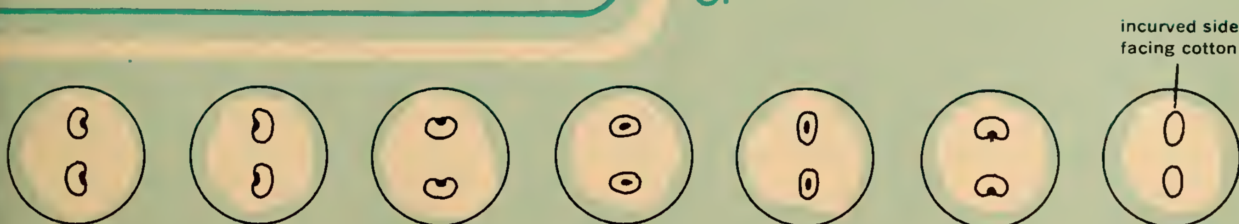
2.



INVESTIGATION

How well are radicles able to change their directions of growth? Set up two lids with soaked seeds as you did before. After the radicles appear, turn one lid halfway around, like a doorknob. Leave the other lid alone. Then watch the growth of the radicles every hour or two. What happens? How soon do you notice changes?

3.



Which way do the roots grow when you place bean seeds in these positions? The dots on the beans show the location of their incurved sides.

HOW WE LIVE IN FLATLAND

WHERE ALL PEOPLE ARE GEOMETRICAL FIGURES AND WOMEN ON THE MOVE ARE VERY DANGEROUS

ADAPTED BY ROY A. GALLANT

In 1884, an English clergyman and school headmaster named Edwin A. Abbott wrote an amusing book with the title Flatland. *The people in his story are geometrical figures—triangles, squares, pentagons, and so on. They live in a world of two dimensions, and to understand how they live as flat figures on a flat surface will make you do some hard thinking. You will have to leave your Spaceland world of three dimensions and imagine you are a Flatlander in order to see the world from their point of view.*

■ I call our world Flatland, although that is not its real name. Perhaps the word "Flatland" will help you, who are lucky enough to live in Spaceland, to understand something about our people.

Imagine a great sheet of paper on which are Triangles, Squares, Pentagons, Hexagons, and other figures. Imagine also that these figures are free to glide about on the surface of the paper, but they do not have the power to stand up, rise above, or sink below the paper. They are very much like shadows—only they are hard and have bright edges. Oh, how difficult it is to describe all of this to you.

You who live in Spaceland would find it easy to tell a Square from a Triangle. All you would have to do is look "down" on the figures. But in Flatland there is no "down," no "up," no such thing as "depth." Our people would not know what you meant if you used the expression "solid" object. In Flatland, a Square and a Triangle appear very much the same to us. They appear as Straight Lines. In fact, in our world everything appears to us as Straight Lines. Let me try to explain.

Place a penny on a table and lean over it, looking down upon it. It will appear as a circle *(see diagram).* But now, move back to the edge of the table and gradually bring your eyes down level with the penny. Half-way down you see an oval; then, when your eyes are level with the edge of the penny, you see a Straight Line. Perhaps now you are beginning to understand how we see things in Flatland.

The same thing would happen if you took an edge-on view of a Triangle, Square, or any other figure. It ceases to appear as a figure and to your eye is a Straight Line.

The inhabitants of Flatland are all figures, such as Triangles, Squares, and so on. But more about them in a moment. I would like to finish making my point about how we see each other. Imagine that you are a Flatlander and that a Circle friend, or a Triangle friend, is coming toward you. What do you see? Since there is no Sun in Flatland, or any kind of light that casts a shadow, we have none of the helps to sight that you have in Spaceland.

As your Flatlander friend comes closer to you, you see only a straight line. Imagine a yardstick, held flat and at eye level, moving toward you through your Spaceland air from the far end of a long corridor. The closer it floated toward you, the longer it would appear to grow. In the same way, as your Flatland friend approaches you, his line appears to become longer. And as he leaves you, it becomes shorter. All the while he looks like a Straight Line—be he Triangle, Square, Pentagon, Hexagon, or Circle. A Straight Line he looks, and nothing else.

At first thought you might wonder how we are able to tell one friend (a Square, say) from another (a Pentagon).

The People of Flatland

As I said earlier, in Flatland there is no such thing as "up," "down," or "depth." In Spaceland, you say that a

This article has been adapted from parts of the book Flatland, *by Edwin A. Abbott, available in paperback edition for $1 from Dover Publications, Inc., 180 Varick Street, New York, N.Y. 10014.*

friend is so many feet and inches "tall." In Flatland, we cannot measure ourselves in height, only in length. A full-grown Flatlander may be as long as about 11 inches.

All our women are Straight Lines *(see diagram)*.

Our soldiers and laborers are Triangles with two equal sides about 11 inches long. Their third side, or base, is rather short—often not more than half an inch, sometimes only a quarter inch. Soldiers and laborers are so very pointed that sometimes it is hard to tell them from women. A woman is a *one* dimensional figure, for she is all length.

Our middle class citizens are also Triangles—but each of their sides is the same length.

Our professional people are Squares; or sometimes they are five-sided figures called "Pentagons."

Next above these come the nobility, who have several shapes. The lowest in rank are six-sided figures, or "Hexagons." People higher in rank have more than six sides and are called "Polygons." Some people have so many sides, and each side is so short, that it is hard to tell them from a Circle. The Circle, of course, is the highest rank of all.

Our Dangerous Citizens

A Spacelander reading this might well think that the soldiers are the most "dangerous" members of Flatland, since they are highly pointed Triangles. Imagine bumping into a soldier at high speed. His sharp point could be very painful. Actually, women are much more dangerous—for they are *all* point, at least at their two ends. To add to the danger, they can make themselves all but invisible at will. A few words will make this clear.

Place a needle on a table. Then, with your eye on the level of the table, look at the needle sideways. You see the whole length of it. But look at it end-on and you see nothing but point. It has become nearly invisible. It is just so with a Flatland woman. When her side is turned toward us, we see her as a Straight Line. When she faces us, we see her only as a bright point; and when she walks away from us, we see nothing but a very dim point.

If running into a soldier produces a gash, imagine the danger of running into a woman! It means instant death. In some of the states of Flatland there is a law saying that women must not walk or stand in any public place without keeping their backs moving from right to left. To any one approaching a woman from the front or rear, this motion makes the woman visible as a line constantly becoming longer and shorter.

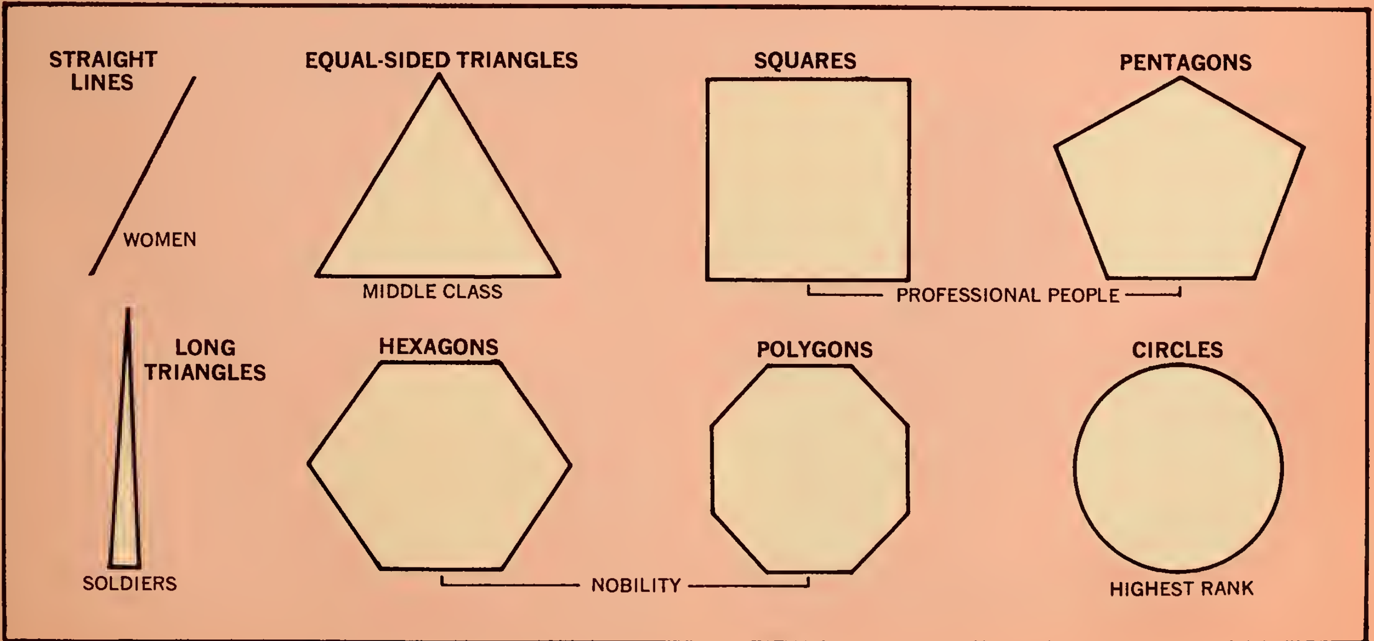
In one Flatland state, women are thought to be so dangerous that the following law was written: *Any Female suffering from St. Vitus's Dance, fits, violent sneezing, or any disease bringing on violent motions which she cannot control shall be instantly destroyed.*

How We Recognize One Another

You in Spaceland, who can see a whole circle, who can actually *see* an angle—how can I make clear to you the trouble we in Flatland have recognizing one another?

Recall what I told you earlier. All people in Flatland, no matter what their shape, *to our view* appear as a Straight Line. Fortunately, in addition to seeing, we have another way of recognizing one another. In a manner of speaking, we "shake hands," but it is really more like touching one another. If a Triangle and a Square are introduced and touch one another, each can tell the shape of the other. But

(Continued on the next page)

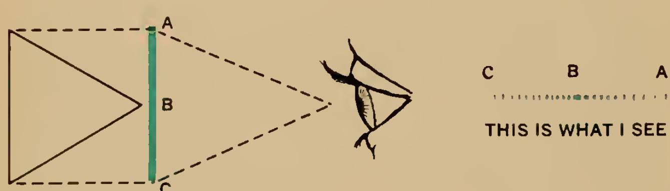


this becomes harder to do with people who have many sides. Imagine the difficulty of telling a 20-sided Polygon without touching the person all the way around!

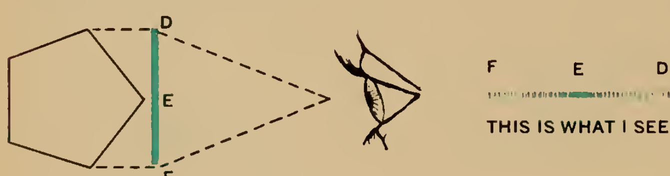
Even though each Flatlander appears to any other Flatlander as a Straight Line, still we can tell a Triangle from a Pentagon by sight. The reason we are able to is because there is nearly always fog in Flatland. Let me explain by giving you an example:

Suppose I see two people coming toward me and I want to know what shape they are. One is an Equal-Sided Triangle, and the other is a Pentagon. I see the Triangle as a Straight Line A,B,C *(see diagram)*. The mid-point B will be bright because it is nearest to me, but on either side—from B to A, and from B to C—the line will shade away rapidly into dimness because of the fog. So point A and point C, which are the Triangle's rear portions, will be very dim indeed.

I see the Pentagon also as a Straight Line, D, E, F. As in the case of the Triangle, I see the mid-point (E) of the Pentagon as a bright point. As I saw points A and C of the Triangle dimly because of the fog, I also see the Pentagon's points D and F dimly, because of the fog. But I see the Pentagon's far points *less* dimly because its sides do not go so deeply into the fog as the Triangle's sides do.



HOW I SEE THE TRIANGLE



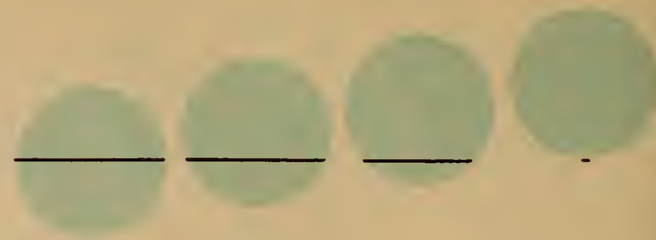
HOW I SEE THE PENTAGON

Recognizing each other by sight is not always easy. Suppose, for example, that my neighbor's son, who is a young Triangle, approaches me. But instead of presenting me with one of his angles, he happens to present one of his sides to me. I must then ask him to turn around, or I myself, have to edge my eye round him in order to see his shape. If I see him only from the side, I cannot tell if he is a Straight Line, in other words, a Woman.

A Visitor from Spaceland

Perhaps you have been wondering how I, an inhabitant of Flatland, am aware of your Spaceland, and have found the words to describe our world to you.

HOW I SAW THE SPHERE AS HE ROSE FROM MY SIGHT. HIS CIRCLE BECAME SMALLER AND SMALLER, UNTIL FINALLY HE VANISHED.



One evening—it was the last day of the 1999th year of our era—I was sitting in my study and felt a Presence in the room. A stranger suddenly appeared, as out of nowhere. I touched him and found him to be the most perfect Circle I had ever met. Clearly he was from another land, for he also talked of a world of *three dimensions,* meaning a world of length, width, *and* height.

Try as he did, the Stranger could not make me understand by words alone what he meant by "height." It is beyond our experience in Flatland. Finally, he said, "Now, sir, listen to me.

"You are living on a vast level surface, without ever rising above it or falling below it. I am not a flat figure, but a *Solid.* You call me a Circle. Actually I am many Circles of different size, but you can see only one of my circles at a time because you have no power to raise or lower your eye out of Flatland. In Spaceland I am known as a Sphere—a solid object.

"Now prepare for proof positive of the truth I speak. See now, I will rise. The effect upon your eye will be that my Circle will become smaller and smaller till it dwindles to a point and finally vanishes." *(See diagram.)*

There was no "rising" that I could see, but he grew smaller and smaller and finally vanished. I winked once or twice to make sure that I was not dreaming. But it was no dream. For from nowhere came a hollow voice: "Am I quite gone? Are you convinced now? Well, now I will gradually return to Flatland and you shall see my Circle become larger and larger."

It was through that action, and others performed by the Sphere, that I came to know about the wonders of Spaceland. It is now many years since that visit from the Stranger, and I am in prison, where I am to remain for the rest of my life.

I tried to tell our people about Spaceland, but they would not believe me. It was "dangerous" talk, they said, for the wisest among our Flatland thinkers say that there are only *two* dimensions—length and width. Perhaps someday, someone else from Flatland will learn the truth of Spaceland, as I have. Perhaps, also, that person will succeed in enlightening our people, where I have failed ■

WHAT'S NEW

by
B. J. Menges

Gold-coated airplane windows may seem like a publicity stunt, but they aren't. The gold coating could make the planes safer by preventing ice from forming on the windshield and blocking the pilot's vision. Gold's high ability to conduct electricity makes this possible.

The gold is heated until it melts, then boils and turns to vapor. Then it is applied to the window glass, where it cools and hardens into a film about two billionths of an inch thick. The film is so thin that it's transparent, but it's thick enough to carry an electric current. During high-altitude flight, an electric current is sent through the coating. This heats the window enough to keep it from icing up even at temperatures as low as -65° F.

The search continues for ways to treat virus diseases. Few drugs have any effect on viruses. But scientists have found that the body already contains a defense against viruses—a protein substance called *interferon.* Interferon seems to help a person to recover from a virus infection, but the body doesn't produce enough of it to cure the illness quickly.

Researchers at the National Institute of Allergy and Infectious Diseases, in Washington, D.C., have now found a man-made substance that makes the body produce more interferon faster. When rabbits infected with a virus-caused eye disease were treated with the substance, the amount of interferon in each rabbit increased enough to cure the disease rapidly. Experiments are now planned to find out whether this treatment can help cure humans of virus diseases such as influenza and some forms of encephalitis.

Sharks aren't so bad, suggests Dr. Perry W. Gilbert, a Professor of Zoology at Cornell University, in Ithaca, New York *(see photo).* After more than a decade of studying these fishes, he reports in *BioScience* that the dangers of their attacks on man are overrated. There are fewer than 100 shark attacks a year throughout the world, and only about half of them cause death. In contrast, bee stings kill about 150 people a year in the United States alone.

Furthermore, says Dr. Gilbert, sharks are of real value to man. Their meat is widely used as food in Japan, Australia, and Mexico. Their skins are made into high-quality leather that's stronger than pigskin or cowhide. And their bodies are being used in disease studies that promise to benefit man.

A twin trip to Mars is planned by the United States for 1971. Two spacecraft are to be launched in May of that year, go into orbit around Mars in November, and stay there for at least three months. The orbit of one spacecraft will cross the Martian equator at an angle of 60 degrees. As Mars rotates, this spacecraft will keep passing over different parts of the planet, so that it will be able to examine about two-thirds of the Martian surface.

The other spacecraft will pass almost over the planet's poles, getting a good look at the white polar caps, which are believed to be ice crystals. The craft may also view the two moons of Mars. Information sent to the earth by the two spacecraft could lay the groundwork for an unmanned landing on Mars in 1973.

Warmer sheep are the goal of scientists in Scotland. They hope to develop sheep that can stay warm in cold weather. Among sheep now in Scotland, some can stand the cold far better than others. The scientists will mate the cold-resistant sheep, and from their offspring will select and breed those sheep that are hardiest in cold weather. Carried out over many generations, this process may produce a new breed of "cold-weather" sheep.

Cold-hardy sheep would be valuable not only in Scotland, but also in Australia, where rain and cold kill many sheep after they are shorn, and in the Soviet Union, where sheep must now be kept indoors to escape the intense cold. Sheep farming could even become possible in areas of the world that are too cold for existing breeds.

A curtain of air bubbles can help to keep pollution away from beaches. Such a curtain has been tried out at a bathing beach in Stamford, Connecticut, that had been ruined by pollution. Pipes were placed under the water, surrounding the swimming area. When compressed air was released through tiny holes in the pipes, it created a barrier of bubbles in the water that kept out oil, garbage, bottles, and other wastes. Inside the barrier, another pipe released chlorine to purify the water.

This method could be useful in keeping swimming areas clean until the sources of pollution can be eliminated. Bubble curtains have already been used to solve other problems. They can keep ice from forming around ships at anchor. They have also been used in the Netherlands and in Norway to prevent salt water from entering fresh-water waterways.

This photo shows Dr. Perry W. Gilbert examining a mako shark at the Lerner Marine Laboratory, a field station of The American Museum of Natural History located in Bimini, in the British West Indies.

BIG EYES ON SPACE

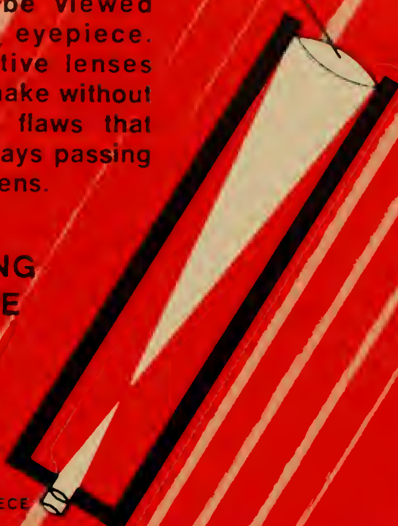
■ A telescope is more than a "magnifying glass." You might even call it a "super-eye," because it does the same thing your eyes do, only better.

When you look at a star, for example, the lens in your eye catches some of the light rays spreading out in all directions from the star. (The star is so far away that the rays reaching the earth are nearly parallel to each other.) As the rays pass through the lens in your eye, they are *refracted*, or bent, so they meet at a point on the back of your eye, forming a tiny *image*, or picture, of the star there.

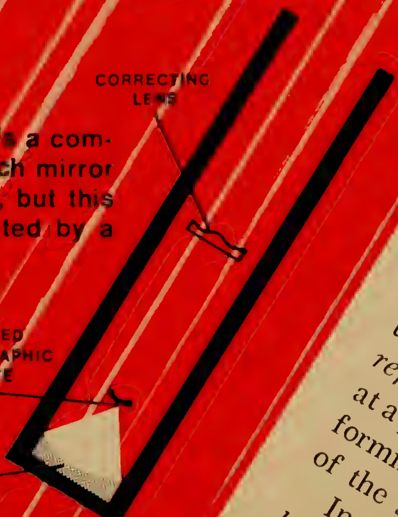
In the same way, the obj... *lens* of a *refracting*... forms a tiny imag... inside the tel... *diagram*)... scope...

The Yerkes Observatory telescope at Williams Bay, Wisconsin, is the world's largest refracting telescope. Its objective lens is 40 inches in diameter. The objective lens of a refracting telescope collects light rays from a distant object and bends them back together to form an image of the object inside the telescope where the image can be viewed through the eyepiece. Large objective lenses are hard to make without bubbles and flaws that distort light rays passing through the lens.

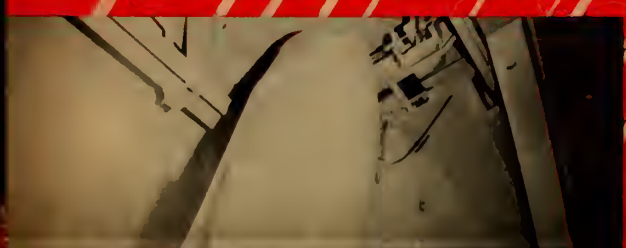
REFRACTING TELESCOPE

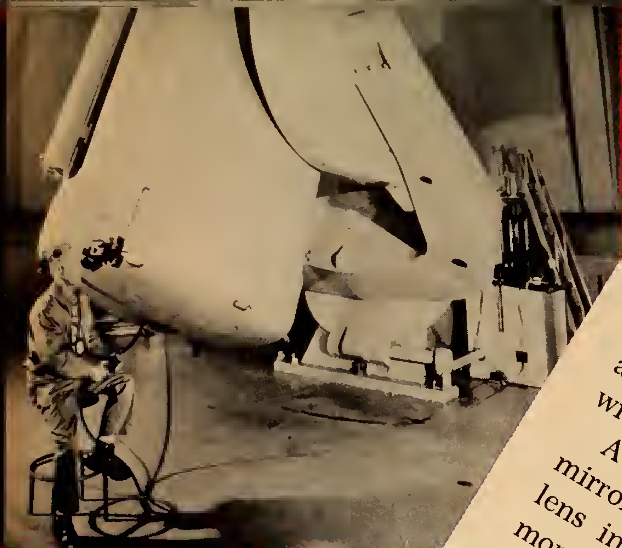


The "Big Schmidt" telescope at Mount Palomar is a combination refracting-reflecting telescope. Its 48-inch mirror is curved to provide a very wide view of the sky, but this causes distortions in the image that are corrected by a ripple-shaped lens above the mirror. The image is recorded on a photographic plate inside the telescope. This telescope is used to photograph large areas of the sky, which can then be studied in more detail through the Hale telescope.



SCHMIDT TELESCOPE





...*g tele-*
...formed by a
...*mirror* instead of
...*diagram*). In either
...telescope, the image can
...viewed through the eyepiece,
which is a magnifying lens, or it
can be recorded on photographic
film, using the telescope as a
camera.

You can see things through even a small telescope that you can't see without it—but not, as you might think, because a telescope makes things "look bigger." In fact, a star is so far away that even through a telescope it still appears to be just a point of light without any "width," or diameter.

A telescope's objective lens or mirror is much wider than the lens in your eye, so it catches more of the light rays from a distant object than your eye catches. This makes it possible to see objects such as stars and the moons of other planets that are too dim to see without a telescope. In addition, the telescope's wider lens or mirror *resolves*, or separates, distant objects that appear as a single object to your unaided eye. That is why you can see the mountains and craters on the moon with the help of even a small telescope or binocular.

With large telescopes like the ones shown on this chart, astronomers can see and study the light from stars and other objects in space that are billions of billions of miles away—far beyond the "reach" of your eyes alone.

—F.K.L.

REFLECTING TELESCOPE

B

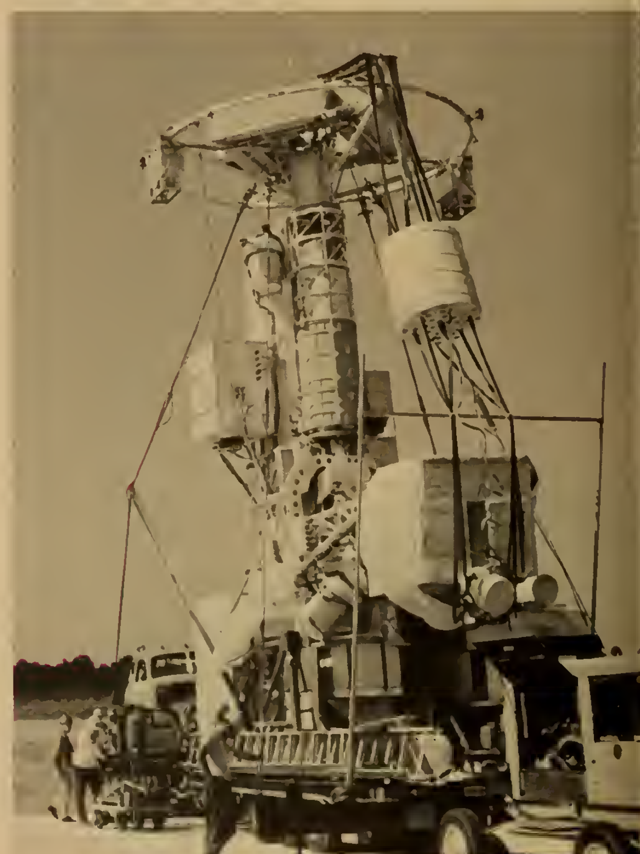
The Hale telescope atop Mount Palomar, near Pasadena, California is the world's largest reflecting telescope. Its curved objective mirror, 200 inches in diameter, gathers light rays from distant stars and forms an image of them inside the telescope that can be viewed or photographed through a hole in the center of the mirror (Diagram A) or from a "cage" mounted in the center of the top of the telescope (Diagram B). The mirror is so wide that an astronomer in the cage (*see photo*) doesn't block much light from reaching it.

Astronomers hoped to get their first really clear view of the stars through telescopes lifted high in the earth's atmosphere. An astronomer who helped send up the telescopes describes the difficulties that arose in . . .

Trying to take the twinkle out of stars

by Robert E. Danielson

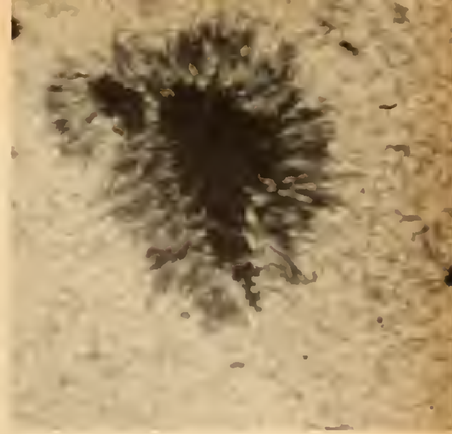
At lift-off, Stratoscope 2 hangs about 700 feet below its launch balloon. The slim white tube beneath the launch balloon is the main balloon, which inflates with expanding helium from the launch balloon as they rise through thinner and thinner air. Under the main balloon are the parachutes that return Stratoscope to earth. The photo below shows Stratoscope 2 on its mobile launch pad.



■ "Twinkle, Twinkle, Little Star" is a delightful song, but not to astronomers, who have long wanted to see the stars as they really are—without any twinkle at all.

The rapid dimming and brightening of starlight that we call "twinkling" is caused by disturbances in the "sea of air" that starlight must travel through to reach our telescopes near the "bottom" of that "sea." *(See "Discovering an 'Ocean' from the Bottom,"* N&S, *November 11, 1968.)*

Air masses of different temperature and density are continually moving around in the atmosphere, changing the amount of starlight passing through them and "bending" the rays of light in different directions. This makes the stars seem to twinkle, and—even worse for the astronomers—it blurs the images of stars seen through a telescope. Putting telescopes on mountain tops, above part of the earth's atmosphere, helps a little—but not enough.



Stratoscope 1 took the sharpest pictures yet made of sunspots. The one shown here is about 15,000 miles across—nearly twice the earth's diameter. Sunspots appear dark only because they are somewhat cooler than the surrounding parts of the sun's surface.

View from the Top

Dr. Martin Schwarzschild, a Professor of Astronomy at Princeton University, and I thought we could solve this problem if we could send a telescope high enough in the sky. So about 10 years ago we sent a telescope up 80,000 feet with a balloon. There in the upper atmosphere, called the *stratosphere,* the thin air did not blur the telescope's view of space. A camera on the telescope snapped the sharpest pictures ever taken of sunspots *(see photo).*

This balloon telescope, called Stratoscope 1, was so successful on its seven flights that we planned to send up a balloon carrying a telescope that was three times more powerful—Stratoscope 2. We wanted to measure the amount of heat given off by Mars, hoping to find evidence of life on that planet.

The first launch of Stratoscope 2 was on March 1, 1963. We controlled the telescope by sending radio signals to it from the ground. A television camera on the telescope sent pictures to our TV sets of what the telescope "saw." This flight was not perfect, though. The radio signals from the telescope were weak, and the instrument that was supposed to measure heat rays from Mars did not work as well as we expected. We found no evidence for or against life on Mars, but we did learn more about the planet's atmosphere.

We launched the second flight of Stratoscope 2 nine months later. We had tried very hard to correct the mistakes in the first flight, and we had succeeded. The entire flight worked perfectly! We measured the amounts of heat coming from the moon, Jupiter, and several stars, and learned a great deal more about these objects.

After this successful flight, we added more equipment so the telescope could take very sharp photographs. Stratoscope 2 was much more complicated now. The motors that turned the telescope to point at different objects had to work 100 times better. The telescope's focus had to be 100 times sharper. Also, we did not want the telescope to change the temperature of the air around it in the stratosphere. Temperature changes would cause the air to move and blur the images. So the entire telescope had to be at nearly the same temperature, and this temperature had to be close to the temperature of the air at 80,000 feet—about 67 degrees below zero Fahrenheit!

When the telescope reached the stratosphere, it would have to cool off before we could start taking pictures. The problem was that we knew some parts of it would cool more slowly than others. In fact, we found that the telescope's mirror, which was 36 inches in diameter, cooled so slowly that we would have to cool it *before* the telescope was launched.

Cooling It

It was not too difficult to cool the mirror before launching, but it was hard to keep it from frosting over in the humid air at the launch site—the National Center for Atmospheric Research Balloon Flight Station at Palestine, Texas. We kept the mirror sealed in a very dry enclosure and planned to open it only after the balloon was all the way up.

By early December 1964, all the preparations for the third flight of Stratoscope 2 had been made. A refrigerator kept the mirror cold. The day after we were ready, the winds were low enough to inflate the balloon with helium gas. But the tubes that carried helium to the launch balloon were 50 feet too short. Three days later we were ready to try again, but the weather was cloudy for several days. Finally, clear weather was forecast. We inflated the balloon and were ready to launch it, when the wind suddenly became much stronger. The launching crew struggled with all their might, but they could not prevent the balloon from acting like a gigantic sail. Disaster struck. The

(Continued on the next page)

Dr. Robert E. Danielson is a Professor of Astronomy at Princeton University, in Princeton, New Jersey.

delicate stratoscope was pulled apart by the sudden force of the wind on the balloon.

It took seven months of hard work before we were ready to launch again—in July 1965. The weather on the launch date was fine, but we had to cancel the flight because the balloon leaked! A new balloon was ready three days later, but we had to wait out thunderstorms that lasted for nine days. On the tenth day, Stratoscope 2 was finally launched.

While the balloon went up, we checked the television, radio, camera, and other equipment that was operated by remote control from the ground. Everything was working perfectly. It looked as if our years of work were going to pay off.

We were soon disappointed, though. When the balloon reached its high point, we tried to move the telescope by radio command. But the latch that held the telescope tube upright was jammed and would not let go. We finally had to give up and return the instrument to earth by letting some of the helium out of the balloon.

We examined the telescope very carefully to try to learn why it had jammed. We found out that the jammed latch had been caused by a failure in the device that kept frost off the mirror during launching.

Try, Try Again . . .

We were a little discouraged by this second failure, but we got ready to try another launch. The faulty device was replaced and Stratoscope 2 was ready for launching again on April 19, 1966. But it began to rain and there was a bad flood near the balloon base. We were not able to inflate the balloon until May 8. Then to add to our troubles, the balloon leaked again! It was May 14 before we finally launched it.

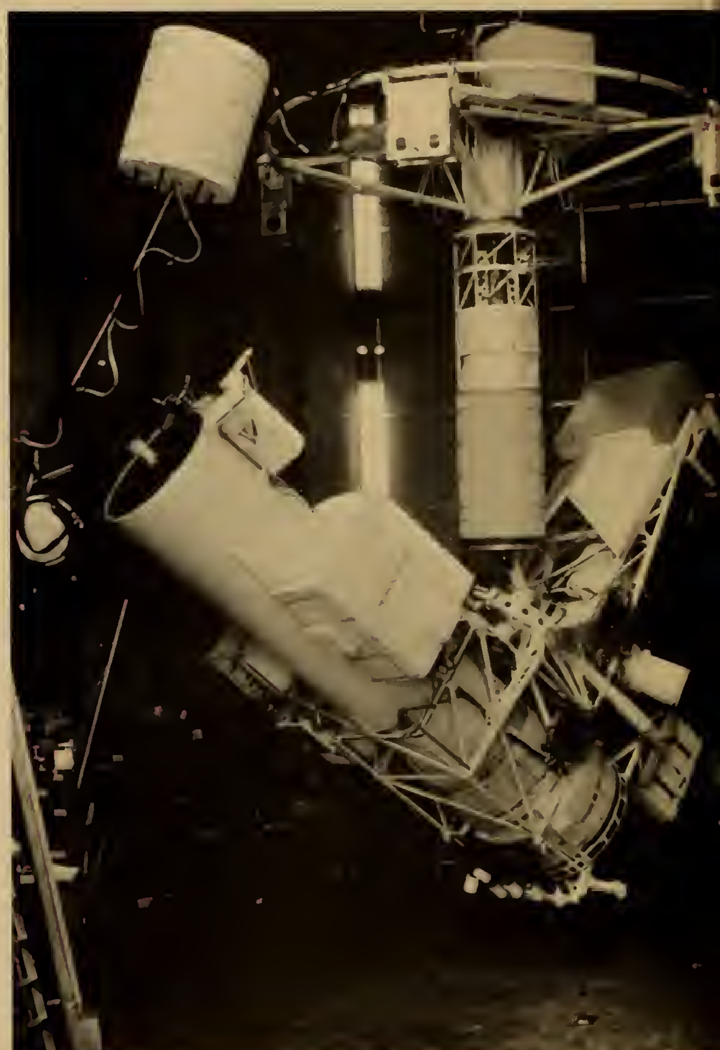
Everything worked perfectly after the balloon was up—until it came time to unlatch the telescope. It was jammed again! Hadn't we found what went wrong on the last flight?

The answer became clear during the next few days. The telescope had jammed for a completely different reason than before. As the stratoscope rises, very tiny steel balls—called *ballast*—are dropped to lighten the balloon so it will rise faster. One of the four ballast containers did not empty, and this made the telescope tilt. The tilt caused a small device to block the latch on the telescope tube.

So a chance series of events had caused our third failure. But was it just chance, or had the telescope become so complicated that it had little chance of working? A group of engineers from the National Aeronautics and Space Administration's Marshall Space Flight Center, in Huntsville, Alabama, was called in to go over our project. These engineers decided that many important parts of Stratoscope 2 would have to be improved before we could be sure that it would work each time.

The engineers who had built Stratoscope 2 finished making the improvements by September 1967. Then we put the entire telescope into a large test chamber where the air pressure and temperature were the same as they are at 80,000 feet.

This time we put Stratoscope 2 through practice flights in the chamber. We found several weak parts during the first practice flights, and changed the equipment to correct them. There were no failures during the last practice



This photo of Stratoscope 2 undergoing tests shows how it appeared "at work." The fat cylinder at the left is the telescope tube, with a 36-inch curved mirror at the bottom end to collect light from distant objects. A flat mirror inside the tube reflects the light out through the side of the tube to a camera and other instruments on the "arm" at the right.

flight, and we felt sure that we had made Stratoscope 2 much more reliable than before.

In February 1968 the telescope was tested on real stars. All of the mirrors and lenses in the telescope were carefully adjusted.

. . . And Again

Tuesday, May 14, we were ready to launch, but it was raining. We had to wait. Saturday morning was perfect, so we inflated and launched the balloon without any trouble. After it had reached 84,000 feet, we started operating the telescope. We held our breath when the radio signal was sent to unlatch the telescope tube. It worked! Then we signaled the telescope to turn toward a star on which we wanted it to focus.

We focused the telescope by moving one of its mirrors until the image of the focus star became sharp. But the image was not as sharp as we had expected. Could there still be blurring in the atmosphere above 84,000 feet? We did not think so. Instead, we decided that something in the telescope was much hotter or colder than it should be. We suspected it was the main telescope tube.

After we focused the telescope, we photographed a *galaxy*—a collection of stars, gases, and dust—and some *nebulae*—"clouds" of gas and dust. We took 160 photographs, hoping that a few of them would be sharp.

After Stratoscope 2 returned to earth, we developed the film. The pictures were more blurred than we had expected, and most of them were useless. Still, some of the photographs were the sharpest ones that had ever been made of the galaxy.

We now know why the pictures were blurred. The lower part of the telescope tube was about 50 degrees warmer than the upper part. We had tried hard to make sure that the entire telescope would be at nearly the same temperature. But we had not realized that the temperature would be so different in different parts of the telescope tube.

Dr. Robert Danielson, shown *(right)* at the ground control station during a Stratoscope 2 flight, has been interested in astronomy since he was a boy. He built three small telescopes while he was in high school. In 1958 he was doing graduate work at the University of Minnesota, in Minneapolis, when he found out that Dr. Martin Schwarzschild *(left)* was working on the Stratoscope program there. Dr. Danielson talked to Dr. Schwarzschild about the stratoscopes and joined the program that same year. Both are now professors at Princeton University, in Princeton, N.J.

What Now?

We hope to launch Stratoscope 2 several more times. But we are already designing telescopes that will be launched into orbit aboard large satellites or space stations in the 1970s. These telescopes will be completely free of the earth's atmosphere and should take even sharper pictures than our stratoscopes could. Many of the designs for the satellite telescopes are based on the design of Stratoscope 2.

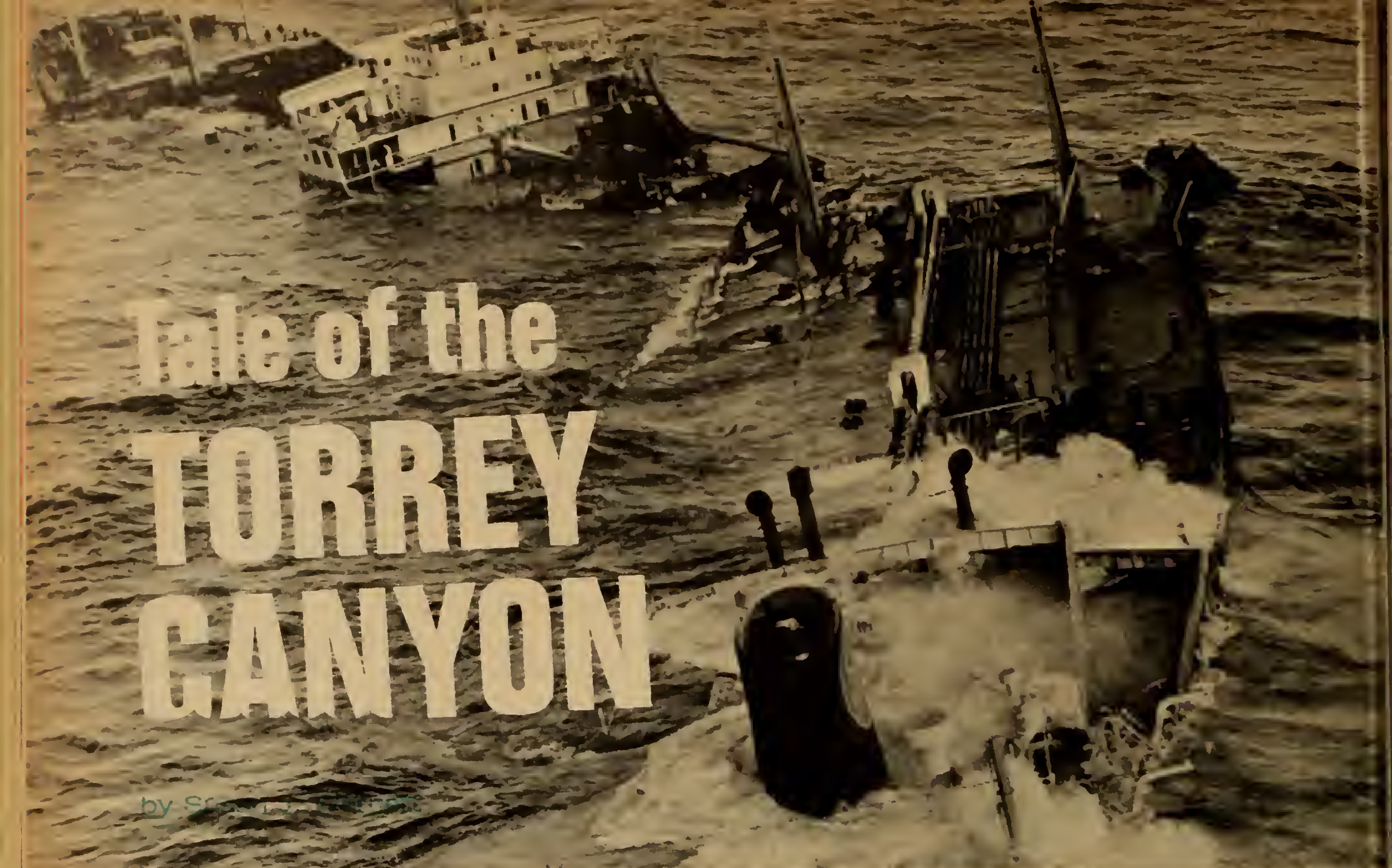
Some of the satellite telescopes will probably fail and some will succeed—just as our stratoscopes did. But what we have learned about building, testing, and operating balloon-borne telescopes should give the satellite telescopes a greater chance for success ■

TELESCOPES IN SPACE

The Orbiting Astronomical Observatory (OAO) shown on the cover of this issue carried 11 small telescopes into space last December. The telescopes are being aimed at young, hot stars, some of which are still being formed. These stars give off ultraviolet light, much of which is blocked from earthbound telescopes by the earth's atmosphere. By measuring the ultraviolet light given off by these young stars, astronomers hope to get clues to how the universe was formed.

Two more OAOs are scheduled to be orbited on similar missions—the third one carrying a telescope with a 32-inch reflecting mirror (see *"Big Eyes on Space," page 8*). Larger telescopes that are designed, like Stratoscope 2, to take sharp, clear photographs of objects in space may be sent into orbit in the 1970s, if funds are available.

Space telescopes will probably never replace telescopes at the earth's surface for continuous study of the stars. In fact, new ground-based observatories are being built now and more are planned for the future. Several of these telescopes will be in the southern hemisphere. The skies are usually clearer there than in the northern hemisphere, and the stars in the southern sky have not yet been studied very much through large telescopes.



Tale of the TORREY CANYON

by [illegible]

Chocolate-brown oil. Foamy detergents. Living things.
What happens when you mix these ingredients?

■ On March 24, 1967, beachcombers in southwest England cried, "We've found oil!" But their cry was one of dismay. This was oil from the *Torrey Canyon,* one of the largest ships in the world. It had been carrying 117,000 tons of oil when it struck a rocky reef a week earlier.

Resort-owners, fishermen, and many other people were afraid of the oil. They knew what damage it could do, for man has spilled oil in the oceans before. The ships that carry oil sometimes leak it into the sea, and illegally wash their empty oil tanks at sea. Oil tanker accidents dump even larger amounts. The oil from the wreck of one tanker wiped out the entire oyster population of Narragansett Bay in Rhode Island. Oil pollution has killed many sea birds near the harbors of New York City.

When oil from the *Torrey Canyon* reached land, government officials decided that detergents would be the quickest cure. These chemicals help oil and water to mix. The officials hoped that detergents would make it easier for the waves to wash away the oil. So planes swooped down to spray the beaches with detergents. Housewives used their kitchen soaps, and children poured detergents from beach pails. But now, it looks as if the "cure" was worse than the pollution itself.

A New Carpet

Luckily, biologists at Durham University in England had been studying life along the southwest coast less than a year before the wreck of the *Torrey Canyon.* Seven months after the wreck, the biologists made new studies

so that they could compare the ocean life before and after the wreck.

Many of their studies were made on rocks that are covered by water at high tide and uncovered at low tide. The biologists found one dramatic change on the rocks. Those rocks that had been treated with detergents were covered with masses of green *algae*, tiny water plants. Before the pollution, they had not had this green "carpet." Neither did the rocks where the oil had not been treated with detergents (*see Photos 2 and 3*).

The green algae grew quickly on the detergent-treated rocks because the animals that usually eat the algae had been killed by the detergent. The *limpet* is the main algae-eater on rocks along the English coast. It is a small, slow-moving animal covered with a cone-shaped shell *(see Photo 2)*. And, sure enough, the biologists found no adult limpets on the detergent-sprayed rocks that they studied. But many limpets survived on the rocks that had been polluted by the oil alone.

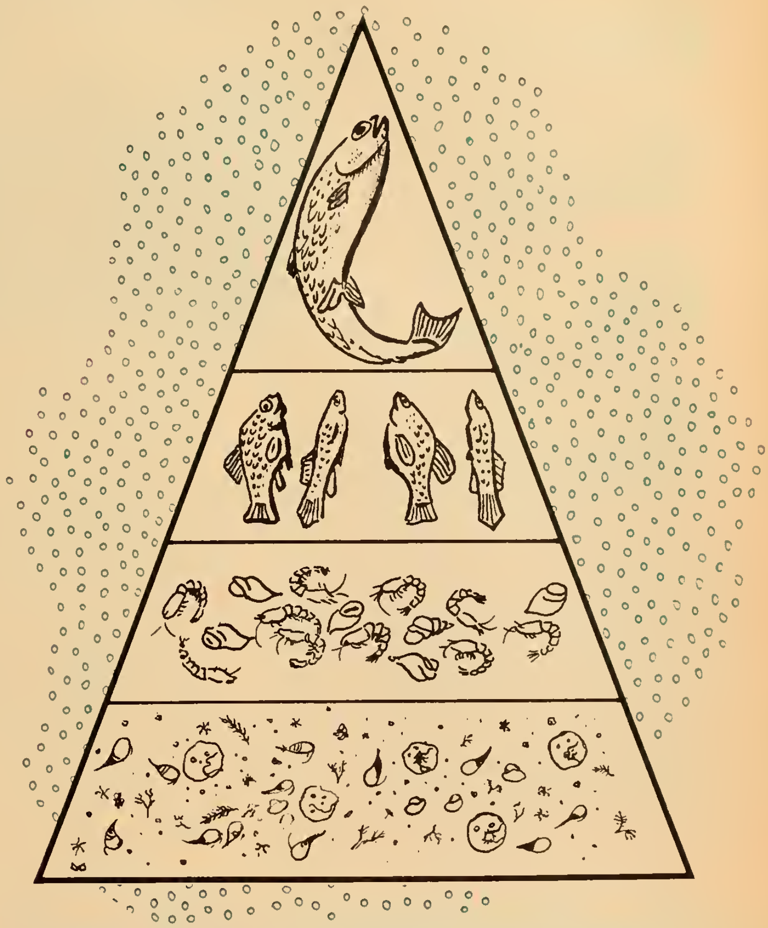
Get Whiter Plankton?

The detergents seemed to have killed the limpets. But their effects might be even more disastrous. Biologists working at the Marine Biological Laboratory in Plymouth, England, discovered that only one part of detergent in a million parts of sea water can kill some kinds of *plankton* —the tiny living things that drift in water.

Many plankton are so small that they can only be seen with a microscope, but their importance is great. They are the main food of many kinds of whales. More important, they are also eaten by small fish and many other animals. Then larger fish eat the plankton-eaters, and still larger animals eat the large fish *(see diagram)*. Because the survival of one group depends on others, death of the plankton in the sea may mean death for many other kinds of living things.

How harmful the detergents have been to life along the English coast may not be known for several years. Meanwhile, half a million tons of oil are spilled in the seas each year. A safe way for cleaning up this oil is needed.

One possible treatment is now being investigated by scientists at Cardiff University, in England. They have mixed certain chemicals with ashes. The mixture makes oil droplets clump together. If certain oil-destroying bacteria can be mixed with the chemicals and ashes and dumped on an oil spill, it might be possible to get rid of the oil quickly. This could be a cure for oil pollution, and one that isn't a threat to life in the oceans ■

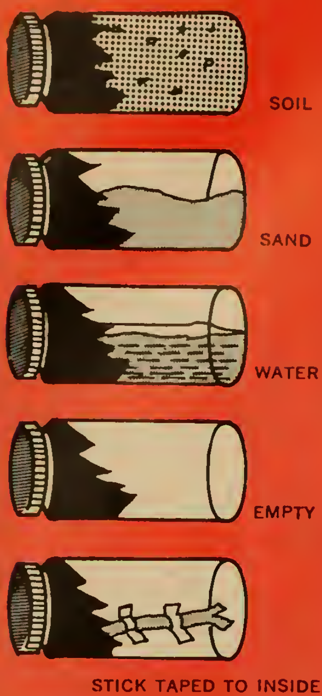


The tiny plants and animals called plankton are eaten by larger animals, which in turn are eaten by still larger animals. The plankton are like the base of a pyramid; without them, all of the animals above the base could not live.

tish sailors sprayed detergents on ches (1) in order to get rid of the On rocks that were not sprayed h detergents (2), animals such as pets (the large-shelled animals in photo) were not killed. On rocks ayed with detergents (3), the lims were killed and the rocks were ered with thick growths of algae light-colored areas in the photo).

BRAIN-BOOSTERS

prepared by
DAVID WEBSTER



Just for fun

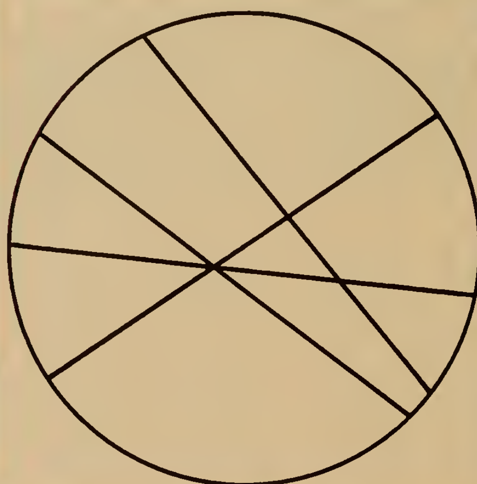
Make some jars that roll in funny ways (see *diagrams*). Paint them black so no one can see what is inside. Roll the jars across the floor and see whether anyone can guess what is inside each one.

Mystery Photo

What causes white lines like this to form near melting piles of snow along the road?

What will happen if?

Put an ice cube into a small strainer and hang it over a pan on the floor. As the ice cube begins to melt, count how many drops of water drip into the pan in, say, one minute. When the ice cube is almost all melted, will the water be dripping slower, faster, or the same number of times each minute as when the cube began to melt?



Fun with numbers and shapes

The four lines drawn divide the circle into 9 parts. Can you divide a circle into 11 parts with 4 straight lines? Into 16 parts with 5 straight lines?

For science experts only

Why does a chunk of ice slowly lose weight even when it is kept at a temperature below freezing?

Can you do it?

Fill a soda bottle with water and put a straw into it. Then take some clay and pack it into the bottle opening around the straw. Now can you drink any water through the straw?

Submitted by Mary Krebsbach, Lake Crystal, Minnesota

ANSWERS TO BRAIN•BOOSTERS IN THE LAST ISSUE

Mystery Photo: When water is under pressure in pipes, there is a lot of air dissolved in it. When the water comes out of the faucet, it is no longer under pressure, so the air comes out of solution and forms tiny bubbles. Is this the same reason that soda pop fizzes when you open the bottle?

What will happen if? Even though the jar of water is turned upside down, the fish inside it won't be. (Can you guess why?) If a fish *is* turned upside down, it will turn right-side-up immediately

Can you do it? To break a toothpick held between three fingers, slap your hand down on a desk or table

Fun with numbers and shapes: Path C would be the one made by a pebble caught in a bike tire.

For science experts only: The girl was born in the southern hemisphere in December, January, or February. In the southern hemisphere it is summer during these months. She now lives in the northern hemisphere, where December, January, and February are winter months.

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

as the rest of the spoon? Can anyone explain what the lens does to the light from the spoon? (The magnifying lens does not change the amount of light that is reflected from the spoon to your eye. It just spreads the light rays farther apart, so they form a bigger image inside your eye. But the larger the image, the less light there is at each point of it. So the more you "magnify" an object, the dimmer it appears. An object appears brighter through a telescope because the lens of a telescope is larger than the lens of your eye, so it lets in a greater amount of light.)

Your pupils can use their own eyes to test the benefits of larger objective lenses or mirrors in telescopes. While they are looking at any object, have them very slowly close and then open their eyelids, letting less and then more light through the lenses of their eyes. They will see that the less light their eyes receive from an object, the dimmer and the more "fuzzy" it appears. As their eyelids gradually let in more light from the object, its increasing brightness and clarity may make it appear closer—as if they were seeing it through a telescope.

Brain-Boosters

Mystery Photo. Snow piles along the road often contain the remains of salt that was used to melt ice on the road. (Salt lowers the melting point of ice, allowing it to melt at temperatures below normal freezing.) As the snow melts, salty meltwater flows away from the snow. When the water evaporates, the salt is left behind in a white line.

You can demonstrate this for your class by putting a little mound of snow or crushed ice mixed with salt on a piece of glass or plastic indoors. A white salt deposit will be visible after the meltwater evaporates. If you place some of the salty meltwater under a microscope, your pupils will be able to watch the salt crystals forming.

What will happen if? As an ice cube melts and gets smaller, a smaller surface area is exposed to the air, so the ice cube melts more and more slowly. This can be demonstrated while the class is engaged in some other activity, since it will take some time for the ice cube to melt completely. Every five minutes, have a pupil count how many drops of water fall from the ice cube in one minute. The numbers can be entered on a chart, and then one of the pupils can draw a line graph to show the decreasing "drip rate."

Can you do it? If no air can get past the clay plug in the neck of the bottle, it will be impossible to suck much water through the straw. Any small amount of water that could be sucked out of the bottle would leave that much more room for the air in the bottle, allowing the air to expand, and decreasing its pressure. The low air pressure in the bottle would then be insufficient to push out any more water. (For more information on air pressure and its effects on liquids, see "Discovering an 'Ocean' from the Bottom," *N&S*, Nov. 11, 1968.)

Ask your pupils why their mothers probably make two holes in the top of a juice can before emptying the can. What happens if you make only one hole in the can?

Fun with numbers and shapes. Here is how to divide a circle into 11 parts with 4 lines, and 16 parts with 5 lines:

After the class has puzzled over these problems, you might put the following table on the board:

number of lines	**1**	**2**	**3**	**4**	**5**	**6**
parts into which circle can be divided	**2**	**4**	**7**	**11**	**16**	**?**
increase in number of parts		**2**	**3**	**4**	**5**	**?**

The class should be able to see that if the progression continues, they should be able to divide a circle into 22 parts with 6 straight lines. Can they do it?

For science experts only. Most solids *melt* into a liquid before *evaporating* into a gas. A few substances, however, can bypass the liquid stage, changing directly from solid to gas through a process known as *sublimation.* Moth balls and iodine crystals can do this, and so can ice that is kept from melting by freezing temperatures.

Ask your pupils whether they have ever noticed vapor rising from an ice cream vendor's open truck during the summer. The "dry ice" (frozen carbon dioxide) that is used to keep the ice cream cold sublimes into carbon dioxide gas, without producing a liquid that would get the ice cream wet.

Just for fun. After your pupils have tried filling jars with the materials suggested and seeing how this affects the ways the jars roll, you might ask them to bring in some "mystery jars" containing other substances or objects. The children can have some fun rolling each other's black-painted jars and trying to guess what is inside each one.

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

sonable book. Mr. Soule presents this controversial topic with the skill of a true reporter. Where a sighting of an Unidentified Flying Object generates excitement, he generates excitement. Where cold and logical techniques of investigation change a UFO into an Identified Flying Object, he presents cold facts. Where mystery remains, he leaves mystery. Far from taking sides in this controversy, Mr. Soule carefully outlines steps that have been successful in solving some of the UFO puzzles, and with equal care he points out cases where investigations have failed and the UFOs remain unidentified. The reader is drawn into each case, and as a result, he is likely to enjoy the experience.

Mars, Planet for Conquest, by Eric Bergaust (G. P. Putnam's Sons, 96 pp., $3.29), is for your older and space-conscious pupils. The general reader would not find it suitable, for its facts are quite abruptly presented; its terminology is often far beyond its brief glossary; and its illustrations are only remotely related to the text. There is also vagueness here, much of it forced by our vague national program for planetary exploration. Nevertheless, scientifically oriented pupils should be able to gain much from this book, particularly about the techniques for searching for life beyond the earth and about propulsion systems for manned vehicles being designed to reach other planets.

On Course! Navigating in Sea, Air, and Space, by S. Carl Hirsch (The Viking Press, Inc., 157 pp., $4.13), really should
(Continued on page 4T)

N&S REVIEWS...
(continued from page 3T)

become part of your library. A combination of careful scholarship and good writing, plus interesting illustrations by William Steinel, make this book a delight for both pupil and teacher. From the voyages of the ancient Pytheas to those of the men of Project Apollo, the story of navigation is cleverly presented. Mr. Hirsch has brought to life cabin boys speeding up time; a prince whose quarterdeck was a rock; the incredible Columbus with his letter of introduction to the Great Khan of China; the non-sailors like Mercator, the chart-maker, and Harrison, the clock-maker. From the angles of Bowditch to the inertial guidance of the submarine *Nautilus*, the story of navigation is there, fascinatingly presented.

Baseball-istics, by Robert Froman (G. P. Putnam's Sons, 128 pp., $3.49). Here is physics in a setting: the year 2000, when the Senators and the Mets finally reach the World Series. The mechanics of baseball are cleverly explained in an account of the big game: the reality and illusion of how a pitch curves, speed vs. velocity, pitching and gravity, momentum and its exchange in the home run, acceleration distribution during a triple play, the knuckle ball, spikes and friction. Entertaining and informative, though for a true baseball fan, the ending gets a little out of hand.

Take a Balloon, by A. Harris Stone and Bertram M. Siegel (Prentice-Hall, Inc., 62 pp., $3.95), poses questions involving simple principles of mechanics, electrostatics, sound, optics, and heat; shows how to investigate these questions with the aid of balloons; and then poses more questions for further investigation. Inquiry and self-learning are stressed. It is well done.

Secret Codes and Ciphers, by Bernice Kohn (Prentice-Hall, 72 pp., $3.95). Children from 8 to 12 will find challenge and intrigue in this fascinating book about the art of "secret writing." The book covers the difference between codes and ciphers, different types of ciphers, some of history's most famous codes, and the art of the cryptanalyst. It shows children how to solve some simple ciphers and make up their own codes and ciphers. Illustrations by Frank Aloise and large print add to the book's appeal. Much rainy-day fun here. —M.E.B.

nature and science

TEACHER'S EDITION

VOL. 6 NO. 11 / FEBRUARY 17, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Pacific Isle

Islands hold a special fascination for man, and biologists have learned a great deal about life in general by studying the special conditions on islands. Charles Darwin's observations of life on the Galapagos Islands, off the western coast of South America, were vital in the formation of his theory of natural selection.

The water that surrounds an island acts as a barrier to life that might reach it. The more isolated an island, the less chance that it will have a variety of life. Even when a seed or spore from a plant is carried thousands of miles on the wind, it may not survive when it lands on an island. The environment there will be suitable only for certain kinds of plants; also, a newcomer may not be able to compete with established plant life.

Birds reach islands much more easily than most other kinds of animals, and oceanic islands such as Kure often have great numbers of birds living on them. There would be far fewer birds living there, however, if they had to depend on the island for all of their needs. But the sea provides the food; Kure is used for resting and nesting.

Topics for Class Discussion

• *How has man affected the distribution of life in the world?* He has circumvented all the major barriers, carrying a variety of life—from viruses to rats—with him. Scientists are trying to sterilize space probes to the moon and Mars so that we can learn something about their environments before they are contaminated by life from the earth.

The author mentions how a rat, perhaps introduced by man, is affecting the bird life of the island. You might discuss with your pupils the "good" and "bad" effects of other organisms which man has introduced into new environments *(see "The Animal Movers,"* N&S, *Oct. 2, 1967).*

• *Why can only a limited number of species of birds live on Kure?* What an organism does in a community is called its *niche*. This may include its nesting place, food, feeding method, and feeding time and place. No two species can occupy the exact same niche; eventually one species will not survive the competition. If Kure were larger, with a greater variety of terrain and plant life, it would provide more niches for birds (and other animals) to exploit.

For Your Reading

• *Island Life,* by Sherwin Carlquist, Natural History Press, Garden City, New York, 1965, $9.95.

• *The Alien Animals,* by George Laycock, Natural History Press, Garden City, New York, 1966, $4.95.

• *Surtsey: The New Island in the North Atlantic,* by S. Thorarinsson, Viking Press, New York, 1967, $6.

A Look at Lenses

Investigating lenses is fun, and much easier than your pupils might think on first glance at this SCIENCE

(Continued on page 2T)

IN THIS ISSUE

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

IN THE NEXT ISSUE

What we know about the birth and death of stars, an article and WALL CHART by Roy A. Gallant... Studying the birds of Kure Island... A SCIENCE WORKSHOP investigation of memory... The mystery of the common cold.

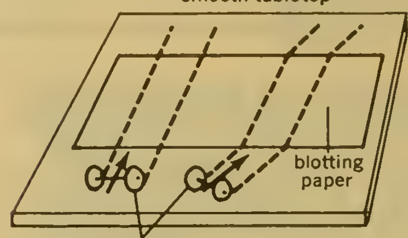
Using This Issue . . .
(continued from page 1T)

WORKSHOP article. Besides finding out how to make a simple telescope and microscope, they can use their findings to formulate some general rules about how convex lenses form images.

Suggestions for Classroom Use

Most of your pupils probably have access to a "reading glass" or some other type of magnifying lens; even a plastic one will do.

- To stimulate interest, have your pupils describe what they see as they (1) move the lens from eye to arm's length while looking through it at an object across the room; (2) with eye to lens and lens against a printed page, slowly raise head and lens together from the page; (3) with eye at different distances from the page, move the lens back and forth from page to eye. The objects they observe through the lens will appear sometimes blurry, sometimes sharp; sometimes rightside up, sometimes upside down; sometimes reduced, sometimes enlarged in size; sometimes they disappear altogether.
- To emphasize the refraction of light beams moving from water into air *(Diagram 1, page 14)*, place one end of a ruler on the penny in the water and move the ruler so that it "crosses the border" (surface of the water) at different angles. Your pupils can see that the part of the ruler in the water appears bent.
- To help your pupils visualize how a light beam is refracted, get an axle with two wheels from a toy car or train, or you can make one with a dowel and two "wheels" from a Tinker Toy set. Place a strip of desk blotting paper on a smooth tabletop and roll the axle across the blotter as shown



here. When one wheel (side of light beam) moves from the tabletop (air) onto the blotter (water or glass) and slows down before the other wheel slows down, the axle tends to change direction. Also roll the axle from the blotter to the tabletop at different angles.

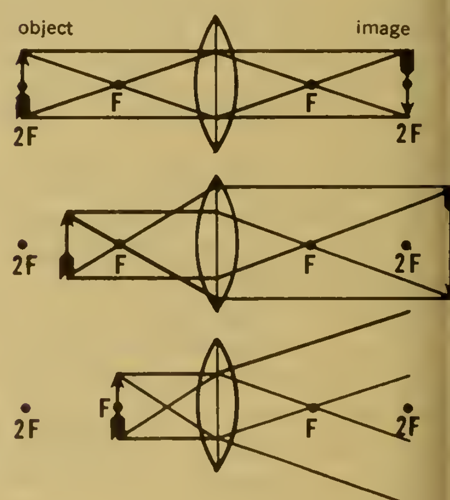
- To see how parallel beams are focused by a convex lens *(Diagram 3)*, chalk dust slapped from an eraser is handy for making beams visible in the dark. Have your pupils punch four more holes in the foil, forming a circle around the center hole. They can see all these parallel beams form a cone between the lens and its focal point, showing that beams do not have to be in a single plane (or "lined up") to be brought to a focus. Have your pupils tip the lens so it is not parallel with the flashlight face and see what happens. (The focal point moves, but its distance from the center of the lens remains the same.)
- Finding the focal distance of a lens by focusing beams of light from a distant object on a screen is fun and easy to do *(see Diagram 4)*. Some of your pupils may know that beams of sunlight focused in this way can produce enough heat at the focal point to burn a hole in the "screen."

Your pupils will notice that the image of a distant object formed by the lens is upside down and much smaller than the object itself. Can anyone guess what common tool uses this particular image-forming ability of a lens? (A camera lens forms an upside-down image on the film to record a picture of a scene or object.)

- Have your pupils project an image from a flashlight face as shown in Diagram 5, then try to complete the paths of Beams C and D in Diagram 6. (C passes through the focal point on its way to the lens, so it leaves parallel to the lens's principal axis. D travels to the lens parallel to that axis, so it passes through F on the other side of the lens.)

Explain to your pupils that for diagraming purposes, a thin lens can be treated as if all the refraction takes place halfway through the lens (at its *vertical axis*), as shown in Diagram 6 and on page 16. The true refraction can then be shown by a line connecting the points where the beam enters and leaves the lens.

- Have your pupils see what happens to the image when the object is placed at other distances from the lens, as suggested in the article, then try to diagram the paths of light beams from the top and bottom of the object in each case (as shown below). By repeating these tests with lenses of different focal lengths, they should be



able to summarize their findings in some general rules about convex lenses, in substance:

If two convex lenses have about the same diameter, the "fatter" lens has the shorter focal distance. For each particular distance of the object from the lens (down to the focal distance or closer) a sharp, upside-down image of the object will form on a screen at a

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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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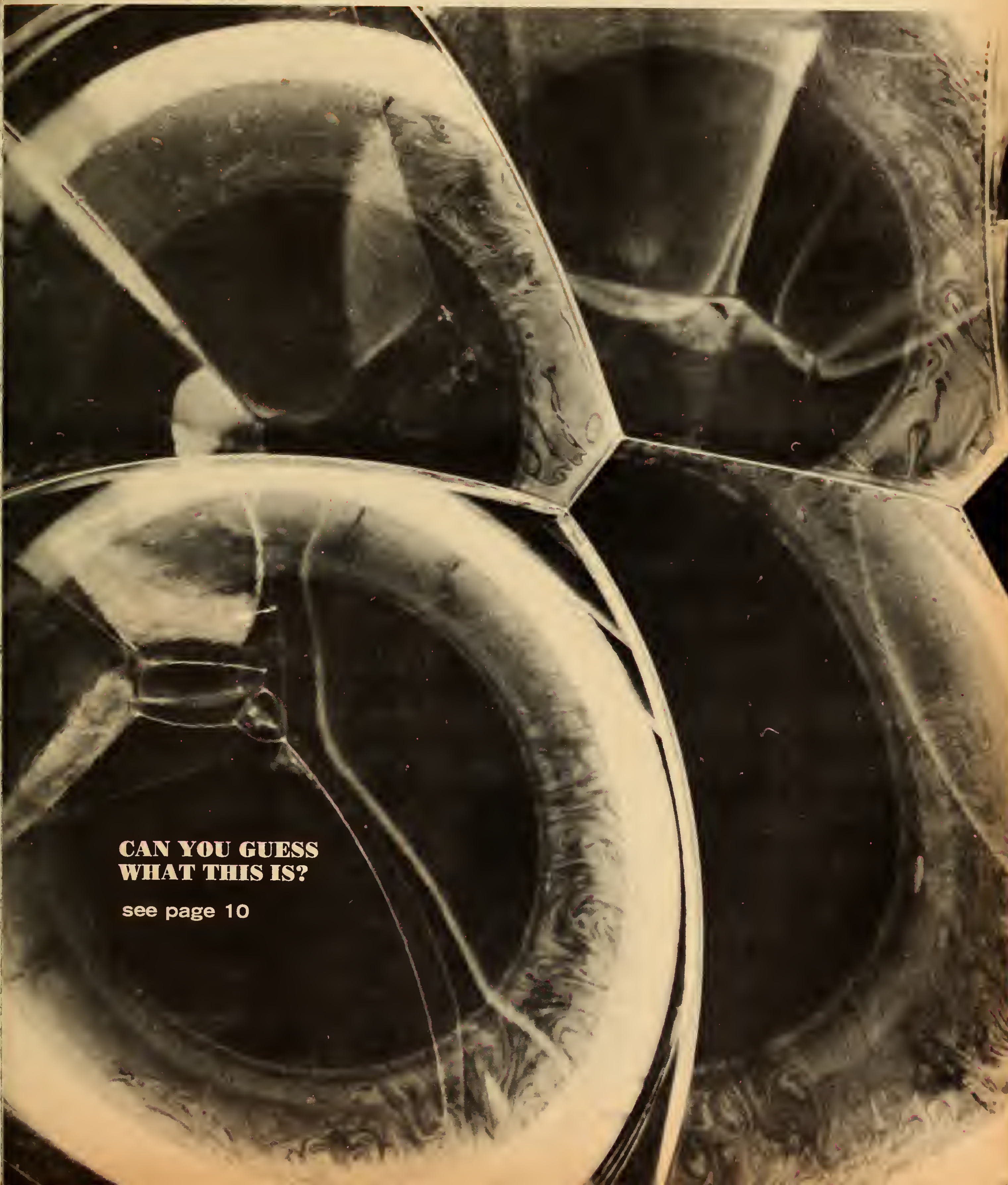
VOL. 6 NO. 11 / FEBRUARY 17, 1969

You can make a simple projector, a telescope, and a microscope with two magnifying lenses.

see page 14

A LOOK AT LENSES



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PICTURE CREDITS: Cover, Fundamental Photographs; pp. 2-3, William Wirtz; p. 4, top, Allen D. Cruickshank, middle, O. S. Pettingill, bottom, T. M. Bailey, all from National Audubon Society; p. 5, top, T. M. Blackman, from National Audubon Society, middle and bottom, Alan H. Anderson, Jr.; pp. 6-12, 14-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 6, photo by Dave Webster; pp. 7, 8 (top), 9, photos by Leonard Lee Rue III; p. 8 (bottom), photo by R. D. Muir, from National Audubon Society; p. 10, Franklyn K. Lauden; p. 12, (1) Wendy Levoy, (2) Marcus Levitt, (3) Jim Donohue; p. 13, Victor Stokes; p. 15, photo by Roy A. Gallant from Science Photo/Graphics, Ltd.

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 EDITOR R. J. Lefkowitz; ASSISTANT EDITORS Margaret E. Bailey, Susan J. Wernert; EDITORIAL ASSISTANT Alison Newhouse; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Donald B. Clausen • CONSULTING EDITOR Roy A. Gallant

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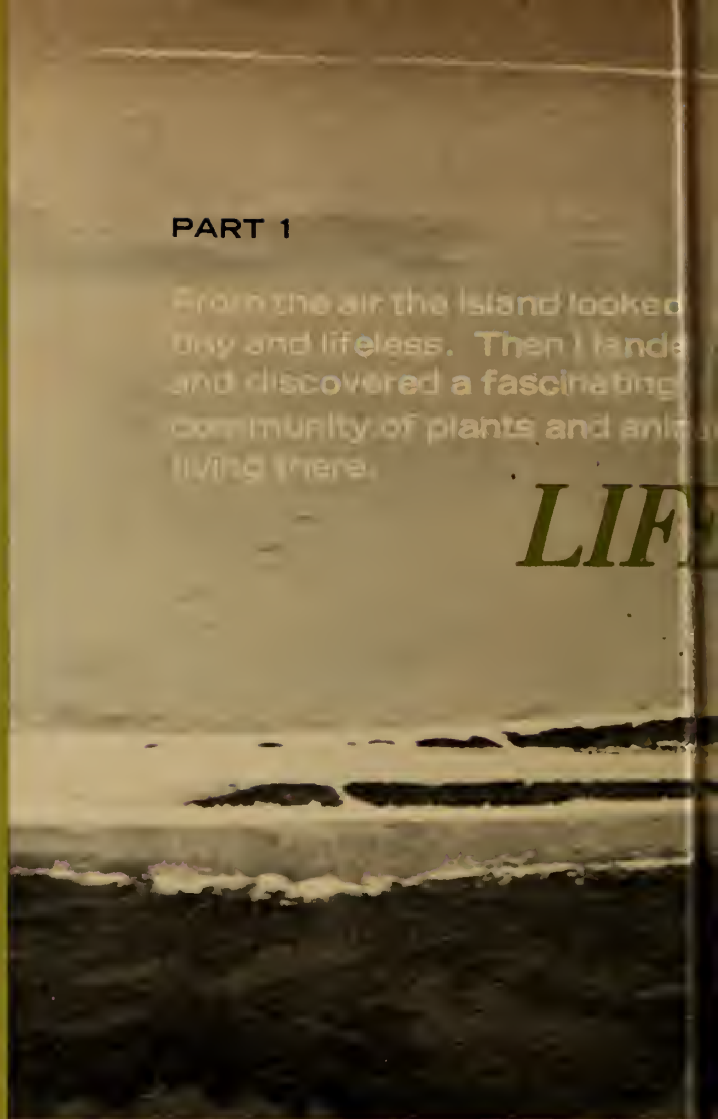
PART 1



From the air the island looked tiny and lifeless. Then I land[ed] and discovered a fascinating community of plants and ani[mals] living there.

LIF[E ...]

■ When I first saw Kure Island, a tiny dot in the Pac[ific] 1,200 miles northwest of Honolulu, I wondered wh[y a] biologist would want to study it. A mile-and-a-half sli[ver] of beach and shrubs *(see photo)*, it just barely deserved [to] be called an island. What could live there, I wondered[?]

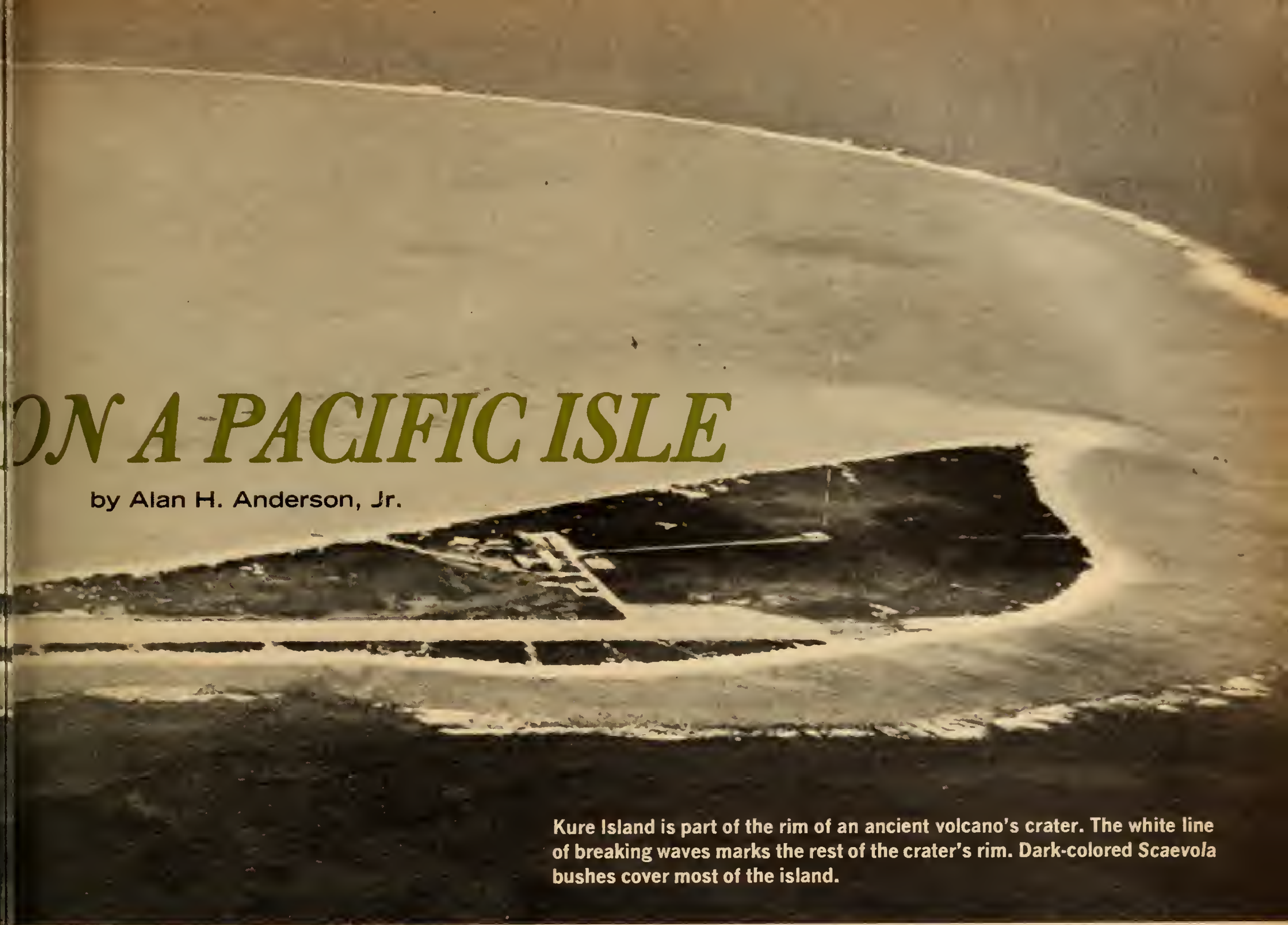
The cold February fog was so thick that our twin-eng[ine] plane had to return 50 miles to Midway Island for anot[her] try later. And for the moment I was glad.

But the next afternoon the sun broke through. The p[ilot] gave me a tour of the gleaming blue-green lagoon, dipp[ing] the plane so low over the reef that the wing nearly skimm[ed] the white-topped waves. As we touched down on the co[ral] sand runway, scores of white-winged albatross ran clums[ily] to get up speed, then caught the wind and soared gra[ce]fully out to sea. I forgot the fog and gloom of the d[ay] before.

Kure was to be my home for the next two-and-a-h[alf] months. I learned before I left: No matter how simpl[e it] looks from the air, any island big enough to land an [air]plane on is sure to have puzzling questions for a biolo[gist].

ON A PACIFIC ISLE

by Alan H. Anderson, Jr.



Kure Island is part of the rim of an ancient volcano's crater. The white line of breaking waves marks the rest of the crater's rim. Dark-colored *Scaevola* bushes cover most of the island.

to investigate.

All About an Atoll

A biologist who wants to study the life of an island (or other area) is called an *ecologist*. Ecology is the study of how living things depend on other living things and on other parts of their living area, or *environment*. This means the ecologist has to be aware of everything: birds, insects, mammals, plants, soils, weather. And this is why ecology is complicated, even on a small island like Kure.

One ecologist said recently that he knew of no island, no matter how small, on which all forms of life were positively known. Something new is always popping up, he said, or something that used to be there is disappearing.

Kure is an *atoll*—the top of a volcano that long ago erupted from the bottom of the sea. Kure used to be quite a bit larger—about 15 miles across—but, like the other western Hawaiian islands, it has been slowly worn away by winds and waves. Now Kure is only one tiny bump in the rim of what used to be the crater of the volcano.

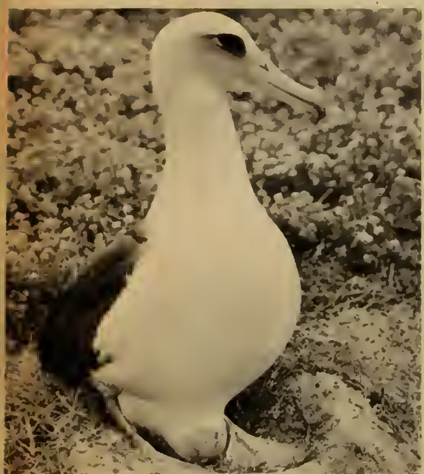
As I stepped out of the plane, I met the other two men whom I would work with. They showed me the small Coast Guard station where we would live. Then we all set out for a walk around the island.

I had already realized that Kure was a special place. Over two-thirds of the land was covered with dense *Scaevola* bushes, whose thick green leaves and tough stems could withstand the punishment of winter storms and constant salty winds. This meant that all the animals that lived there had to "learn" to live with the *Scaevola*. Where, I wondered, could the 14 kinds *(species)* of birds that lived on Kure make their nests?

I knew that no two species of animal can lead exactly the same way of life in exactly the same place. One would survive the competition; one would not. On Kure, for example, this meant that two species of birds eating the same food and behaving in the same way could not use the same nesting areas.

Some 50 species of birds visit Kure, but I was most in-

(Continued on the next page)



Frigate birds (above) scoop their food from the surface of the sea, or chase other birds until the birds drop food they carry. The Laysan albatross (left) also catches food from the surface of the sea.

terested in the 14 that nest there. They included the Laysan albatross and its slightly larger relative, the black-footed albatross, both of which have wingspreads of seven feet or more. There were three kinds of boobies, which are gull- to goose-sized birds with strong, jagged bills for grasping slippery fish. There were also smaller brown-and-white shearwaters and petrels; pure white tropicbirds with a one- or two-foot-long red tail feather trailing behind; frigate birds, strong, black pirates of the island that steal fish from the other birds; and chattering terns whose cries filled the night air over the island.

Here were 14 species of birds, all getting their food from the sea and all nesting on a small area covered largely by one kind of plant. What differences could there possibly be in the way they lived?

When an Albatross Throws Up

We walked north from the Coast Guard station through the central plain, the only large open area of the island. Amid the clumps of grass, Laysan albatross and blue-faced boobies had made their simple nests, side by side.

This seemed to break our "rule"—two species were living on the same island, nesting side by side, and perhaps eating the same food.

But were they? Answering this question turned out to be simpler, though less pleasant, than I thought. I decided to try to catch my first albatross. I did this by approaching the bird from the direction of the wind. These birds are so big and heavy that they must take off into the wind, as an airplane does. With no wind to help, they may run several hundred feet, flapping furiously, only to tumble in a graceless heap in the sand.

After a few misses, I caught a Laysan albatross by the neck just as it was about to rise into the air. No sooner had I gotten a firm grip with two hands than it "threw up" its lunch, and perhaps its breakfast—several pounds of purple squid and squid eggs. Most sea birds of this area do the same thing when they are handled. Perhaps they have learned that it is the only way to escape a pursuing frigate bird. This pirate will chase another bird until it empties its throat and stomach. Then the frigate bird dives after the falling food.

In any case, I was partly repaid for the mess on my shoes by finding out what the albatross eats. The next step was to try the same method on the blue-faced booby. This time I held the bird's head at a good distance. It threw up a glistening, partly-digested fish about 10 inches long.

The booby dives for its food, its body streamlined as an arrow, its bill tremendously strong and jagged. By contrast, the albatross does not dive. It catches squid and other food on the surface. So the two birds have quite different ways of life.

As I was walking across the open area, one leg suddenly gave way and I fell headlong. I had accidentally discovered how another species of bird nests on Kure. The wedge-tailed shearwater digs a deep burrow for its nest by using its strong legs and sharp toes. In this way it does not compete for nesting places with its upstairs neighbors, the

Even with a wingspread of seven feet, the heavy-bodied black-footed albatross must run a long distance into the wind before it is able to lift into the air.

albatross and the booby.

At the edge of the beach I saw a reason why the two albatross, so much alike in looks and food habits, could share the same island. The blackfoots did not compete with the Laysans for nesting space in the open areas. Instead, they chose a more dangerous area, near the beach. I was told that they had paid for their choice earlier that winter when a storm destroyed a third of their nests. Some birds had been found dripping wet, trying—between waves—to sit on eggs which were afloat or rolling down the beach.

By digging a nest burrow several feet underground, the wedge-tailed shearwater avoids competing with other birds for nesting space on the surface of the ground.

Under and On Top of the Bushes

Near the western beach we found both red-footed boobies and frigate birds making nests out of twigs and vines in the tops of the *Scaevola* bushes. This seemed odd, since the frigates often chased boobies returning to the island with fish. For a time, it seemed that these birds were competing with each other for both food and nesting sites. By applying the "throw-up test," it was easy to find out that they probably were not. We discovered that the boobies ate whole fish, while the frigates either scooped squid from the surface or pirated their meals from other birds.

As we cut in from the beach toward the runway, a loud squawk came from near my right foot. I looked down and saw a tropicbird with feathers bristling. It had found a way of life on the ground *beneath* the bushes *(see photo).* Here it did not compete for nesting space with any of the other birds.

Past the next clump of high bushes I discovered a sleeping Hawaiian monk seal *(see photo),* about six feet long and probably weighing over 500 pounds. It awoke with a start and grunted loudly, then hunched and flopped past us onto the beach. It is one of the rare seals of the world, living on less than a dozen atolls in the Pacific. At Kure, it sleeps on the beaches and gives birth there to jet-black, gruff-voiced pups in the spring.

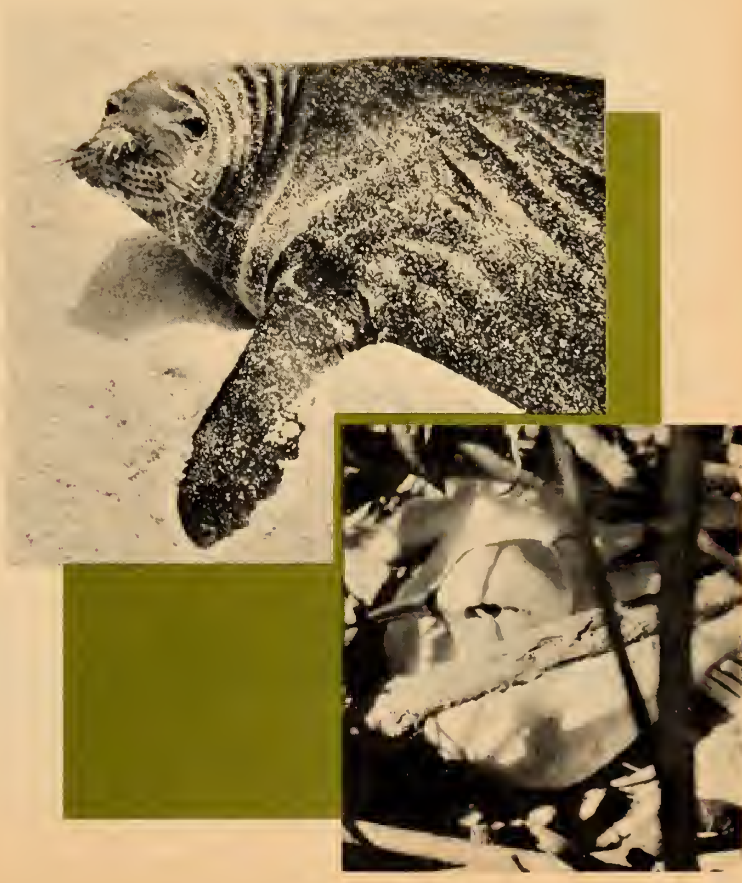
Crossing the lower half of the open area on the way back to the station, I noticed one effect of another animal on Kure Island, the Polynesian rat. No one knows whether this small rat reached Kure by stray dugout canoe or by shipwrecked sailing vessel, but thousands of them live amid the *Scaevola* bushes, eating seeds and buds.

I found an adult Laysan albatross with a two-inch-wide wound in its back. The rats had discovered how to climb onto a sleeping bird without disturbing it and chew a hole through the feathers and skin of the back. The bird would die in a day or two from loss of blood or from infection. Then the rats would eat it completely. The rats were killing not only the adult and young albatross but also young tropicbirds.

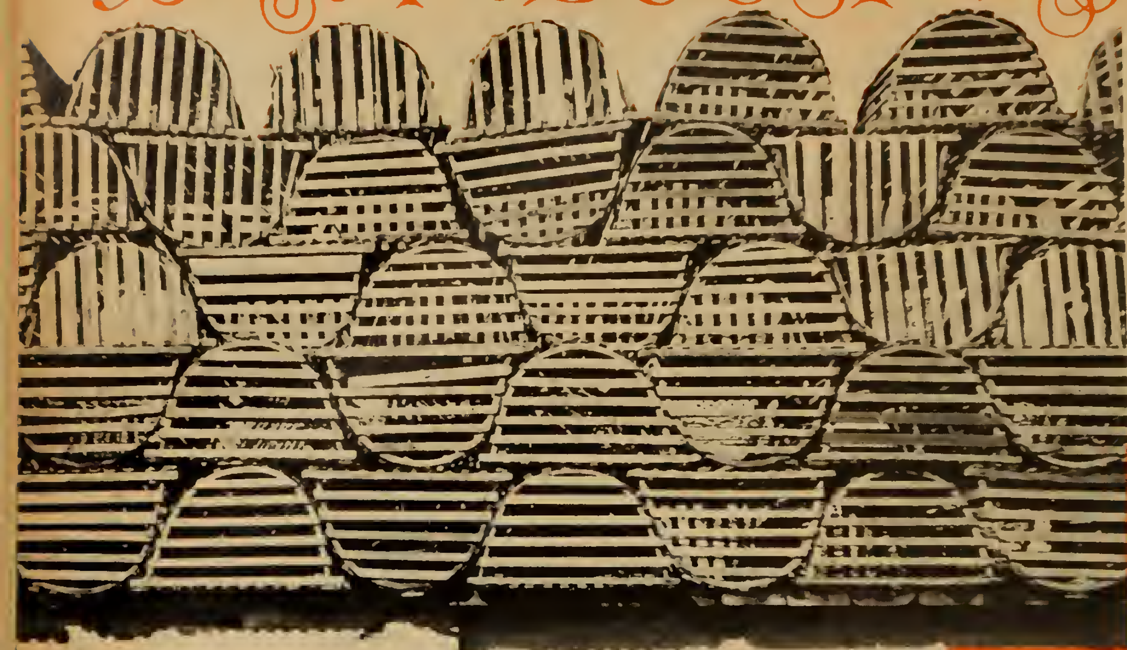
How long have the rats been doing this? What is likely to be the effect on the bird populations? These are questions an ecologist can answer only after much more study ■

In the next issue, the author describes some of the things he learned about the animals during the 10 weeks he stayed on Kure Island.

On his first hike around Kure Island, the author found a Hawaiian monk seal near the beach. He also discovered that the red-tailed tropicbird nests under the *Scaevola* bushes.



BRAIN BOOSTERS



JUST FOR FUN

Here is how to make a hose tro[mbone]: Make a bend as shown in [a] garden hose that has some wat[er] in it. By lifting the end of the ho[se] up and down, you can make t[he] water level rise and fall. This w[ill] change the length of the air colum[n] inside the hose. If you blow acro[ss] the open end of the hose, you w[ill] hear a sound that is higher or low[er] depending on the length of the a[ir] column. How does shortening t[he] air column change the sound?

MYSTERY PHOTO What are these?

CAN YOU DO IT?

Can you get a tin can exactly half full of water without using any kind of measuring device?

FUN WITH NUMBERS AND SHAPES

$$\frac{55}{5} - 5 - 5 = 1$$

Here are five 5s arranged to equal 1. Can you arrange five 5s to equal each of the numbers from 2 through 12?

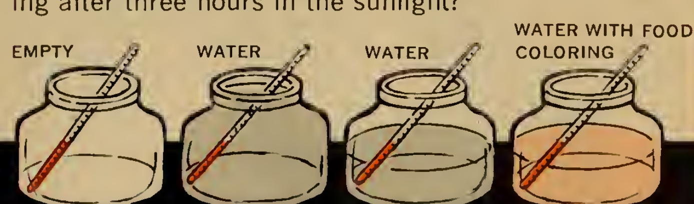
Submitted by M. Bruce, Victoria, Canada

FOR SCIENCE EXPERTS ONLY

Why does the water in a toilet move up and down when the wind blows hard?

WHAT WILL HAPPEN IF?

Which thermometer will go up fastest when these jars are put in sunlight? Which will show the highest reading after three hours in the sunlight?



HAVE YOU AN IDEA FOR A BRAIN-BOOSTER?

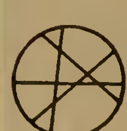
Send it with the solution to David Webster, R.F.D. #2, Lincoln, Massachusetts. If we print it, we will pay you $5. Be sure to send your name and address. If several readers submit the same idea, the one that is most clearly presented will be selected. We regret that ideas cannot be returned or acknowledged.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

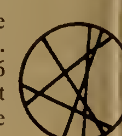
Mystery Photo: Snow piles along the road often contain the remains of salt that was used to melt ice. As the snow melts, salty meltwater flows away from the snow. When the water evaporates, the salt is left behind in a white line.

What will happen if? As an ice cube melts, it drips slower and slower. This is because a small piece of ice has a smaller surface area exposed to the warm air than a larger piece of ice has.

Can you do it? If no air can get into a soda bottle filled with water, you will be unable to suck out much water through a straw. What will happen if you blow into the straw?



Fun with numbers and shapes: One circle has been divided into 11 parts with 4 lines. The other circle has been divided into 16 parts with 5 lines. What is the greatest number of parts into which you can divide a circle with 6 straight lines?



For science experts only: Some solids, such as ice, mothballs, and iodine crystals, can slowly change into a gas without first going through a liquid stage. Ice can change into water vapor even at freezing temperatures.

WHAT'S NEW?

by
B. J. Menges

Bloodsucking moths have been discovered in Thailand and Malaya. Most moths sip nectar, not blood. But a few years ago, a Swiss scientist found blood in the stomachs of certain moths. Other scientists joined the investigation, and Dr. H. Bänziger of Zurich, Switzerland, was first to identify the moths that drink blood.

There are two ways in which moths can drink blood. Some kinds *(species)* of bloodsucking moths sip blood from open wounds or from drops of blood left by mosquitoes. Other species of bloodsucking moths pierce the skin of an animal, and then sip. In both cases, the moth drinks through its *proboscis,* a long, hollow tube that rolls up in a coil under the moth's head when not in use. The proboscis of the skin-piercing moths has a hard, sharp end that can pierce the skin of a water buffalo, an antelope, or a man. This feels like being jabbed with a red-hot needle, according to a man who let himself be "bitten" for science.

Sailing a tall ship under a low bridge may be possible with a scheme dreamed up by two Soviet inventors. The scheme calls for a motor-driven barge as wide and long as a football field and as tall as a four-story building *(see diagram).* The hollow barge is filled with water until it floats three-quarters submerged, with the water level inside the same as that outside.

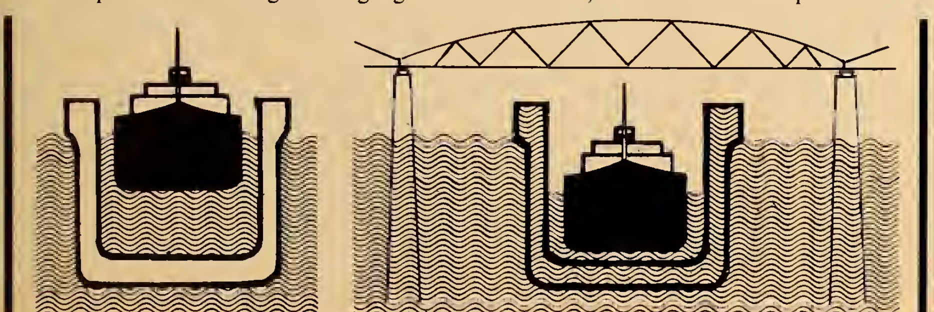
A ship enters the barge through gates at the rear. Then the gates close, and some of the water inside is pumped out. It isn't pumped to the outside, though, since the barge would then be lighter and would float higher. Instead, the water is pumped into tanks between two outer walls of the barge. Since the total weight of the barge remains the same, the barge floats as before. But the water level inside the barge drops below the water level outside the barge. This lowers the ship enough so that the barge can carry it under the bridge. Once the ship is past the bridge, the water level inside the barge is raised, gates in the front are opened, and the ship sails on its way.

Collisions with birds are a serious danger to airplanes in flight. For years, scientists have tried to eliminate this danger. Now a research team in Canada believes radar may be the answer. Radar signals are generally used to detect objects that are in the dark, or that are too far away to be seen. But the signals have also been found to "sweep" birds out of their way, making them fly higher or lower.

Radar beams sent forward from a flying aircraft could thus clear birds from the path of the plane. The signals don't harm the birds; for some unknown reason they simply nudge them away. It is hoped that this method can eventually be used to save millions of dollars, as well as the lives of many humans and birds.

Worrying about schoolwork could be bad for your teeth. So says Dr. Martin R. Protell, a dentist in New York City. For the past 10 years Dr. Protell has treated the teeth of people in a mental hospital, as well as those of the people who visit his office. From his experience, he has concluded that tension and worry can cause tooth troubles.

Dr. Protell believes that when tensions are "held inside" a person and not released by shouting, fighting, or similar behavior, extra strain is put on the nervous system. This causes the blood to carry a less-than-normal load of various substances that promote health and fight disease. Some of the unfortunate results may be trenchmouth, bleeding gums, and tooth decay.



Trumpeter swans have won their fight for survival. In 1935, only 73 of these big birds were left in the United States. Now there are over 4,000. The trumpeter, named for its powerful horn-like call, is the heaviest of all North American wild birds, sometimes weighing over 30 pounds. The species was hunted for its meat, as well as for its decorative white feathers, until it was in danger of becoming extinct.

The United States government then began a program to save the trumpeter. The birds and their breeding grounds were protected, some birds were moved to new areas, and young trumpeters were raised in zoos. Today, after over 30 years of effort, the trumpeter is apparently safe. Conservationists hope that a similar protection plan can remove the whooping crane from the list of threatened species *(see "Egg-Stealing Scientists," in "What's New?",* N&S, *October 14, 1968).*

Caviar is hard to find in Russia these days. Caviar is the salted eggs of certain fishes. Black caviar, the eggs of sturgeon, is a favorite Russian delicacy, and one of the country's major exports. But sturgeon and their eggs are becoming scarce. One reason is that industries are polluting the Caspian Sea, where sturgeon live, and the Volga River, which flows into it. Also, many of the sturgeon's breeding grounds in the Volga have been destroyed by a steady drop in the water level. Too much river water is used for industry and irrigation.

As a result, Russians must pay about $10 a pound for black caviar, or else settle for the less appetizing red caviar produced by salmon. And they have to import from Iran some of the black caviar they sell abroad.

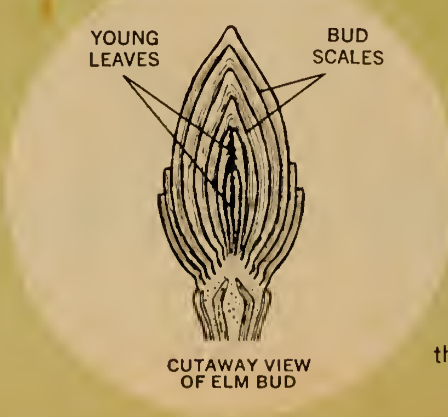
Spring Is on the Way

■ Spring begins officially about March 21, when the rays of the sun shine directly down on the equator and begin moving northward. But there's snow and cold in many parts of North America on March 21; "real" spring seems far away.

Since December 21, however, the days have been getting longer. The lengthening days have triggered many changes in nature. Spring is an important time of growth and reproduction for plants and animals. Some of them have ways of behavior or other characteristics that enable them to begin their spring activities long before spring is officially here.

Even now—in mid-February—you can find signs of spring outdoors. The photos and drawings on this WALL CHART show some examples to look for in your area. Can you find some others?—LAURENCE PRINGLE

NESTING IN THE SNOW, the great horned owl gets an early sta on raising its young. Two or three eggs are usually laid in Febru ary, and the parent birds keep the eggs warm even when the a temperature drops below zero.

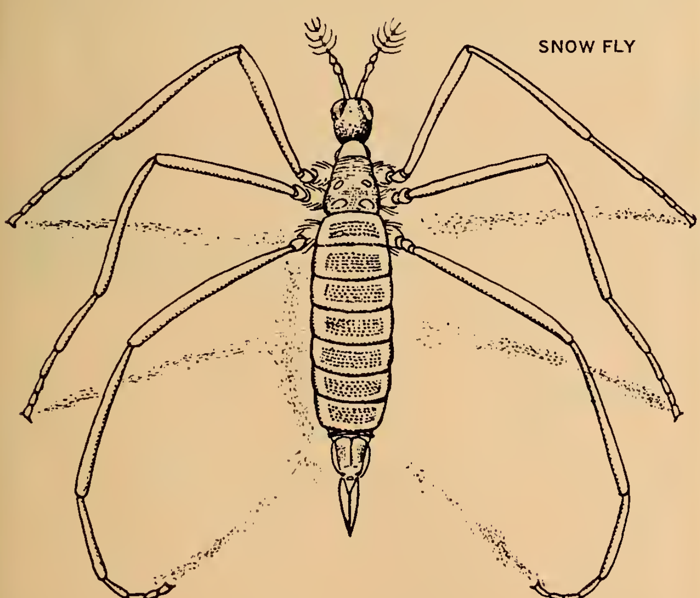


BUDS ARE READY to develop into flowers, leaves, and twigs of trees and shrubs. If you cut down through the center of a bud, you may find the young leaves (*see diagram*) that would have appeared in the spring. They are protected from drying out by layers of tough bud scales. Even now you may be able to find buds that are swelling and changing color as growth begins inside. Cut twigs from different kinds of trees and shrubs, set them in water inside near a window, and watch to see what grows from the buds.

MIGRATING BIRDS are a traditional sign of spring. In most of the northern United States, the robin is thought to be the "first bird of spring." But some robins spend the entire winter in the north, and other birds—such as these red-winged blackbirds—may actually arrive before those robins that migrate. Start watching to find out which kind of bird is first to return from the south to your area.

GROUNDHOG DAY (February 2) is supposedly the one winter day when groundhogs (woodchucks) come up from their underground burrows. According to an old saying, "If the groundhog sees its shadow on February 2, there will be six more weeks of winter weather." But woodchucks may be seen on many other winter days, and their appearance has nothing to do with the future weather. Groundhogs spend most of the winter in a deep, death-like sleep called *hibernation*. They sometimes wake from this sleep, however, and come to the surface, especially on warm winter days.

SNOW FLEAS hop like fleas but are really members of a group of insects called springtails. They are just one of several kinds of insects you may see on the snow, especially when the temperature is a little above freezing. Snow fleas swarm by the millions so that the snow is sometimes blackened for yards around the place where they have come up through a crack in the snow. They feed on decaying plant material and apparently come to the surface of the snow when their food supply runs out. Another kind of insect, the snow fly, mates on the snow. Then the female digs down to the earth and lays her eggs.



MELTING THROUGH THE SNOW, the skunk cabbage plant grows even when the air temperature is below freezing. Inside the brown and green shell-like structures called *bracts* (*see photo*) are the skunk cabbage flowers. As the flowers develop, they "burn" food energy that was stored in the plant's roots, and give off heat. The temperature of the flowers may reach 120° Fahrenheit. Some of this heat is given off into the air and melts snow around the plant.

SOAP BUBBLES

by Madison E. Judson

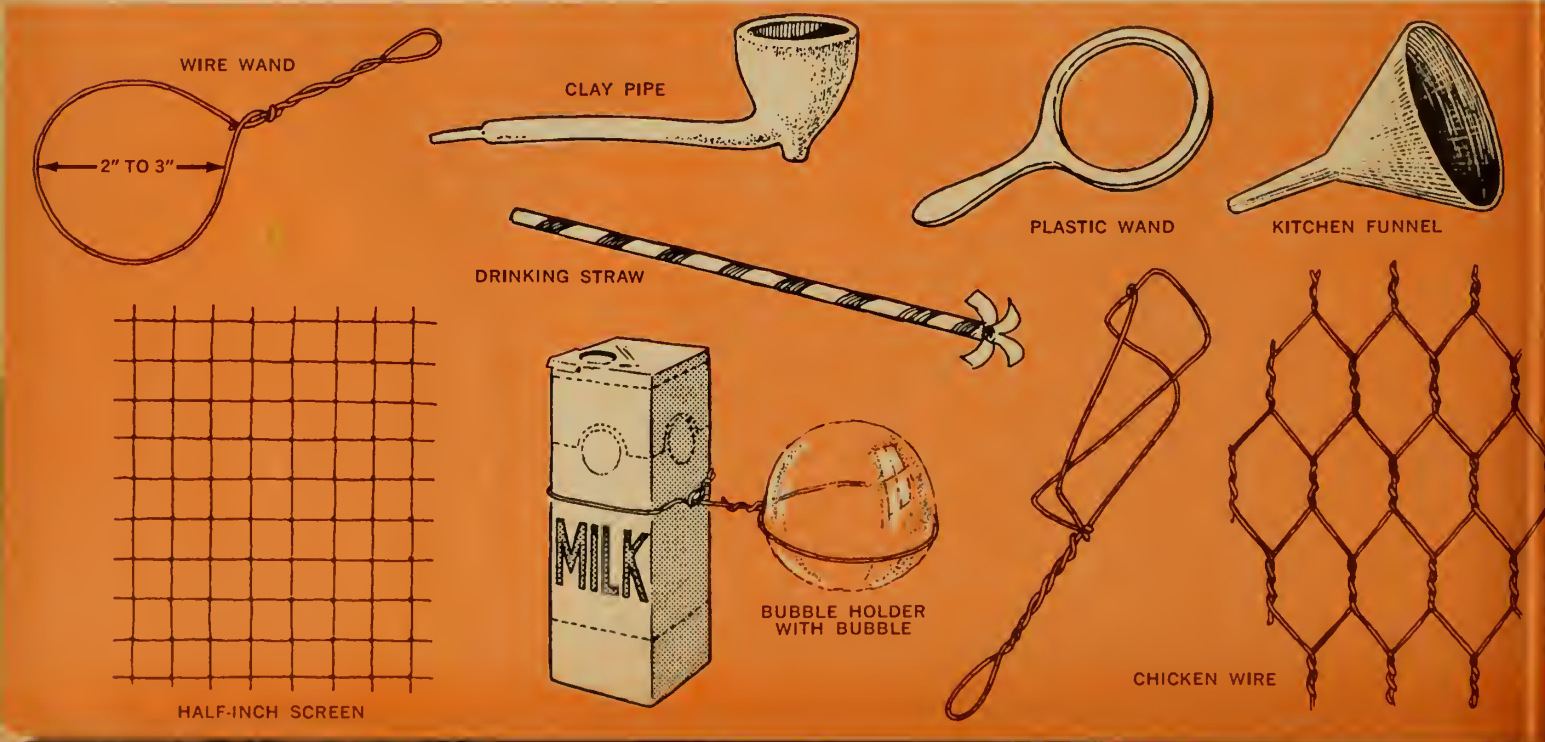
Beetles can't blow bubbles well,
But boys with bubble pipes excel;
They know that bubbles make no sound,
Except for those that weigh a pound,
But can they tell what makes them round?
—UNKNOWN BUBBLE BLOWE[R]

Soapy water makes bigger and better bubbles than plain water because a soap bubble's "skin" is made of a thin layer of water sandwiched between two layers of soap. The soap layers help keep the water layer from evaporating.

■ "What do you know about soap bubbles?", I asked a friend of mine in the fifth grade. "They pop!", she said, and that was that. What she meant was that bubbles usually break just when you want to look at them a little while longer. The amazing thing about bubbles, though, is not that they pop, but that they form at all.

If you want to become a bubble observer, there is no need to go out and buy bubble mixes; you can make your own. Just mix two capfuls of dishwashing liquid with one cup of water. Then if you add one teaspoon of sugar, the bubbles you make will last longer than bubbles made with soapy water alone.

You can use water from the tap, but rainwater is better, because it doesn't contain the chemicals that sometimes



make tapwater "hard." When you mix the detergent and the water, make sure that the water is cold. Cold water will keep the suds down.

The drawings on this page show several bubble-blowing tools that you can make or buy. You can even use an ordinary drinking straw; if you do, split and fold the end back, as shown in the drawing. A kitchen funnel works well, too, but you will have to wet the inside of the funnel with the soap liquid before blowing through it. You can buy a plastic wand, or you can easily make one out of wire. Making bubbles with wire screening—half-inch screen is best—can also be fun. Try using large-hole screen, such as chicken wire, also.

Whatever kind of bubble wand you use, dip the wand into the soap liquid, lift it out, then gently wave it through the air to form bubbles. To free a bubble from the wand, twist the wand gently when the bubble is just about formed. If you blow through the wand, blow gently; otherwise you will break the soap film. If you want to make large bubbles, dip the big end of the funnel into the bubble solution (after wetting the inside of the funnel), then blow gently through the small end. If you run out of breath before you finish making the bubble, stick your tongue over the opening while you take another breath. This will keep the bubble from collapsing.

When the large end of the funnel is dipped in the soap liquid, a soap film will form across the mouth. Watch the soap film. It will travel up the funnel. Can you figure out why it does?

Make a bubble holder *(see diagram)*, so that you can study a bubble closely. After you make a large bubble with the funnel, see if you can put the bubble on the wet wire loop of the bubble holder. Then, using another wet wire loop, see if you can remove the bubble again.

PROJECTS

For Bubble Experts Only

- Did you know that you can put your finger inside a bubble? First wet your finger with the soap liquid. Your finger will then pass easily through the wall of the bubble without breaking it.
- Place a large bubble on a wet surface. Then wet a drinking straw in the bubble liquid and push the straw into the bubble. Now see if you can blow another bubble inside the first bubble.
- Dip a soap film frame into the bubble liquid and put it into the freezer of your refrigerator. What happens? Can you find a way to freeze a soap bubble? Try using frames of different shapes. Can you freeze a bubble outside on a cold night?

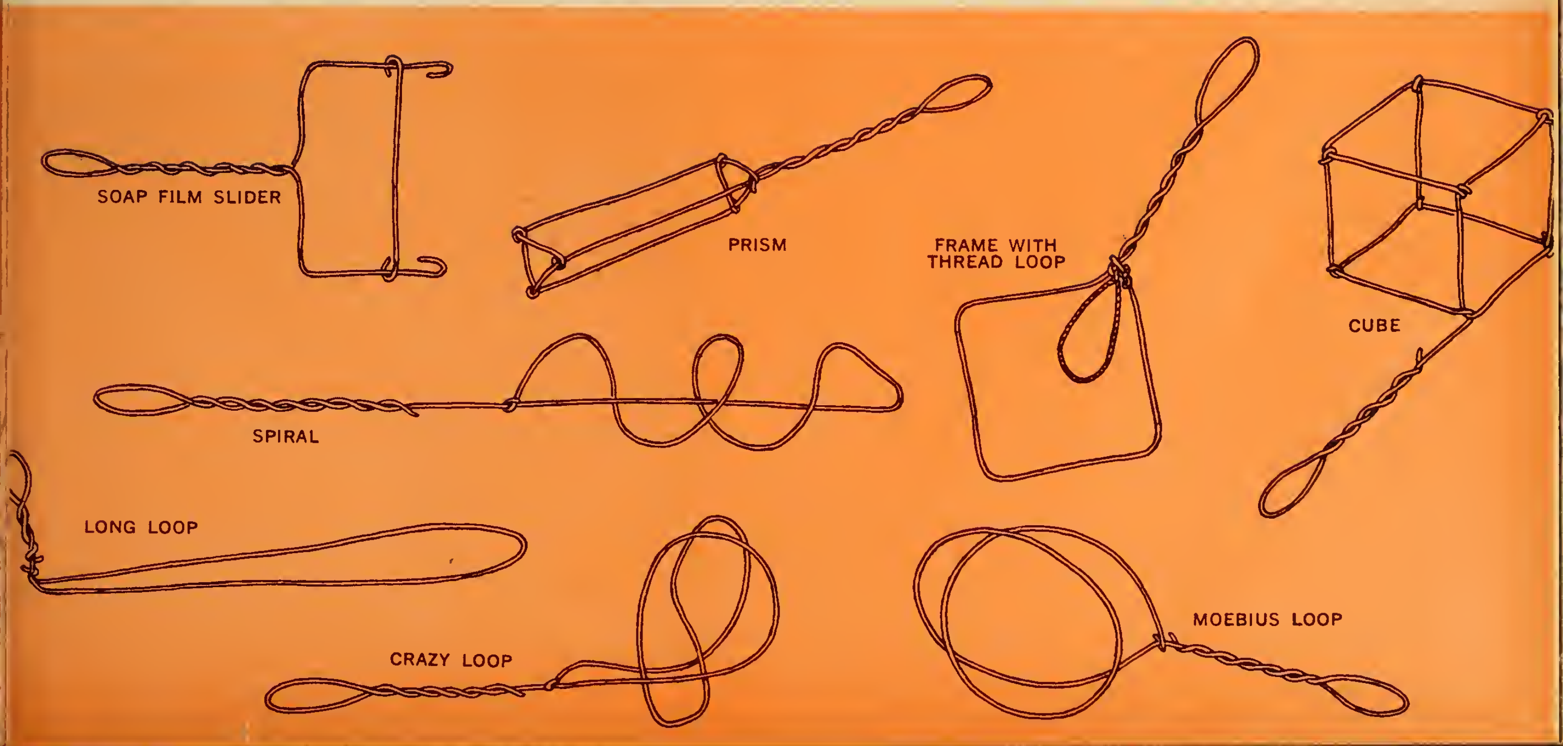
Experimenting with Soap Films

A bubble is only one shape that a soap film may take. Many other shapes are easy to make by bending wire into frames of different shapes and stretching a soap film over them. Number 20 copper wire is easy to bend, but any kind of wire that stays in the shape you bend it will do.

Make a long-loop bubble wand *(see diagram)*. The loop should be about two or three inches across. After you have dipped the loop in the soap liquid, lift it out and hold the wand edge-up. Watch the soap film as it gradually develops bands of color.

By making a soap film slider like the one shown in the diagram, you can have a tug-of-war with a soap film. When you remove the slider from the liquid, watch to see what happens. Pull the slider out and watch the soap film stretch. Release the slider and watch the film contract.

(Continued on the next page)



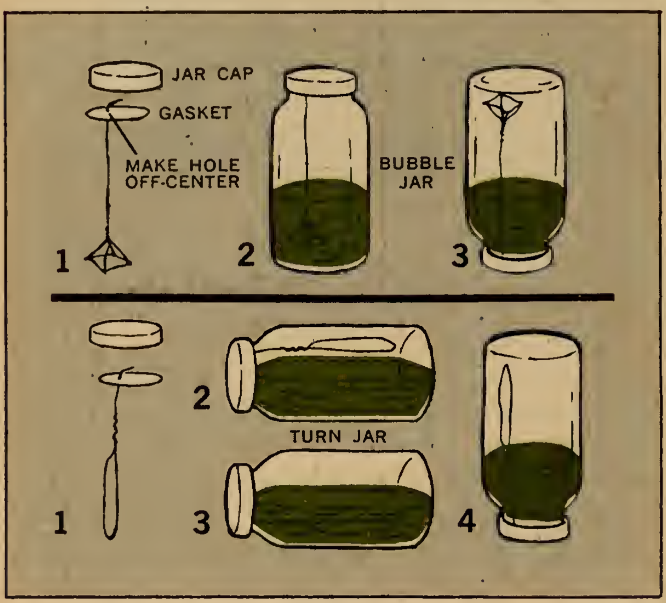
Soap Bubbles (continued)

Make a thread loop inside a square wire frame. The thread should be light weight and made of silk or rayon. Dip the frame and loop in the bubble liquid, take it out, then touch a paper towel or tissue to the inside loop. Watch what the rest of the soap film does.

Invent some wire-frame shapes of your own. Maybe the cube and prism shapes shown in the diagram will give you some ideas. The soap films form in surprising ways when you use frames like these. Try to make a soap film form on all six sides of the cube. Maybe it can't be done.

Some unusual things happen when you use a spiral frame. Study the one in the diagram, see how the loops wind around, then make one like it. Make a "Moebius" loop and find out what happens after you dip it into the liquid.

You can watch a soap film for quite a long time if you



use a bubble jar *(see diagram)*. Your wire frames can be held firmly by the gasket, or cardboard, inside the cap. You can cut a good gasket from an old inner tube. As the diagram shows, make the hole in the gasket near one edge of the disc, *not at the center*. By making the hole near the edge you will not need as much bubble liquid as you would if you made the hole in the center of the disc. When the bottle cap is tightened in place, turn the bottle on its side and roll it so the wire loop dips into and then out of the liquid. You can then stand the bottle upright to study the soap film. Make a four-sided frame also, and see what happens to the soap films that form on it.

The many projects in this article are only a few of the things you can do with bubbles and soap films. Once you start experimenting you will discover dozens of other things to do and to look for ■


1


2


3

Do these pictures puzzle you?

They should! They're mystery object CONTEST winners

■ *What in the world is this?* That's what our Mr. Brain-Booster kept asking himself as the postman kept bringing him mystery objects and photos sent by *Nature and Science* readers. The objects and photos were entries in the Mystery Object Contest announced in the October 14, 1968 issue of *Nature and Science,* and Mr. Brain-Booster's job was to try to identify the mystery objects, then pick out the ten "best" ones.

It wasn't easy to identify such things as a piece of chameleon tail, a sheepshead mushroom, a foot massager, or a clarinet valve pad. And who had ever seen a ball bearing separator, a lobster trap bait bag, an Eskimo yo-yo, or a hexahexaflexagon? But the real problem was deciding which of the 382 mystery objects should be chosen as winners. Was a seagull skull more puzzling than an old-fashioned clothespin? Would more readers recognize a wasp stinger than a spark plug gapper? Was a worn-out sweeper brush "better" than some hair from a peccary?

Somehow, though, Mr. Brain-Booster made his choices, and you can see some of the winning mystery objects here. Can *you* figure out what they are? ■

Give Up?

Turn the page upside down to learn the identifications of the mystery objects shown, along with the names of the readers who submitted the objects or photos.

1. a coiled-up garden hose (*from Wendy Levoy, Bayside, New York*)
2. a blob of water on a hot frying pan (*from Marcus Levitt, Brooklyn, New York*)
3. a patio umbrella stand, on a snow-covered patio (*from James Donohue, Brooklyn, New York*)
4. a golf ball "pickup" to attach to the end of a golf club (*from Steve Miller, Massapequa, New York*)
5. a tool for removing a fishhook from a fish's mouth (*from Ralph Dean, Oak Park, Illinois*)
6. a rolled-up cutting edge from a box of waxed paper (*from Sean Murphy, Martinsville, Virginia*)
7. a lemon slice holder (*from Michelle Guevin, Sparks, Nevada*).

Other winning mystery objects that are not shown were:

- a mold for freezing ice cubes that fit into soda bottles (*from Ruth Martinson, West Alexander, Minnesota*)
- a clip to hold the cord from an electric iron to the ironing board (*from Gary Hill, Randolph, New York*)
- a labeling tag for marking plants (*from John Collins, Frederick, Maryland*).

Each of the persons named received a prize of $10.

A LOOK AT LENSES

A little distance makes a big difference in what you see through a magnifying lens. With a flashlight and some common materials, you can find out why.

■ Have you ever looked at nearby and distant objects through a reading glass or pocket magnifying lens as you moved the lens toward the object and away from it, or as you moved your eye toward the lens and away from it? Try it and you will see that a magnifying lens can make objects appear smaller as well as larger, turn them upside down, and even make them seem to disappear.

With a flashlight and some other common materials, you can investigate your magnifying lens and find out how it does all these different things. To begin with, though, it helps to know what a lens does to light beams as they pass through it.

PROJECT

Put a penny in a bowl, "sight" the penny over the tip of your finger, and see if you can put your finger-tip directly on the penny. If you keep your fingertip moving in the straight line between your eye and the penny, you should hit the "bull's eye." Now fill the bowl with water, roll up your sleeve, and see if you can put your fingertip on the penny on the first try. Does it make any difference whether you are sighting straight down on the penny or from the side of the bowl?

When you are looking straight down at the penny, a beam of light from the penny travels straight up through the water and the air to your eye. It follows a straight path that crosses the "border" between the water and the air at a right angle.

When your eye is near the side of the bowl, however, the light beam from the penny crosses the border at a slant. Instead of following the same straight path all the way from the penny to your eye, the beam changes direction as it crosses the border. Since you are used to receiving light in a straight path from an object, the bent beam fools you into thinking the penny is where it *appears* to be, instead of where it *is*.

The light beam is bent, or *refracted*, because light travels slower in water than in air. Diagram 1 shows what happens when the light beam from the penny moves from the water into the air at a slant to the border. The light at one side of the beam moves into the air and speeds up before the light at the other side of the beam gets out of the water. With one side moving faster than the other side, the beam is turned in the direction of the side that is still in the water.

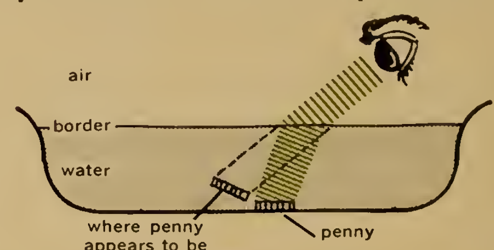
Light travels even more slowly through glass than through water. So a light beam is also refracted as it moves from the air into a block of glass and back into the air *(see Diagram 2)*. Because of its shape, however, a magnifying lens refracts light in a special way. Notice that the sides of your magnifying lens are curved outward, making the lens thickest in the center and thinnest around the edge. A lens that is curved this way is called a *convex* lens.

Focusing Light Beams

To see how your convex lens refracts light, wrap a piece of aluminum foil around the head of a flashlight so that the foil is stretched flat over the flashlight lens. Push a sharp pencil point through the foil to make three small holes, as shown in Diagram 3. Cover a table with wrapping paper or a newspaper, rest the lighted flashlight on a box, and pour a little talcum powder onto a sheet of paper.

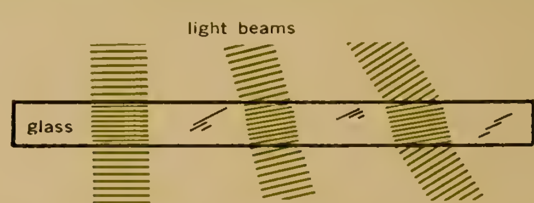
Now, with the room darkened, hold the magnifying lens so the light from the center hole passes straight through the center of the lens, and gently shake a little powder into the air beyond the lens. Looking from the edge of the table, you should be able to see the three parallel beams of light from the flashlight brought together, or *focused*, at a single point beyond the lens, as shown in the photo. This is called

1



A beam from the penny changes direction as it moves from water into air, so the penny appears to be where it isn't.

2



Light beams passing through a glass block are bent according to the angle at which they cross the "borders."

the *focal point* of the lens, and it may be from a few inches to a foot or so beyond the lens, depending on how much the sides of the lens are curved.

A line running through the exact center of each side of the lens is called the *principal axis* of the lens. You can see that a light beam that passes through the lens along its principal axis is not bent at all. But light beams that are traveling parallel to the principal axis are brought together at the focal point of the lens. (Do you think the lens has a focal point on both sides? Turn the lens around and see if the light beams are brought together at the same distance from it.)

The distance from the focal point to the center of the lens is called the *focal distance* of the lens. It's hard to measure in the dark, but you can measure it easily by focusing the light from a distant tree or house on a sheet of paper held behind the lens *(see Diagram 4)*. Move the lens toward the "screen" and away from it until the *image,* or picture, on the screen is as sharp as you can get it. The distance from the center of the lens to the screen is the focal distance of the lens.

With this information and a tabletop at least four times as long as the focal distance of your lens, you can find out how different kinds of images are formed by your lens. Fasten a piece of white paper over the head of your flashlight with a rubber band so the paper is flat over the flashlight lens. Use a marking pen or crayon to draw a large arrow on the flat circle of paper *(see Diagram 5)*.

Cover the table with paper. Place the flashlight on a few books at one end, and a white paper screen supported by a book at the other end. You might think the lighted flashlight would project an image of the arrow on the screen. Darken the room and you will see that it merely lights the screen a bit, without forming an image of the arrow. Remember that light beams are moving out in all directions from each point on the flashlight face. At least two beams from the same point on the flashlight face must be brought together at the screen to form an image there.

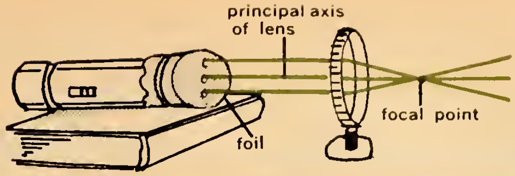
Use some modeling clay to stand your lens near the middle of the table. On each side of the lens, measure the focal distance of the lens and mark it F on the paper. Also mark 2F at twice the focal distance on each side of the lens, as shown in Diagram 5.

With the flashlight face several inches beyond 2F on one side of the lens, move the screen between 2F and F on the other side until a sharp image of the arrow forms on the screen. Diagram 6 shows how the image is formed.

Now move the flashlight face to position 2F on one side of the lens and the screen to 2F on the other side. What happens to the image? Can you draw a diagram to show how this image is formed?

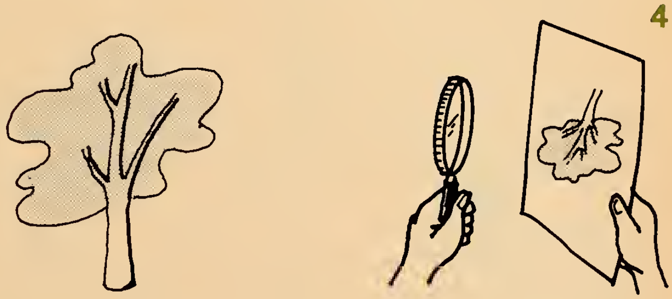
(Continued on the next page)

3



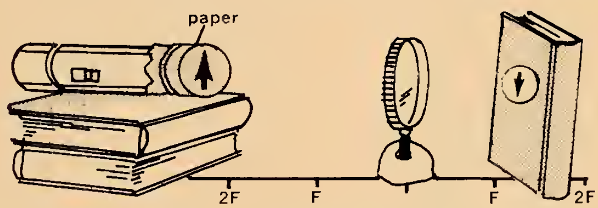
Beams moving parallel to the principal axis of a convex lens are brought together at its focal point beyond the lens, as shown in the diagram and photo.

4



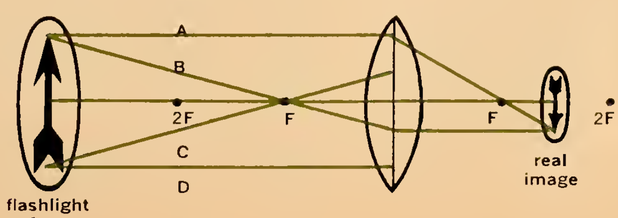
When a sharp image of a distant scene forms on the sheet of paper, it is at the focal distance from the lens.

5

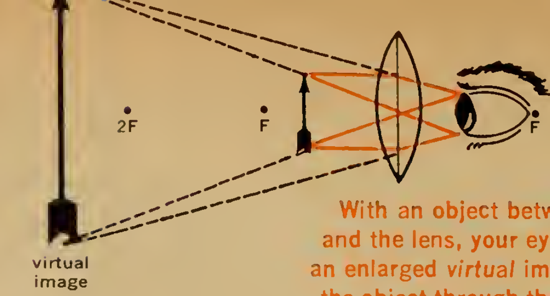


With flashlight and screen as shown above, an image forms on the screen as shown below. Beam A moves parallel to the principal axis of the lens, so it is bent through the focal point on the other side. Beam B moves through the focal point on one side, so it leaves the lens moving parallel to the principal axis. Where A and B meet, an image is formed of the point on the flashlight face where both beams started. Can you draw in the paths of Beams C and D from the lens to the screen?

6



7



With an object between F and the lens, your eye sees an enlarged *virtual* image of the object through the lens.

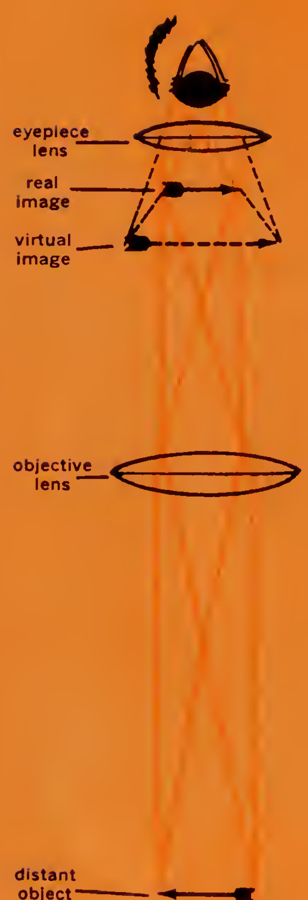
A Look at Lenses (continued)

Try placing the flashlight face between 2F and F and move the screen back and forth on the other side of the lens until a sharp image of the arrow is formed. (A slide projector works this way, and you can see why the slide must be placed upside down in the projector.) Can you diagram the paths of light beams that form this image?

Do you think that an image will form if you place the flashlight face at F, or closer to the lens? Try it and see. Can you explain your findings?

Suppose you put your eye in place of the screen in each of the above investigations. Try it with the arrow at each of the places you tried before. Move your head back and forth just as you moved the screen to sharpen the images.

Be sure to look for an image with the flashlight face placed between F and the lens. The image you see will be familiar, but different from the *real* images that you have been looking at. This one is called a *virtual* image, because it doesn't form on a screen. Diagram 7 shows how this image is formed. Does it remind you of the penny you saw where it wasn't in the bowl of water?—F.K.L.



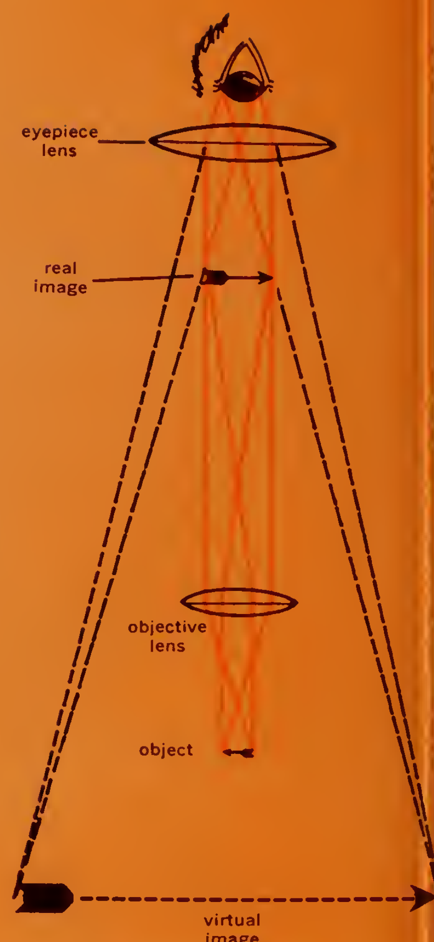
If you have two magnifying lenses with different focal distances, you can make a simple refracting telescope *(see "Big Eyes on Space," N&S, February 3, 1969)* and a microscope.

Hold the lens with the longer focal distance at arm's length, pointed toward an object across the room from you. Now hold the other lens to your eye and look through both lenses, moving the first lens back and forth until you can see the object clearly. What you see is a magnified virtual image of the real image projected by the first lens *(see diagram).*

By looking at the object through the telescope with one eye and at the same time with your unaided eye, you may be able to line up the image with the object and guess about how many times the telescope "enlarges" the object. You can figure out the magnifying "power" of your telescope more exactly, however, by simply dividing the focal distance of the eyepiece lens into the focal distance of the *objective* lens, at the far end of your telescope.

Now hold the lens with the shorter focal distance (the *objective* lens for the microscope) near these words to form an enlarged real image (upside down) of them at your eye. Hold the second (eyepiece) lens near your eye and move it up and down until you see an enlarged virtual image of the real image *(see diagram).*

The magnifying power of your microscope is harder to figure out than that of the telescope. To begin with, you have to find the distance of the real image from the objective lens and divide that figure by the focal distance of that lens. This tells how many times the real image is bigger than the object being viewed. Then you have to multiply this figure by the number of times the eyepiece lens enlarges the real image to find out how much bigger the object appears when viewed through your microscope.



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

particular distance beyond the lens.

If the "object distance" is much larger than the focal distance (F), the "image distance" is about equal to F. If the object distance is greater than 2F, the image is smaller than the object. When the object distance is 2F, an image the same size as the object forms at 2F. When the object is between 2F and F, a larger image is formed someplace beyond 2F.

When the object is at F or closer to the lens, no *real* image is formed, because beams of light from each point on the object are not brought together at a single point beyond the lens.

However, with the object at F or closer, your eye can see through the lens an enlarged image of the object *(Diagram 7)*. This is called a *virtual* image because it is just an effect caused by the refraction of light beams from the object–not a *real* image formed by beams of light from the same point that meet on a screen.

Topics for Class Discussion

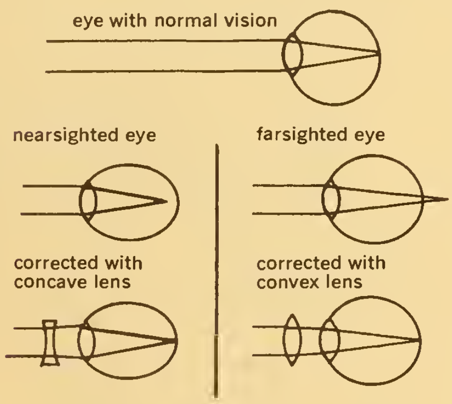
• *Why should a distant object be used to find the focal distance of a lens?* By moving an object farther and farther away from a lens with a long focal distance (1 foot or so), your pupils will find that the image distance gets closer and closer to the focal distance of the lens. By diagraming this case, your pupils can see that the farther the object is from the focal point of the lens, the closer the beams of light from each point on the object come to reaching the lens parallel to its principal axis. And beams parallel to that axis converge at F beyond the lens.

• *Why doesn't the flashlight project an image on the screen when no lens is between them?* The light beams from each point of the flashlight face reach the screen at all different places, so the screen is lighted, but no image is formed.

• *How, then, can you see the arrow on the flashlight face?* The convex lens of your eye forms an image of the flashlight face and arrow on the *retina*, or "screen" in the back of your eye. This is a real image, much smaller than the object, and upside down. (The image is changed into electrical signals and carried by the optic nerve to your brain, which "reads" the signals so that you "see" the object rightside up.)

• *Since the image distance in your eye is always the same, how can you see objects at different distances so clearly?* The eye lens is soft, and can be stretched or squeezed by the eye muscles to make it thinner or fatter, changing the focal distance to fit the object distance. (Have your pupils move a finger to one eye and see where it begins to appear fuzzy because the eye lens can't be squeezed any fatter.)

• *Why do many people need eyeglasses to help them see clearly?* The diagram below shows how nearsightedness is corrected with *concave* (inward curving) lenses and farsightedness with convex lenses. *Astigmatism* (blurry vision due to irregularities in the eye lens) is corrected by an anastigmatic lens, shaped irregularly to compensate for the eye lens.



Activity

Your pupils can make a water lens by bending a paperclip around a nail to make a tiny ring. Dipped in water, the ring picks up a tiny, convex-shaped drop. A larger drop, convex on top only, can be held on a piece of cellophane fastened flat over a round hole in a piece of cardboard. Both work as a magnifying lens. Can your pupils find the focal distances of these lenses?

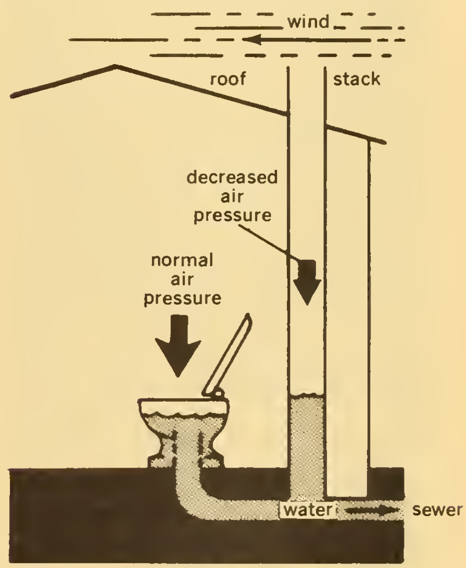
Brain-Boosters

Mystery Photo: The photo shows lobster traps stacked up on a wharf.

What will happen if? Have your pupils try to guess the answers to these questions and explain them. Then set the jars where the sun can shine on them for several hours. The temperature in the "empty" jar will rise fastest; it takes less heat to raise the temperature of air than to raise the temperature of an equal volume of water the same number of degrees.

After the jars have been allowed to reach their maximum inside temperatures, the thermometer in the colored water should show the highest reading. The colored water will absorb more heat than clear water (or air) absorbs. Some pupils might try putting other liquids or materials, such as sand or soil, into the jars, and report on which heat up fastest and which reach the highest temperature in sunlight.

For science experts only. The sewer line in a house is vented with an open pipe, or *stack*, that sticks out through the roof *(see diagram)*. When wind



blows across the top of the stack, the air pressure down the stack is decreased. Normal air pressure inside the house then pushes the water down lower in the toilet and it rises in the stack. When the wind dies down, air pressure in the stack returns to normal or near-normal, pushing the water in the stack down, and the water in the toilet up. On a windy day, small changes in wind velocity can keep the water level in the toilet constantly

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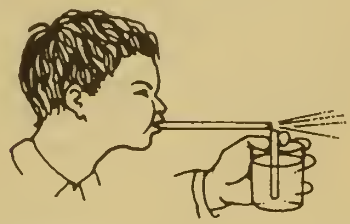
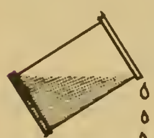
(continued from page 3T)

fluctuating up and down.

The changes of air pressure inside the stack are examples of the *Bernoulli effect:* As a fluid flows faster, it exerts less outward pressure at right angles to its direction of flow. Another example is shown here:



Can you do it? An easy way to get a can just half full of water is to fill the can, then pour off water slowly until the water level just reaches the bottom of the can *(see diagram)*. The can should now be half full. You can check this by pouring the water from the can into a separate container, half-filling the can again by the same method, and then pouring the water from the second container back into the can. If the can was filled half way each time, it should now be full.



Fun with numbers and shapes. Here is how five 5s may be arranged to produce each of the numbers 2 through 12:

$\frac{5+5}{5} - 5 + 5 = 2$

$\frac{5+5}{5} + \frac{5}{5} = 3$

$\frac{5+5+5+5}{5} = 4$

$\frac{55}{55} \times 5 = 5$

$\frac{55}{55} + 5 = 6$

$\frac{5}{5} + \frac{5}{5} + 5 = 7$

$\frac{5+5+5}{5} + 5 = 8$

$\frac{55-5-5}{5} = 9$

$\frac{55}{5} + \frac{5}{5} = 10$

$\frac{55}{5} - 5 + 5 = 11$

$\frac{55}{5} + \frac{5}{5} = 12$

Can your pupils produce other numbers with five 5s, or produce 1 through 12 with several of another number?

Just for fun. The "hose trombone" described works on the principle that the shorter the length of a column of air, the higher pitched sound it produces when the air is set in vibration (as by blowing).

nature and science
TEACHER'S EDITION
VOL. 6 NO. 12 / MARCH 3, 1969 / SECTION 1 OF TWO SECTIONS

Putting Our Hows and Whats in Order

by Roy A. Gallant

■ Whatever the reasons, a youngster who is looking for a science book to read usually heads for the astronomy shelf first. Unfortunately, however, too many of the astronomy books he finds turn out to be unimaginative (and uninformed) descriptive essays dealing in an abstract way with the diameters, distances, atmospheric compositions, and so on of the planets or the stars; and, of course, how it all began; and, inevitably, the expanding universe. Also, usually there is a lavish display of "gee-whiz" illustrations whose captions too often miss the point. Nevertheless, space and astronomy books for young people continue to be science best sellers.

What saddens me most about such books is that the youngsters are being cheated. The real excitement is not the fact that the giant star Betelgeuse, for instance, is a red giant with a diameter 400 times that of the sun (wow!), but in *how* astronomers think that Betelgeuse got that way, and what will happen to it next. In the hands of an imaginative and informed author, there is the topic for a whole book, a "gee-whizzer" in the best sense of the expression, an intellect-stretcher, rather than a fancy-tickler. It's a matter of putting the "how" before the "what."

A few years ago I was privileged to be a member of the University of Illinois group preparing astronomy materials for the middle elementary grades.

Roy A. Gallant, consulting editor to N&S, *is the author of about 20 science trade books and textbooks for young people.*

In our teacher's guides we made the following point:

"The modern astronomer's work exemplifies many facets of scientific inquiry. But unlike the biologist or chemist, the astronomer is far removed in both space and time from the objects of his study. Because of this problem, the astronomer must use fully every bit of information he can obtain in order to construct a satisfactory theory. In so doing, long lines of reasoning are sometimes employed in order to interpret the observational data."

In my article on page 6 of this issue, I have tried to reflect this approach to astronomy teaching by writing a very brief, and therefore necessarily superficial, account of how men over the centuries have searched for an understanding of what the stars are made of and what keeps them shining.

Analyzing a Star's Light

Just about everything we know about stars has been learned by analyzing their light with *spectroscopes (see Glossary, page 4T)*. By the use of a prism or a diffraction grating, a spectroscope analyzes the light from a star by separating that light into its component colors, or wavelengths.

If you look at a candle flame or a light bulb through a piece of grating, you see a *continuous* spectrum; that is, you see all of the colors from violet to red, each color smoothly blending into the next.

If you hold a bit of sodium, a bit of iron, a bit of gold, or a bit of any other element in a flame and vaporize the

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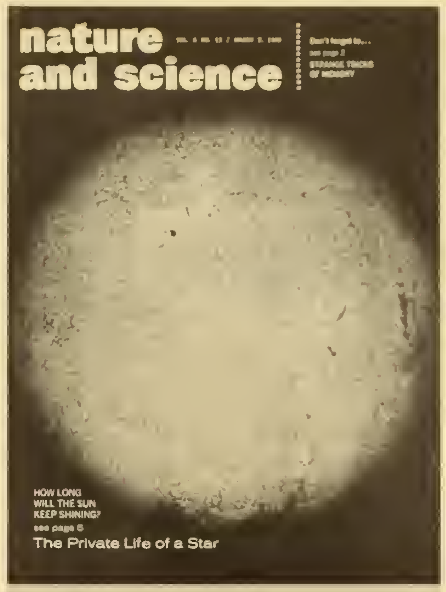


IN THIS ISSUE

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

IN THE NEXT ISSUE

What's being done to kill off—and to save—whales . . . Human reactions to sonic booms . . . How scientists use "superior" trees to improve the species . . . A SCIENCE WORKSHOP in dissolving solids and taking them out of solution.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Private Life of a Star

You will not have any trouble convincing your pupils that the sun and other stars have been shining for a "very long time," at least by human standards. The stars in the constellations that we see tonight are much the same as when they were plotted by Arabian, Egyptian, and Greek astronomers several thousand years ago.

Your pupils may wonder how fossil evidence shows that the sun has been shining for *hundreds of millions* of years with about the same intensity. During the Ordovician Period (about 500 million years ago), there was a marine organism known as *lingula*. The organism persists to this day, relatively unchanged through that vast stretch of time. That and many other examples that can be drawn from the evolutionary record are pretty convincing evidence that the sun's radiation output has been essentially the same for at least 500 million years.

An explanation for the constancy of the sun's radiation over so long a time could not be offered until Albert Einstein showed that matter can be changed into energy according to the equation $E=mc^2$ (energy equals mass times the square of the velocity of light). This made it possible for scientists to figure out how, when hydrogen nuclei fuse, a small amount of mass is changed into radiant energy (*see "Energy from Fusion"*).

In these reactions, four hydrogen nuclei are converted into one helium nucleus, but its mass is slightly less than the total mass of the four hydrogen nuclei. What has happened is that 0.007 (seven-tenths of one per cent) of the mass of the hydrogen taking part in the fusion is changed into energy, while 0.993 (99.3 per cent) of the mass is changed into helium.

The energy from a single fusion reaction is just about what a mosquito uses to "take off" from your neck. But when you add up the energy from the vast number of fusion reactions taking place every second, the energy output is enormous. Equally important, the mass remaining is sufficient to keep the star shining for billions of years.

Energy from Fission and Fusion

Some of your pupils may ask: Is the fusion process that keeps stars shining the same as the fusion process in a hydrogen bomb? Essentially, yes. Some may also wonder whether this is how the "atomic" (uranium) bomb and nuclear power plants produce energy. It is not.

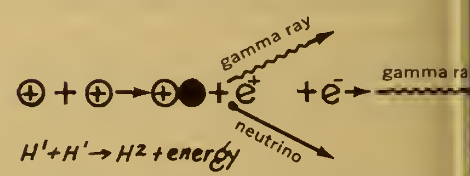
Energy is obtained from the heavy element uranium by a process called *fission*, or "splitting." In the uranium bomb, two masses of U^{235} are brought together to make a "critical" mass—a mass large enough so that a "chain reaction" begins to take place. In a critical mass of U^{235}, free neutrons collide with the uranium atoms, splitting them and releasing some of the energy that holds them together. Each split atom releases two new neutrons, each of which is free to split another atom of U^{235}, and so on. This chain of reactions takes place quickly and violently, resulting in an explosion.

A chain reaction of U^{235} can be slowed down to produce a continuous supply of energy, rather than a single powerful blast. This can be done by inserting carbon rods into the mass of U^{235} to intercept many of the free neutrons that would otherwise split uranium atoms. Energy produced in this way is usually used to heat water, making steam to turn generators that produce electrical energy.

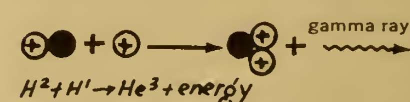
Scientists are trying to find a way to slow down the *fusion* process so that it releases energy gradually, instead of in a single blast. If this can be achieved, it will offer two great advantages over energy production by fission: 1) a much larger, and probably cheaper, "fuel" supply (deuterium from the nearly limitless supply of heavy water in the oceans, as opposed to uranium ore), and 2) no radioactive wastes like those from the fission process that pose difficult disposal problems.

(Continued on page 3T)

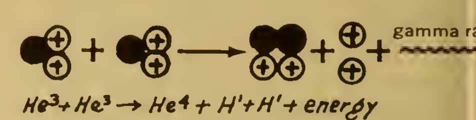
ENERGY FROM FUSION



STEP 1: Two protons, or hydrogen nuclei (H'), collide and fuse into a nucleus of heavy hydrogen, or *deuterium* (H²). In the process, one of them loses its electrical charge and becomes a neutron. The charge is carried away by a *positron* (e^+)—a positively charged particle with the mass of an electron. A high-energy photon, or *gamma ray*, is the major energy packet released by this initial fusion. Also released is a *neutrino*, a tiny particle without an electrical charge. As the diagram shows, the positron collides with a free electron (e^-). The two annihilate each other and are changed into another gamma ray.



STEP 2: The new deuterium nucleus fuses with a free proton, forming the nucleus of a light helium atom (He^3) and releasing a gamma ray of energy.



STEP 3: What usually happens next is that two lightweight helium nuclei fuse and produce the nucleus of an ordinary helium atom (He^4). In the process, two protons are freed and so made available for other fusions, and one gamma ray of energy is released.

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SUBSCRIPTION PRICES: In U.S.A. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

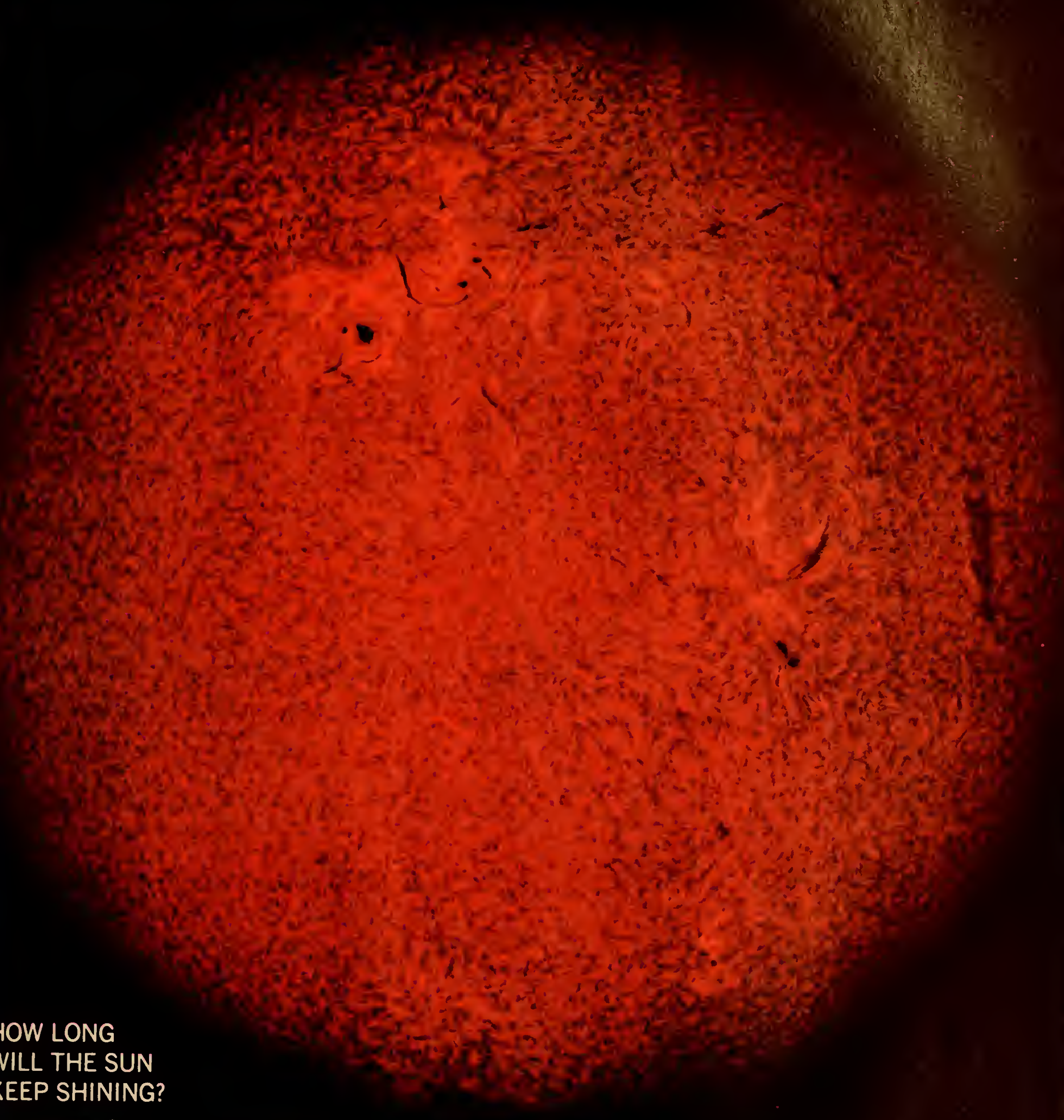
nature and science

VOL. 6 NO. 12 / MARCH 3, 1969

Don't forget to . . .

see page 2

STRANGE TRICKS OF MEMORY



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PICTURE CREDITS: Cover, pp. 7, 10, 11, photographs from the Mount Wilson and Palomar Observatories; p. 3, Frederic Lewis, Inc.; p. 5, photo by David Webster; pp. 5, 7-9, 11, 12, drawings by Graphic Arts Department, The American Museum of Natural History; p. 6, photograph fom the Lick Observatory; p. 12, photo by Thomas Eisner; p. 13, top photo by Laurence Pringle, bottom photo courtesy of Cartwright Aerial Survey Inc.; p. 14 (top), 15 (bottom) photos by Alan H. Anderson, Jr.; p. 14, bottom photo by William Wirtz; p. 15, top photo by Alfred M. Bailey and R. J. Neidrach from National Audubon Society; p. 16, Donald B. Clausen.

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 EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **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 September, October, December through March, monthly November, April, May, 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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Do you have a photographic memory? Have you ever gone to some entirely new place and remembered being there before? Scientists have studied some of these . . .

STRANGE TRICKS OF MEMORY

by Robert M. Goldenson

■ The Olsen family was hopelessly lost. After driving f
what seemed like miles, they finally passed an old farm
house. John, the older son, went in to ask the way. A fe
minutes later he returned with a puzzled expression on h
face. "I got the directions all right," he said, "but som
thing very strange happened. When I went into the livir
room, I was sure that I had been there before. I know it
impossible, but I can't get this queer feeling out of m
head!"

The "feeling of having been there before" is so commo
that it has been given a special name. It is *déjà vu,* which
French for "already seen." People have been trying t
explain déjà vu for more than 2,000 years.

Psychologists who study how people think and beha
have two possible explanations. One is that the déjà vu
something that has happened to you before—but not in th
exact same way. People usually remember in a general wa
what they see and hear, but they seldom remember the de
tails. If something like it happens again, they may thin
that they have been through the *whole* experience befor
John, for example, had never seen that actual livin
room before, but he might have seen a room—or a pictur
of a room—with the same general look. Perhaps the furni
ture had been arranged in the same way. And this mad
the entire room seem familiar to him.

The second explanation is that John might have see
the room in a dream. Our dreams are made of bits an

Dr. Robert M. Goldenson, a psychologist, is the author of Al
About the Human Mind, *for young readers, and* Encyclopedia o
Human Behavior.

pieces of what we have actually seen and heard. A picture put together in one of John's dreams might have been very much like the farmhouse room, and what he had merely dreamed about appeared to be a real experience. No wonder it seemed so mysterious!

Psychologists have tested the idea that dreams seem to become real. They described a building in great detail to several people who were in the sleep-like condition called *hypnosis*. A few days later, the people visited that building, which they had never seen before. And, sure enough, most of them remarked, "You know, I have a queer feeling I've been here before!"

Forgetting

Memory sometimes plays a trick that is the very opposite of the déjà vu: People or things look strangely *un*familiar. We're sure we have never seen them before, even though we really have. This experience is called *jamais vu*, French for "never seen."

The simplest example is failing to recognize someone we ought to remember. Think back to the last time this happened to you. Ask yourself how you feel about the person you did not recognize. You'll probably find there is something about him you dislike very much, or else there was a bad experience connected with him in some way.

We tend to protect ourselves from something unpleasant by blocking it from our minds. For example, a boy might have a terrible time remembering the name of a teacher who had scolded him many times in the classroom. The odd thing is that we don't really *try* to block out unpleasant memories. Something deep inside our minds does it for us.

Psychologists have tested this blocking, too. In one experiment, they asked a group of young people to write

(Continued on the next page)

MEMORY

DO YOU HAVE A PHOTOGRAPHIC MEMORY?

You can use this photo, or one something like it from a magazine or newspaper, to find out whether you have a photographic memory. A good test photo shows a number of different objects, signs, and people doing different things. Have someone use a watch with a sweep second hand to time you as you look at the photo for just 20 seconds. When the time is up, look away, close your eyes, and try to picture the scene as quickly as you can. Describe exactly what you see, and have your helper write down what you remembered. Compare the list with the photo to see how well you remembered what you saw.

Strange Tricks of Memory (continued)

down the five most pleasant and the five most unpleasant experiences each had had within the past few months. Their lists were kept in a file for one year, then each person was asked to recall as many of the experiences on his written list as possible. The people usually remembered almost twice as many of the pleasant happenings as the unpleasant ones. They had automatically protected themselves from the unpleasant experiences by forgetting them.

Few Photographic Memories

Try the memory test that is described in the photo caption on page 3. You'll probably be able to remember the picture fairly clearly, and you'll give quite a few details. But you'll overlook many others, or give some wrong ones. If so, you have a rather normal memory.

But if you happen to be one of those unusual people with what is sometimes called a "photographic memory," here is what will happen. You'll see the picture so clearly that the scene will appear to be right in front of you, not simply a picture in your imagination. You'll probably be able to *read off* the signs in the photo forward or backward, not just *remember* them. And, most surprising, you'll be able to "enlarge" part of the picture and describe details you didn't seem to notice when you stared at the photograph.

About one out of 10 or 20 children has this amazing ability of photographic memory, but most lose it by the age of 9 or 10. Sometimes, though, it lasts into adult life. President Theodore Roosevelt must have had it, for he was able to look at an entire newspaper page for just a few moments and then repeat everything on it, word for word. The ability is also found in many mathematical "whizzes" who can multiply large numbers in their heads very quickly. Such a person sees the numbers as if they were written on a blackboard. Then he quickly does one part of the problem and leaves it on his "blackboard" while he works on another part.

You've probably heard about people who perform amazing feats of memory for audiences. They can repeat the names of 50 people in the audience, or recall hundreds of dates after hearing them only once. A few of these memory experts have photographic memories, but even this isn't enough to explain their ability. How can it be explained?

Try To Remember

First, they were probably born with an unusually good ability to remember, just as some people are born with the ability to become good musicians. Second, often they have discovered early in life that they have better memories than most people. Because other people admire them for the tricks they can perform, they spend a great deal of time working with numbers or memorizing names. And third, they usually use some kind of "system," which they practice very often.

Some of these people try to find ways to connect a name with something they already remember; for instance, "Mr. Mason" might remind them of the Masonic Lodge. Others make a "mind picture" based on the name. For example, when they hear "Mr. Donaldson," they picture Donald Duck with a duckling trailing after him. When they see the man again, they are reminded of the duckling picture and have little trouble in remembering the name—unless they call him "Mr. Duck!"

Many people can perform surprising feats of memory if they work hard enough at it. But the real question is whether it is worth all the effort. Usually they can recall only a lot of details that don't mean much. Their memory tricks don't apply to things that count, like important ideas of science and history.

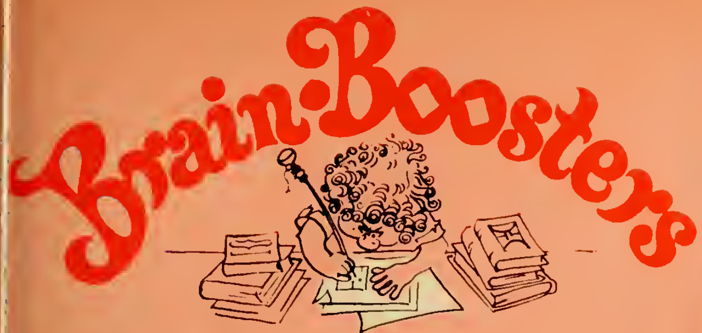
There is really only one way to remember such ideas. That is to study them until you understand them. That's the secret of a good memory. For if you look for the meaning behind the facts, you won't need a photographic memory or any special tricks at all ■

PROJECT

Does the meaning of words make any difference in how fast you can memorize them? Have someone time you with a stopwatch, or a watch with a sweep second hand, as you memorize the words in List A. How long does it take you to memorize the list so that you can repeat it once correctly? Do the same thing for Lists B and C, waiting a few minutes between lists. Which list did you memorize in the shortest time? Which took the longest? Can you explain why?

See if you can work out a "system" for memorizing a list of words like those in Lists B and C, as suggested in this article.

List A	List B	List C
DAX	PAPER	STAR
KIV	FENCE	GRASS
YOR	LAMP	OWL
ZEP	MEAT	SHELL
NAL	SKY	TREE
MIZ	TWIN	ELK
CEF	HUT	SAND
GAH	TRAIL	PLANT
BIS	BOTTLE	BAT
QOP	CLAY	SEA



prepared by **DAVID WEBSTER**

MYSTERY PHOTO

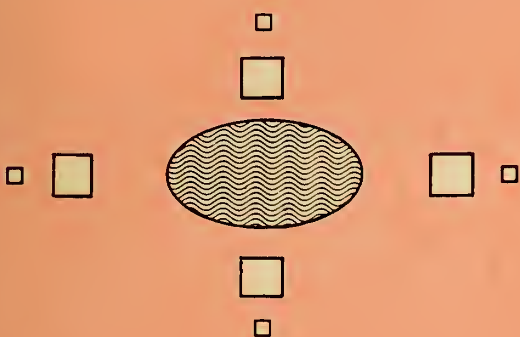
Why are all the branches growing out from only one side of this pine tree?

FOR SCIENCE EXPERTS ONLY

A balloon filled with helium was floating on a string outdoors. Then it began to rain, and the balloon fell to the ground. Can you explain why?

JUST FOR FUN

Get some soil that has no plants growing in it, and keep it watered for a few weeks. Does anything grow?



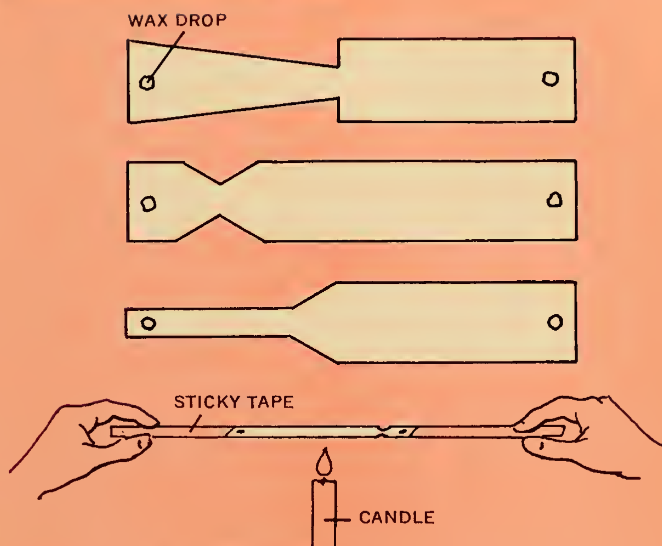
FUN WITH NUMBERS AND SHAPES

Around the lake are four big houses and four little houses. The people in the little houses want to build a fence to keep the people in the big houses away from the lake. But the people in the little houses want to be able to get to the lake themselves. Can you draw a line to show them how to build their fence?

CAN YOU DO IT?

Can you make an ice cube of three different colors?

Submitted by Edie Pullman, New York, New York

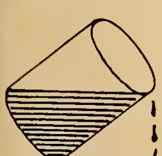


WHAT WILL HAPPEN IF?

Cut small pieces of aluminum foil into the three shapes shown here. Then put drops of wax on the ends of each strip. Attach sticky-tape "handles" and heat each strip at the center, as shown. Can you guess which end of each strip will heat up faster and melt the wax?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

What will happen if? The thermometer in the jar without any water will go up fastest when the jars are put in sunlight. After three hours the thermometer in the colored water will probably show the highest temperature. Would an empty jar with a cover get even hotter?



Can you do it? One way to get a can exactly half full of water is to fill the can, then slowly tip it to pour some of the water out. When the water level just reaches the bottom of the can, the can should be just half filled. How could you check to see if it really is?

For science experts only: The sewer line in a house is vented with an open pipe that sticks out through the roof. When wind blows across this pipe, it lowers the pressure of the air in the pipe, so the pressure of the air inside the house pushes the water farther down in the toilet.

Mystery Photo: The photo shows a stack of lobster traps.

Fun with numbers and shapes: Here are ways to arrange five 5s to equal the numbers from 2 through 12. What other numbers can you make with five 5s?

$$\frac{5+5}{5} - 5 + 5 = 2 \qquad \frac{5}{5} + \frac{5}{5} + 5 = 7$$

$$\frac{5+5}{5} + \frac{5}{5} = 3 \qquad \frac{5+5+5}{5} + 5 = 8$$

$$\frac{5+5+5+5}{5} = 4 \qquad \frac{55-5-5}{5} = 9$$

$$\frac{55}{55} \times 5 = 5 \qquad \frac{55}{5} - \frac{5}{5} = 10$$

$$\frac{55}{55} + 5 = 6 \qquad \frac{55}{5} - 5 + 5 = 11$$

$$\frac{55}{5} + \frac{5}{5} = 12$$

The Private Life of a Star

by Roy A. Gallant

It wasn't until about 30 years ago that astronomers found out what makes a star shine . . . and what keeps it shining for millions or billions of years.

■ Have you ever wondered how old the sun is? Or other stars? Some people in the past have thought the stars were "ageless"—shining forever without beginning or end. But with modern telescopes *(see "Big Eyes on Space,"* N&S, *February 3, 1969)*, astronomers have found what they think may be the "birth-yards" of stars, stars in different stages of "life," and stars that are "dying."

Some kinds of stars are different from others, but this article tells how a star like our sun probably forms, passes through various stages of its "life," and eventually "dies."

New stars are formed in clouds of glowing gas and dust that are called *nebulae*. This photo shows the Great Nebula in the constellation of Orion. You can see it without a telescope (see *diagram on page 11*).

Bonfires in the Sky

The sun gives off heat and light. Your senses tell you that. Certain Greek astronomers 2,500 years ago reasoned that the sun and other stars are fire. Around 500 B.C., Heraclitus supposed that the sun was a bowl of "moist vapor." Each morning it rose out of the sea and caught fire, he said. In the evening it returned to the sea, and its fire went out.

Others supposed that the sun and other stars were globes of hot iron. Maybe they got that idea from watching the fiery trails of *meteors*, or "shooting stars," and sometimes finding their remains, called *meteorites*. Some meteorites are made of iron, so you can see why people got the idea that the stars might be molten iron.

The idea that the sun and other stars are fiery globes hung on for about 2,500 years. Before it could be disproved, the sciences of chemistry and physics had to grow up.

Let's take a closer look at the idea of a sun that burns, as fire does. By reading accounts of day-to-day life written by the ancient Greeks and Romans, we know that the sun was neither hotter nor cooler in their times than it is today. The fossil remains of animals and plants also tell us that the sun has been just about as hot as it is today for many millions of years. Now if the sun were a burning lump of something, how long would it last before it burned itself out?

Suppose that the sun were a burning pile of wood or coal. A chunk of coal the size of the sun would burn for only a thousand years or so, if it burned fast enough to give off as much heat and light as the sun does. That doesn't come very close to the *millions* of years that fossil evidence shows that the sun has been shining as it does today.

A Contracting Sun

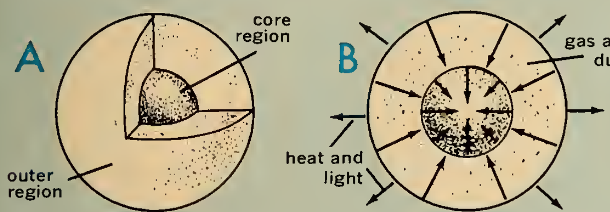
By the 1800s, the idea of burning stars had been given up. In the 1850s, two scientists came up with an idea that did not use fire at all. They were the British scientist Lord Kelvin and the German, Hermann von Helmholtz. They said that the sun produces its energy by *contracting*, or by

ABOUT THE COVER

This photo shows the churning clouds of hot hydrogen that make up the surface of the sun, our nearest star. The nuclear reactions inside the sun that keep it shining heat the surface gas to about 12,000 degrees Fahrenheit. At that temperature hydrogen glows with the reddish light by which this photo was made. Dark spots on the photo are the tops of clouds that are cooler.

packing the material it is made of tighter and tighter around the *core region,* or center part. (You make a snowball contract when you pack it. But you cannot pack a snowball tight enough to make it heat up so that it shines like a star.)

Try to picture a star that is contracting. First of all, there is more material packed into the core region of the star than there is in its outer region *(see Diagram A).* The material in each of these regions is "pulled" toward the material in the other region by the force we call *gravitational attraction.* But the core region material wins this "tug-of-war," because there is more of it. The result is that atoms of the material in the outer region keep falling inward toward



According to the "contracting star" theory, the greater mass of material in the core region of a star pulls material from the outer region toward the core, packing the core material more tightly and giving off heat and light.

the core region *(see Diagram B).* Gradually the material around and in the core gets packed tighter and tighter.

That is pretty much the situation that Kelvin and Helmholtz imagined. Year by year, century by century, the sun was gradually contracting—and, as a result, heating up. That is what enabled our local star to pour out huge amounts of heat and light—or so the two scientists thought. But eventually this idea, too, had to be given up. Here's why:

We can figure out the total amount of energy given off by the sun during one second, a minute, or a century. We can also figure out how much the sun would have to contract to produce each of those amounts of energy. It turns out that in one year the sun would have to contract hardly at all to keep shining the way it does now. Its diameter would become smaller by only 50 yards or so. But over hundreds of millions of years, the change in diameter would be very large.

For the sun to have kept shining over the ages by contracting, only 100 million years ago it would have been more than three times as large as it is today. That would suggest that it was sending out much more heat and light and other kinds of radiation at that time than it is today. There would have been too much radiation reaching the earth for certain animals and plants to have existed.

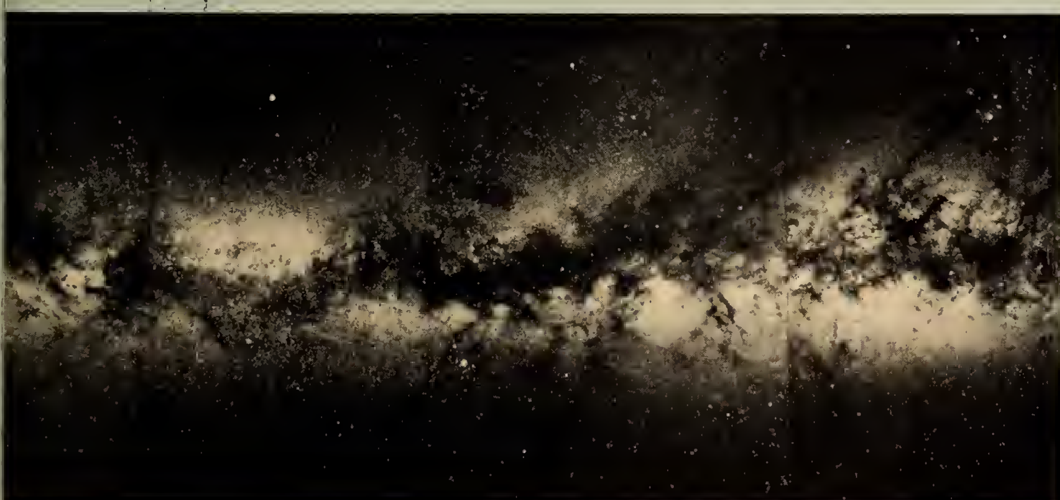
The fossil remains of such animals and plants, however, suggest that the size of the sun has changed hardly at all over the past 500 million years or more. Today, last year, a million years ago, a billion years ago, the sun cannot have been shining simply by contracting. But that does not mean that it *never* has produced energy by contracting. From what we know today, it seems certain that the sun and other stars do spend at least part of their "lives" shining by contraction. But they do not spend the "active" part of their lives shining that way.

Power Plant for a Star

In the 1930s, scientists thought of a "model" for a power plant that would make the sun—or most other stars—pour out the same amount of energy century after century, and without changing in size. This model still fits well with what astronomers are finding out about the stars. The model depends, first of all, on the way we now think that a star is formed.

In many parts of our galaxy—the vast collection of stars in which our Solar System is located—we see huge clouds of gas and "dust" *(see photo).* The gas is hydrogen. We are not sure what the "dust" is made of.

(Continued on page 10)



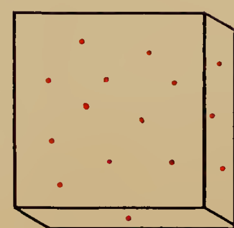
This photo shows part of the Milky Way, the galaxy in which our Solar System is located. The dark bands running through the galaxy are clouds of gas and dust that block from our view many more of the stars in the galaxy.

The Birth and Death of Stars

● For thousands of years men wondered what makes a star shine, and what keeps it shining. It wasn't until the 1930s that we came to understand what probably goes on in the unimaginably hot and dense core region of a star.

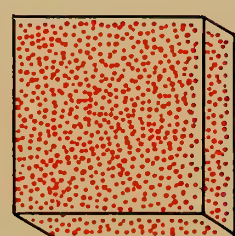
The heat and light given off by stars is produced by atoms ramming each other and fusing, or locking together to make new and heavier atoms. The process seems to begin with the collision of hydrogen atoms in the core of the star. But later in a star's "life-span," atoms of heavier elements, such as carbon, take part in the fusion. Eventually, however, the star runs out of the various kinds of atoms that can take part in fusion. The star's "life" then runs out.

The diagrams and captions on these pages show in simple outline what we now think may happen in the life-history of a star. However, there are still many details of this process to be discovered.—Roy A. Gallant



Space is not empty. It contains gas and "dust." In the Milky Way, our home galaxy, each cubic inch of space in our neighborhood contains about 15 atoms of hydrogen gas.

Great dense clouds of gas and dust are found here and there in our galaxy. One is the Great Nebula (seen in the constellation Orion). Each cubic inch of space there contains about 15,000 hydrogen atoms, mixed with dust particles. There is enough gas and dust in the Orion Nebula to make about 3,500 stars like the sun.



GLOBULES

Dense patches of gas and dust form in some nebulae. By gravitational attraction, the larger patches draw surrounding gas and dust into themselves and so grow larger. Gradually they take the shape of a sphere, and are then called "globules."

PROTOSTAR

Gravitational attraction within a globule causes the gas and dust to pack itself tighter and tighter in the core region. If the globule is massive enough, it becomes a *protostar*. The temperature and pressure then rise very high. The result: The protostar begins to

The temperature and pressure in the core of the protostar climb higher and higher as gravitational attraction causes matter near the surface of the new star to fall in toward the center. Eventually, hydrogen atoms there are ramming into each other with so much force that they *fuse*, or join, and become helium atoms. This fusion of hydrogen makes the protostar give off much more heat and light than before. It then becomes a *star*. Our sun (*see cover.*) is in this

BLUE GIANT

Huge globules containing lots of gas and dust form blue giant stars. These stars have core temperatures around 20 million degrees. They are so hot that they use up their hydrogen fuel rapidly. Such stars may have a "life-span" of only 10 million years or so.

STAR LIKE THE SUN

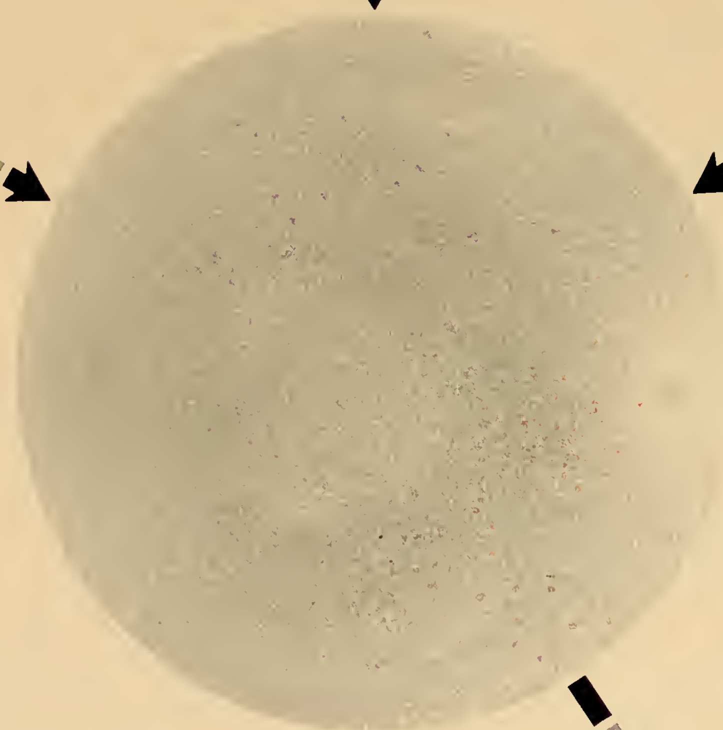
Medium-size globules form whitish-yellowish stars like the sun, which have lower core temperatures of about 15 million degrees. Such stars have life-spans lasting about 10 billion years.

RED DWARF

Small globules form reddish dwarf stars with still lower core temperatures—around 10 million degrees. These stars use up their hydrogen fuel at a much slower pace, so their life-spans are measured in trillions of years.

A NOTE ABOUT SIZE

The diagrams on this page have not been drawn to scale. The cloud of gas and dust containing the globules is several billions of miles from edge to edge. A globule itself may be several hundred millions of miles in diameter. When a typical protostar begins to shine by fusion, its diameter is somewhat less than 100 million miles. A blue giant star may have a diameter 10 or more times greater than that of the sun (sun's diameter: 850,000 miles). The diameter of a red dwarf may be only three-quarters that of the sun. The red giant star Betelgeuse has a diameter 400 times that of the sun. A white dwarf star may be about the size of the earth, or even smaller.



RED GIANT

Sometime after the hydrogen fuel in the core of a star is used up, the star swells and becomes a red giant. The star Betelgeuse (in the constellation Orion) is a red giant. It has a diameter some 400 times that of the sun. At the red giant stage, a star is entering "old age."

WHITE DWARF

Eventually a star runs out of atomic fuel and begins to collapse. What happens next is a mystery. Our guess is that the star caves in on itself as all of its atoms fall in toward the core. Once again the star shines because its atoms are being packed tighter in the core. The star becomes smaller and shines with an intense white light. It has become a white dwarf. Gradually it grows dimmer and dimmer, eventually becoming a "black dwarf."

Private Life of a Star (continued from page 7)

The spiral arms of many other galaxies also have a lot of gas and dust *(see photo)*. Sometimes, gas and dust are arranged in great patches, which we call *nebulae (see photo on page 6)*. The gas and dust making up a cloud gather in more and more material by gravitational attraction. Eventually, the cloud becomes very *dense (see "How Dense Are You?"*, N&S, *September 30, 1968)*, and it begins to take on the shape of a sphere. This is the first stage in the birth of a star, but it is not a shining star yet. At this stage, we call it a *globule*.

From Globule to Protostar

A globule becomes larger and larger by drawing more and more gas and dust into itself from the surrounding nebula-cloud. As more and more material falls into the core region of the globule, that part of the globule begins to heat up. It heats up because the atoms of gas and the particles of dust are packing themselves tighter and tighter together. This is just what Kelvin and Helmholtz had suggested.

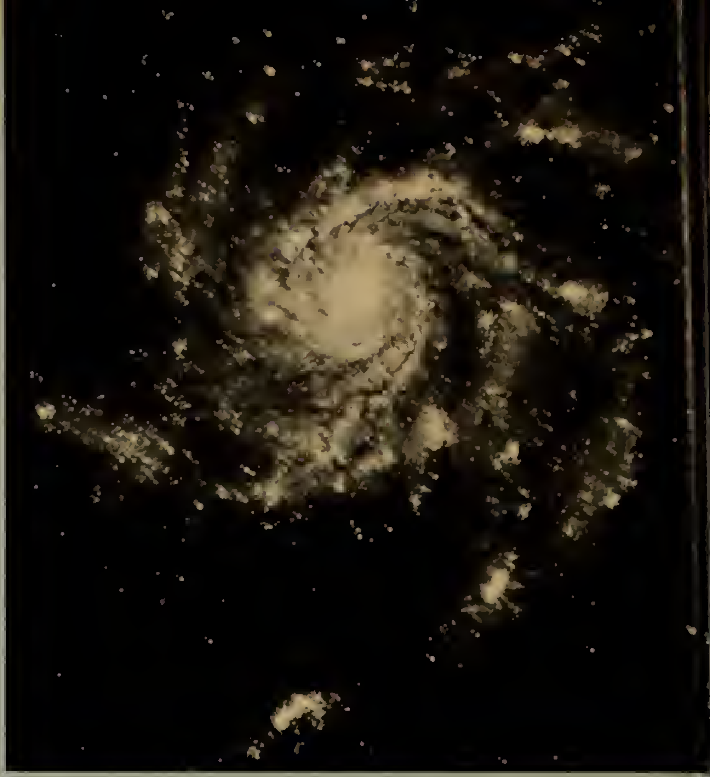
The tighter the packing, the more often the hydrogen atoms and dust molecules collide and the harder they ram into each other. This repeated ramming of particles produces energy in the form of heat and light, and the globule begins to glow dimly. It is now what astronomers call a *protostar*—a star that is in its first stage of shining.

In this stage, the star is shining by contracting. Material from near the surface of the star tumbles in toward the core region. As it does, the protostar gets hotter, and smaller.

A hydrogen atom has a *nucleus*, or center part, with one tiny particle called an *electron* moving around it. After a while, the hydrogen atoms in the core region of a protostar are ramming into each other so hard that their electrons are knocked free. This leaves the electron and nucleus of an atom free to fly about on their own. Eventually, the hydrogen nuclei in the core of the protostar are packed so tightly together, and are ramming each other so hard, that they begin to lock together, or *fuse* with each other.

From Protostar to Star

When hydrogen nuclei fuse, they form the nucleus of an atom of a heavier gas, helium. In the process, heat, light, ultraviolet, x-ray, and other kinds of energy are given off. Matter (hydrogen nuclei) is being changed into energy (light, for example). The star is no longer shining by contracting. It is shining because the hydrogen nuclei in its core are fusing. Each second, countless billions of hydrogen nuclei are fusing into helium, and releasing the heat energy and light energy that we feel and see from earth. The protostar has become a *star*. It has entered its *active life*, the period in which it is shining by fusing hydrogen in its core region.



The "arms" of spiral galaxies such as the Milky Way and NGC 5457 (shown here) are made up mostly of new stars and clouds of gas and dust from which new stars are formed.

How long can the sun and other stars keep shining in this way? Since they keep using up their hydrogen fuel, there must come a time when there is hardly any hydrogen left in the core region.

Scientists have figured out that the total amount of hydrogen fuel that the sun can use for fusion in the core region is about 3,100,000,000,000,000,000,000,000,000 pounds. And the sun is using up its fuel supply at the rate of about 310,000,000,000,000,000 pounds per year.

If we divide the smaller number into the larger one, like this:

$$\frac{3{,}100{,}000{,}000{,}000{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0}{310{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0{,}\not0\not0\not0},$$

we find that the sun's total *active life* is about 10 billion (10,000,000,000) years.

Astronomers believe that the earth and other planets of the Solar System were formed about the same time as the sun, out of the same mass of gas and dust. Measurements of the age of the earth's rocks suggest that this happened about 5 billion years ago. So the sun is a middle-aged star with about 5 billion years more to go in its active life.

As the diagrams on pages 8 and 9 show, the length of a star's active life depends on the *amount* of gas and dust that form a star in the first place. Because big stars have very high core temperatures, they use up their hydrogen fuel much more quickly than medium-sized and small stars do.

So the active lives of big stars are much shorter than the active lives of stars like the sun, and smaller stars.

Red Giants and White Dwarfs

Big, medium-sized, or small—most stars seem to go through a period of "old age" as *red giants* and end their lives as *white dwarfs.*

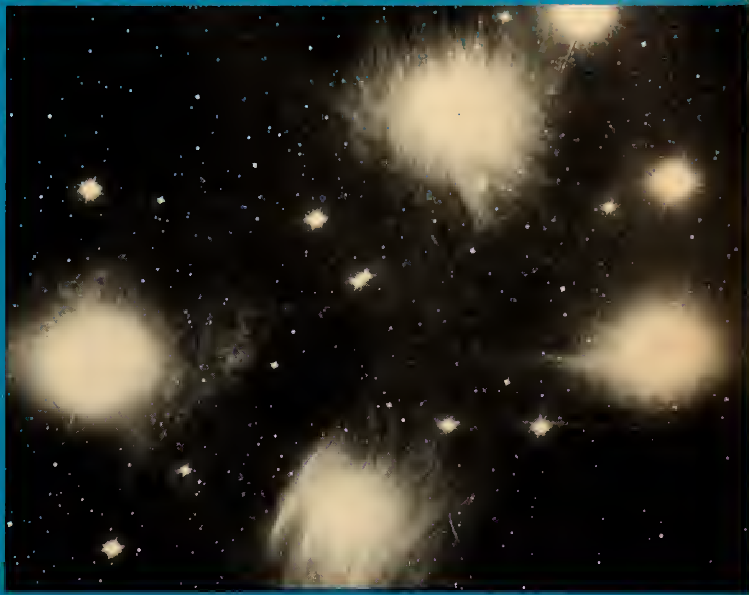
When a star begins to use up the last of its core hydrogen, it is ending its "active" life. Earlier, the outpouring of light, heat, and other energy from the core kept the star from collapsing in on itself. But now, with the core hydrogen nearly gone, there is less energy flowing outward from the core.

The star begins to "cave in" on itself, heating up again and drawing more and more hydrogen into the core from the outer region. As this hydrogen—additional fuel—is fused into helium, more heat reaches the outer region of the star than ever before. So the outer region begins to swell up, even while the core is shrinking.

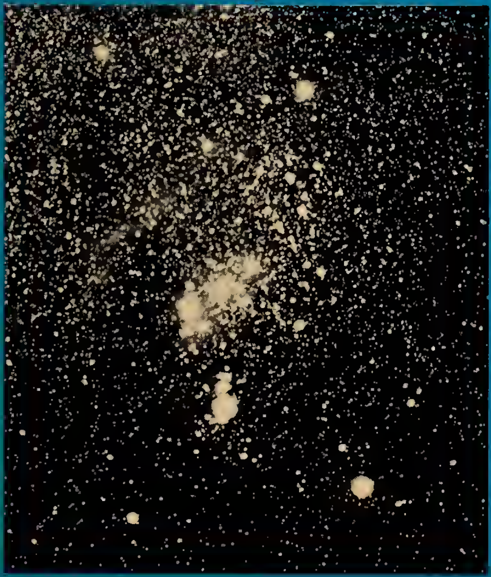
Over a few million years or so the star may grow thousands of times bigger. This makes it shine brighter. But its surface has grown so much in area that the amount of energy sent out from each point on the surface is less than before. So the star shines with a cooler, redder light. It has become a red giant, like the star Betelgeuse in the constellation Orion *(see photo and diagram).* The star continues enlarging and getting redder until the shrinking core becomes hot enough to make helium nuclei fuse and form the nuclei of heavier atoms, such as carbon.

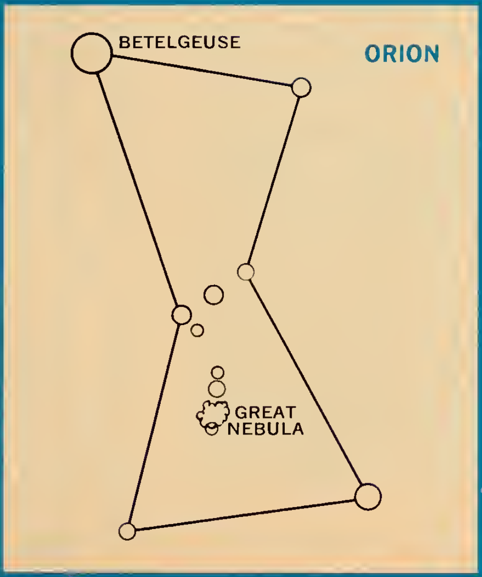
Astronomers aren't sure what happens next, though they can make a pretty good guess. They think the helium fuel must also get used up eventually, as do a few other kinds of atoms that also fuse and help keep the star shining. Once again, the star collapses. But this time there is no swelling up afterwards. As its matter tumbles in toward the core region, the star packs itself tighter and tighter, becoming smaller and smaller. It is now a dwarf star and its surface glows white-hot. But with its fuel for fusion all used up, the star gradually gets dimmer and dimmer as it slowly cools.

Eventually, after many more millions of years, the star probably becomes a cold, dark, extremely dense, burned-out star that might best be called a "black dwarf" ■



Stars in the cluster known as the Pleiades are newly formed and still surrounded by leftover gas and dust. These stars are *blue giants* (see *diagram on page 8*).





Betelgeuse, in the familiar constellation of Orion, is a *red giant* star. Because its surface is thousands of times bigger than the sun's, it shines thousands of times brighter, but with a cooler, redder light.

The Catnip Chemical

■ A whiff of catnip makes a cat lively and excited. Exactly why catnip has this effect on a cat is still a mystery. But another catnip question is closer to being answered.

What good is catnip for the plant that produces it? This question puzzled Dr. Thomas Eisner, a biologist at Cornell University, in Ithaca, New York. Catnip is actually a chemical found in the leaves of certain mint plants. "Surely," said Dr. Eisner, "a mint plant gains nothing from being able to excite cats." He wondered why the mint plants make catnip in the first place.

Scientists have been able to separate the catnip chemical, called *nepetalactone,* from the other substances in mint leaves. Chemicals similar to nepetalactone are made by insects. The chemicals help the insects defend themselves against their enemies, including other insects. So Dr. Eisner decided to investigate the effect of the chemical on insects.

Looking for insect food, ants swarmed around the dead cockroach on the left but avoided the cockroach on the right, which had a drop of the catnip chemical on it.

Chasing Insects with Catnip

He filled a small tube with nepetalactone and held it near different kinds of insects. Most kinds, including spittlebugs and several species of beetles, tried to get away from the tube. Some flew away. Others turned and walked away. Dr. Eisner found that he could move them in any direction he wanted by "chasing" them with the tube. It wasn't the tube itself that they were trying to avoid, for they did not respond to the tube when it was filled with water. The insects were avoiding the catnip smell that came from the tube.

With a glass rod dipped in nepetalactone, Dr. Eisner drew a circle around a group of ants. The insects stayed inside the circle; they would not cross the ring of nepetalactone. Another time, he put a drop of the catnip chemical in front of a group of ants that were marching toward some food. The ants immediately halted—and then made their way *around* the drop.

Dr. Eisner placed two dead cockroaches near a colony of ants. The ants belonged to a species that sometimes uses dead insects for food. A little nepetalactone was dropped on one roach, and none on the other. Within minutes, the one without the chemical was swarming with ants. Few ants went near the other cockroach *(see photo).*

These experiments showed that many kinds of insects avoid the catnip chemical. Dr. Eisner believes that catnip plants are protected from plant-eating insects because the nepetalactone keeps the insects away.

Over many thousands of years, these plants have changed in ways that help them to survive insect attacks. Some other kinds of plants produce chemicals similar to nepetalactone. Scientists are now searching for ways to use such chemicals to help protect food plants from insect pests.—SUSAN J. WERNERT

WHAT'S NEW

by
B. J. Menges

The earth wobbles as it spins through space. Scientists have long been aware of this, but they've been puzzled about what causes the wobble. The cause must be a continuing one. Otherwise the wobble would gradually get smaller and disappear.

Now, two scientists believe they've found the cause. In a study of the earth's wobbling motion over a 10-year period, Drs. Lula Mansinha and Douglas Smylie of the University of Western Ontario, in Canada, noticed that the wobble seemed to follow a pattern. It would decrease slowly for a while, then suddenly increase. Each increase, they found, happened at the same time as a major earthquake. They now believe that earthquakes may jolt the earth enough to cause it to wobble.

A tiny space engine has been developed by the National Aeronautics and Space Administration. It is a one-foot-long electric engine that produces a *thrust*, or push, of only 20 millionths of a pound. In comparison, each of the five engines used in the lift-off of the Saturn 5 lunar rocket produces a thrust of 1.5 million pounds.

The weakness of the new engine isn't a drawback, though. Its tiny thrust is just what is needed to help keep communications and navigation satellites on course. These satellites complete one orbit in the same time that the earth completes one rotation. Thus they should always remain over the same spot on earth. But because of slight variations in the force of gravity, these satellites tend to drift from their positions. Only a slight push is needed to keep them from doing so, and this push can be provided by the little rocket engine. A tenth of a pound of fuel will be enough to keep a satellite where it belongs for more than three years.

Wolves are back in Yellowstone National Park. Rare in the United States, wolves seemed to have disappeared entirely from the huge Wyoming park. But recently six wolves have been seen there.

All wildlife is protected in the park. The wolves are welcome because they can help control the numbers of some large animals there. Elk herds in the park, for example, have become so big that there is not enough food for them. Since wolves hunt and eat elk, they are expected to help reduce the size of the herds.

The Loch Ness monster is making news again. For hundreds of years, people have reported seeing a large, strange creature in Loch Ness, a big, deep lake in Scotland. Now a team of scientists from the University of Birmingham, in England, has found evidence that there may indeed be something unusual in the lake.

The scientists explored the depths of Loch Ness with sonar equipment, which detects underwater objects by the sound waves they reflect. Sonar echoes detected three large moving objects that an engineer with the team said were "clearly" animals. One object seemed to be several yards long, and moved through the water at speeds up to 17 miles per hour. It dove at the rate of 450 feet per minute, a speed that "makes it seem unlikely" that it was a fish, according to one of the scientists. The men hope to investigate further to see whether the Loch Ness "monster" can be identified.

As people grow old, they often lose sight in an eye because the lens of the eye becomes cloudy. This condition is called a *cataract.* The only known cure is to remove the lens. In the standard operation, a surgeon simply cuts out the lens. The resulting wound is uncomfortable and takes about a month to heal. But now Dr. Charles D. Kelman, a New York City surgeon, has found a way to remove the lens with "silent sound." The sound is "silent" because it has a higher pitch than human ears can hear.

Dr. Kelman first inserts a hollow needle into the cloudy lens. Then the needle is made to vibrate 40,000 times per second. This produces sound waves that shatter the lens into pieces. The pieces are then sucked out of the eye through the hollow needle. Because the needle makes only a tiny wound, the eye heals in a few days.

The newest threat to our rivers and lakes is heat. Sewage and chemicals are already polluting many of our bodies of water. Now heat is a problem, largely because of the rapid increase in the number and size of electric power plants.

Most of these plants use enormous amounts of water from nearby rivers or lakes for their cooling systems. The water takes up heat, and is returned to the river or lake 10 to 20 degrees hotter than before. This gradually raises the temperature of the whole body of water, causing some kinds of plants and fish to die. As more electricity is needed, this "thermal pollution" is bound to get worse—unless the water used in power plants is cooled before it is returned to the rivers and lakes.

This photo, taken from an airplane by a camera fitted with infrared film, shows a small temperature difference between the Sacramento River (left) and the warmer American River that joins it. (Warm objects show up lighter than cooler objects on infrared film.) This kind of photography can be used to detect thermal pollution in waterways. **(See *"The newest threat,"* on this page.)**

By counting and banding birds, and by studying their ways of nesting, I helped solve some of the...

Secrets of Kure Island

by Alan H. Anderson, Jr.

This aerial view of Kure Island shows the buildings of the Coast Guard station, the runway, and the dark *Scaevola* bushes that cover most of the mile-and-a-half-long island.

■ For 10 weeks I joined other biologists who were studying the life of Kure Island, a small island 1,200 miles northwest of Honolulu. We had a small lab building behind the United States Coast Guard station. There I learned more about the investigations that were being done on the island, and the kinds of questions the other biologists had been trying to answer.

For example, how many birds were living on the island, and how did their numbers change? There is no magic way to answer this question. We used a very old technique: counting. We spent one day a week counting all the birds on the island, species by species. A small motorcycle helped the work around the airplane runway, but the rest of the island was covered on foot, including a three-mile walk around the beach. The total count made in the daytime was low, since most of the birds are on the island only at night. And the birds that "use" the island are not all there at the same time, so the exact numbers could not be known by this method.

We also wanted to find out where the birds went when they were not on the island. We did this by banding as many birds as possible. We looped an aluminum band with a code number around each bird's leg. Then the number was recorded in a book, along with the date and place.

When a banded bird is recovered—either dead or alive—

The boobies lay two eggs but raise only one chick (above). The author put numbered bands on the legs of boobies (left) and other birds, to learn more about their travels.

by someone in another place, we can learn something about its travels by using its band number to find when and where it was banded. Banding has told us, for example, that the young Kure albatross, which leave the island soon after they can fly, spend three or four years at sea before they return to the tiny island and breed for the first time. We spent many hours of the day and night banding thousands of birds to get information such as this.

When the Birds Return

A problem I worked on for part of my stay was the daily movements of nesting blue-faced boobies. We wondered how long birds were away from their nests while their mates cared for the egg or chick. How long did one bird of a pair sit on the nest before being relieved by its mate? I spray-painted some dots on the upper breasts of several nesting birds so that I could recognize the individual birds. Then, beginning at one o'clock one morning, I checked each nest hourly to see if and when the birds on nests had been relieved by their mates.

I found that all of the birds came back to the island around dusk to spend the night. Shortly after sunset, clouds of shearwaters, petrels, and terns swarmed offshore like airplanes waiting to land at a crowded airport.

The boobies usually landed in the same spot night after night. The incoming bird would spot its nest from afar; the female would give a honk to identify herself, and the male would answer with a call like a wheeze. They would greet each other with calls, gestures, and bill-touchings as though they had been separated for years rather than hours.

I discovered that most of the boobies seldom sat on their nests for more than 12 hours at a stretch. Those that kept long or irregular hours turned out later to be poor parents whose eggs might not hatch. One bird sat on her eggs for four days; even then she was relieved only for a few hours. As I expected, she and her mate failed to raise a chick.

An Extra Egg

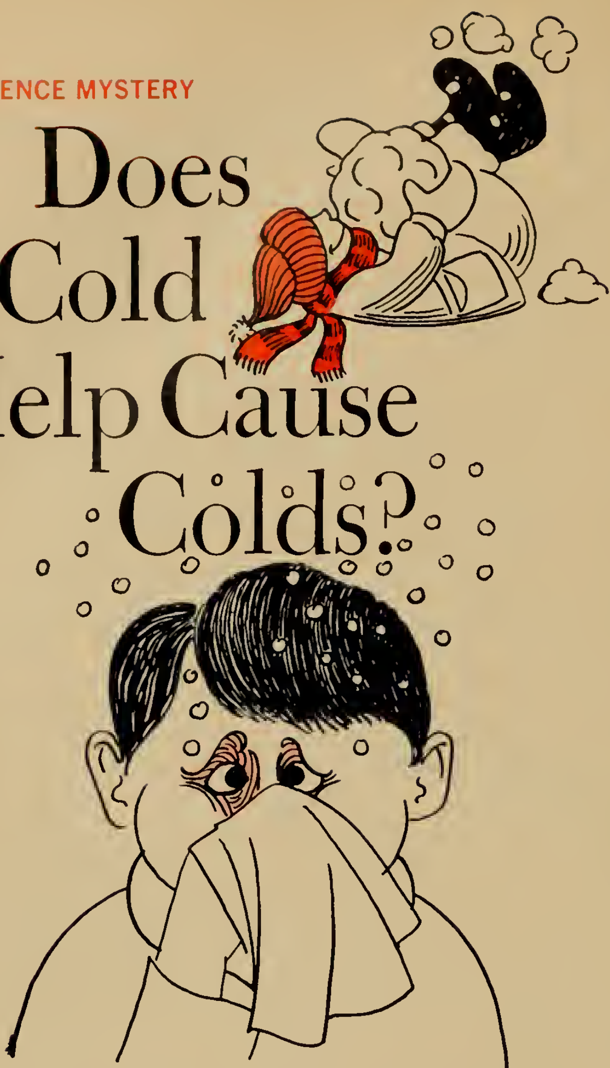
During my visits with the boobies I noticed that they lay two eggs but raise only one chick. With this system, there is a "back-up" egg in case one fails to hatch. Several times, when it seemed that neither egg would hatch, I replaced one with an extra egg from another nest. Each time, the foster parent accepted it.

When the time came for me to leave Kure, conditions had changed a great deal since that foggy afternoon when I saw the island for the first time. The days were now warm and sunny. Several dozen seal pups paddled around the lagoon in their first tries at swimming. The largest booby chicks—helpless white balls of fluff that were constantly stuffed with fish—weighed even more than their parents.

I had learned something of how creatures "earn a living" on a Pacific atoll. But most of all I had seen how wrong it had been for a scientist to say, in 1881, that everything that needed to be known about islands was already known. Very likely there will always be new puzzles on islands for a biologist to solve ■

A SCIENCE MYSTERY

Does Cold Help Cause Colds?



■ "Don't stay out in the snow too long—you'll get a chill and catch cold!" That's what mothers always seem to be saying. But does getting a chill or staying out in the cold for a long time really make you catch cold?

Scientists have known for a long time that colds are caused by *viruses*—tiny particles of matter that can invade your body cells and make the cells produce many more viruses of the same kind. When a cold virus gets into the surface cells in your nose or throat, the cells also produce more of the *mucous* fluid that makes you cough or blow your nose so often.

Viruses alone aren't enough to explain a cold, though. There are usually many viruses inside your nose that *could* give you a cold, and yet you don't have a cold all the time. Since most colds occur in winter, many people believe that cold weather must have something to do with it.

Does a Chill Make You Ill?

Recently, Dr. R. Gordon Douglas, of Baylor University College of Medicine, in Houston, Texas, did some experiments to see whether cold or chilling seemed to help viruses cause colds. Dr. Douglas and his co-workers exposed some healthy men to cold and damp, some to cold viruses, and some to both. No colds developed in the men who had been exposed to cold and damp but not to cold viruses. What's more, the men who had been exposed to cold, damp, *and* viruses caught no more colds than the men who had been exposed to viruses alone. And the colds were no worse for one group than for the other.

This seemed to show that cold and chilling don't increase a person's chances of catching cold, or of having a worse cold than he would without having been cold or chilled. Why, then, do most colds occur in winter? The scientists at Baylor University suggested that it may be because in winter people tend to crowd together indoors, where cold viruses can be easily spread by a cough or sneeze. Also, since viruses are only active when they are in contact with living things, it may be easier for a virus to survive under these conditions. A virus wouldn't have as far to travel between people in, say, a movie theater, as between people in a park.

Warm Rooms and Cold Viruses

Another possibility is that going from warm to cold places and back again may help cause people to catch cold. Most people going to work or to school in winter start out from a warm home, go out into the cold, and then go into a warm office, factory, or school. If they have to ride in a car, bus, or train, they will go through still another warm-cold change before they get to where they're going. Possibly these rapid changes in temperature reduce a person's resistance to colds.

Another idea is that winter *heat* may help cause colds. The heating systems used in many homes and other buildings tend to reduce the *humidity*, or amount of moisture in the air. Low humidity can "dry out" the sensitive lining of your nose, which helps protect you against cold viruses. When this happens, the lining may be less able to keep the cold viruses from getting past it.

Any or all of these ideas may help explain why people get their colds mainly in winter. Or there may be some other explanation that no one has thought of yet. Some scientists think that when a person has just caught cold, but before he is aware of it, he becomes more sensitive to low temperatures and chills. If he feels cold or chilled before he begins coughing or sneezing, he is likely to feel that the chill brought on his cold, rather than that his cold made him feel chilly. This can explain why a person thinks the cold weather made him catch cold, but it still doesn't explain how he caught the cold.

For that answer, we will just have to wait—handkerchief in hand.—R. J. LEFKOWITZ

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

The Catnip Chemical

Your pupils may want to know what happens to *cats* when they sniff catnip. Fresh, fragrant catnip will not affect all cats, because the ability to respond to the catnip chemical is inherited. When it does have an effect, the cat responds by head-first rolling and face-rubbing. This behavior is similar to that of a female cat "in heat," the period when she is sexually excited. So some scientists believe that nepetalactone smells like a chemical normally produced by cats at the beginning of courtship.

• To a person who doesn't understand how scientists work, the question —What good is catnip for the plant that produces it? — might seem "silly," or "not worth wasting time on." But all new knowledge is obtained by testing what we already know in new situations. In Dr. Eisner's question, the part we already know is that some plants produce chemicals that repel insects or other animals that might eat the plants.

In addition, Dr. Eisner had some knowledge that is not implied in the question. He knew that scientists have recently found that some insects make chemicals similar to the catnip chemical and use them to repel other kinds of insects that attack them. This suggested that the catnip chemical might protect the mint plant from insects that would otherwise endanger its survival.

These facts make it easier to understand why Dr. Eisner asked the question he did and sought the answer by testing the catnip chemical on insects. While he did not start out to find a new substance that would protect plants against insects without harming either the plants or the insects, it is conceivable that the catnip chemical, and similar chemicals produced by other plants, might be used for that purpose.

• Have your pupils think of other ways that plants have become adapted for survival in their environments. For example, thick skin and sharp spines help protect certain species of cactus from being eaten by animals. Some plants trap and digest insects that provide minerals needed for growth. Others have colors, odors, and food substances that attract insects, which spread pollen from plant to plant, enabling the plants to reproduce.

Brain-Boosters

Mystery Photo. The lopsided pine tree is near the ocean. Strong winds blowing from the sea prevent the tree from growing normally.

A tree growing at the borderline between a field and a forest may also grow in this way. The greater amount of sunlight reaching the tree across the open field causes more branches to grow on the field side of the tree than on the forest side. Can your pupils find any such trees in their neighborhood?

What will happen if? The wax drop at end B of each aluminum foil strip should melt first, since more heat can flow through the wide part of each strip than through the narrower part. If your pupils perform this investigation in class, be sure that they attach the sticky-tape "handles" to the aluminum strips, to avoid burning their fingers.

You might encourage the class to try the investigation with aluminum strips of different lengths, widths, or shapes.

Can you do it? To make ice cubes of three different colors, first color some water with food coloring, fill the bottom third of an ice tray with it, and freeze it in the school refrigerator. Then add a second layer of different-colored water. When the second layer is frozen, add a layer of a third color.

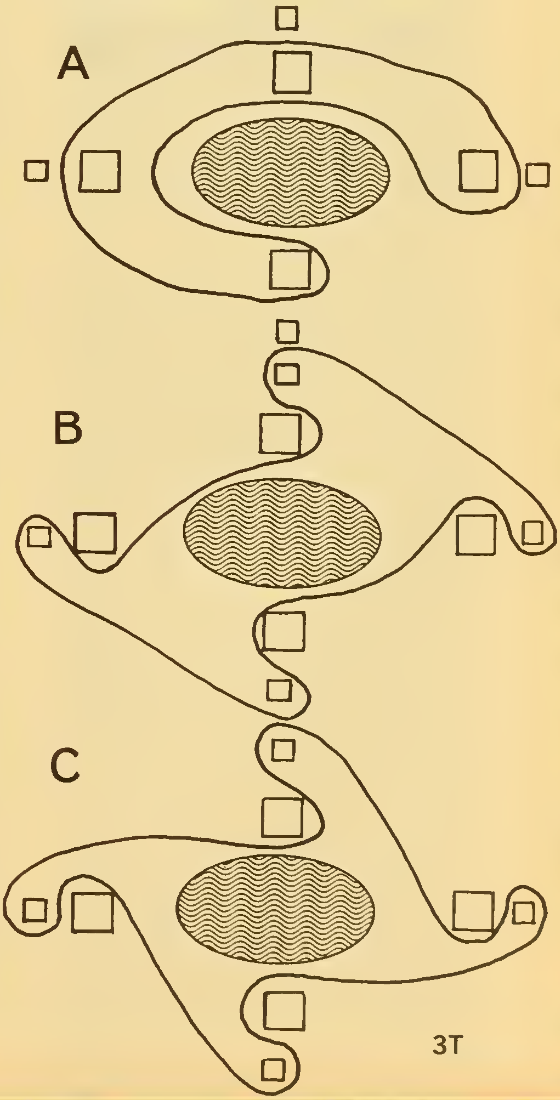
Challenge your pupils to try making other kinds of unusual ice cubes at home. Can they make a round ice "cube," a hollow ice cube, an ice cube with a pebble inside, or a milk or soda pop "ice" cube?

For science experts only. When it rained, raindrops collected on the helium-filled balloon. The weight of the water made the balloon fall to the ground.

If you or a pupil can bring a helium-filled balloon to school, the class can experiment with it to find out how much weight it can hold up. How many paper clips can they attach to the balloon's string before the balloon sinks to the floor? Will the balloon hold up more paper clips in the cold air outdoors, or in the warm classroom air?

Just for fun. Have some pupils bring in some barren soil from outdoors, and set it on a windowsill in a flowerpot, pie tin, or other container. Assign some pupils to keep the soil watered and make observations daily. Can your pupils identify whatever may grow in the soil? If nothing grows, do your pupils think that this means that there is nothing in the soil that *can* grow? Or can there be some other explanation for why nothing is growing?

Fun with numbers and shapes. The diagrams show three different ways for the people in the little houses to build a fence that will allow them access to the lake while keeping out the people in the big houses. Can your pupils figure out which would be the cheapest fence to build? (If they measure the three fences with a length of string, they will see that fence A is the shortest and would require the least amount of fencing materials.)



Putting Our Hows and Whats . . .
(continued from page 1T)

element, the spectroscope reveals an *emission-line* spectrum. When the element is vaporized, its atoms become part of the hot gas of the flame and radiate light of certain wavelengths *characteristic of that element.* Each element has its own set of wavelength "fingerprints" *(see diagram).* This

Each element has its own characteristic pattern of spectrum lines, bright or dark depending on whether the vaporized element is emitting or absorbing light at those same wavelengths.

property of atoms is an invaluable aid to the astronomer. It enables him to identify the gases making up stars (and the atmospheres of the planets).

It so happens that atoms can absorb the same wavelengths of light that they radiate. If you vaporized some sodium in a flame you would see a single bright (emission) line against the continuous spectrum of the flame. Now suppose that you take the sodium out of the flame. Also suppose that there is now a thin cloud of sodium gas between your spectroscope and the flame. The sodium atoms of that cloud absorb the light of their characteristic wavelengths being radiated by the flame. So, instead of seeing a bright (emission) line, you see a dark *absorption line* spectrum.

Spectroscopes have enabled us to work out the chemical composition of the sun, and of other stars. The sun's surface radiation produces a continuous spectrum. But the gases in the sun's atmosphere produce an absorption line spectrum. So far, we have observed in the sun's atmosphere absorption line patterns of about two-thirds of the hundred or so elements. By far, most of the atoms identified are hydrogen, with the rest being mostly helium. In far lesser amounts, next come oxygen, followed by nitrogen, carbon, and neon.

Unfortunately, we cannot see through the bright surface of the sun to find out what is inside, not even with spectroscopes. However, we have very good reasons to suppose that the surface and atmospheric gases of the sun are a reliable sample of the remaining solar matter. Hydrogen, then, seems to make up the bulk of the sun, and of the other stars.

But what about matter spread out between the stars? In the early 1950s astronomers made a major discovery—an emission line in the *radio* region of the spectrum at the 21-centimeter wavelength position. Hydrogen radiates radio waves of that length. Using radio telescopes tuned to the 21-cm wavelength, a survey of space between the stars in our galaxy has been underway for about 15 years. It turns out that by far most of the gas in space is hydrogen–perhaps 9 out of 10 atoms ■

A GLOSSARY OF TERMS

Apparent brightness: The brightness a star appears to have as we view it from a distance. *(See also Luminosity.)*

Constellation: The grouping of certain stars. The ancients recognized the groups as human and animal figures, for example, Orion, "the Hunter." By international agreement, 88 constellations are recognized. Because the stars are in motion relative to each other, the shape of each constellation is slowly changing.

Galaxy: A huge system of stars. The galaxy of which the sun is a member has the shape of a flattened disk with a central bulge. It contains about 100 billion stars and has a diameter about 100,000 light-years *(see below).* In addition to its stars, our galaxy also contains vast clouds of dust and gas, out of which new stars are being formed. Our galaxy rotates like a great pinwheel, different parts of it rotating at different speeds. The part containing the sun takes about 230 million years to complete one rotation. The sun lies close to the galaxy's central plane and about 30,000 light-years from the central hub, which is about 10,000 light-years thick.

Light-year: The distance light travels in one year, at a speed of about 186,300 miles per second. One light-year is about 6,000,000,000,000 miles.

Luminosity: The total amount of energy emitted by a star per unit of time. (The sun's luminosity, for instance, is 5.6 x 10^{27} calories per minute. Betelgeuse, a red giant, has a luminosity 4,000 times that of the sun. The red dwarf star known as Ross 248 has a luminosity only 0.0001 that of the sun.) *(See also Apparent brightness.)*

Milky way: The luminous band of stars seen on any clear night. The effect is caused by our looking into our galaxy edge-on; we see millions of stars that appear to be crowded together, the effect being a hazy belt. The term *Milky Way* is sometimes used to designate our galaxy, which most astronomers refer to as *The Galaxy.*

Nebulae: All nebulae are clouds of dust and gas. A *dark nebula* blocks the light from a field of stars behind it, and so appears dark by contrast with the surrounding lighter sky. (The "rift," or dark band in the summer Milky Way is caused in this way.) A *reflection nebula* is mostly dust that reflects the light from nearby stars, so the nebula appears to glow. (One of the most spectacular reflection nebulae is the one in the Pleiades. As the photograph on page 11 shows, stars in the Pleiades look like street lights in the fog.) An *emission nebula* contains much gas that intercepts light from nearby hot stars. The atoms of the gas become excited and re-emit the energy. We then see the nebula glow. (One emission nebula is the Great Nebula in Orion, shown on page 6.)

Spectroscope: An instrument that separates light into its component colors. A prism or a grating may be used in a spectroscope. A diffraction grating is a polished glass or plastic sheet with as many as 30,000 grooves to the inch. When a star's light falls on this grating, the light waves of different lengths are diffracted at different angles and so form a spectrum.

Star: A hot, glowing globe of gas, that shines by generating its own light. Most stars are very much larger than planets. Stars generate their energy not by chemical means, but by nuclear reactions.

nature and science
TEACHER'S EDITION
VOL. 6 NO. 13 / MARCH 17, 1969 / SECTION 1 OF TWO SECTIONS

◄ N & S REVIEWS ►

Recent Books on Anthropology and Archeology for Your Pupils

by Elizabeth B. Gould

The Early Days of Man, by Roy E. C. Burrell; illustrated by Tony Dyson and the author (McGraw-Hill, 164 pp., bibliography and index, $4.95). This excellent book about Old World prehistory is for the serious young reader. It is crammed full of information and does a remarkable job of summarizing and making comprehensible a subject of vast proportions. Beginning with brief mentions of the appearance of life forms, evolution, and natural selection, it touches on fossil remains of early man, and continues with a good explanation of archeological techniques. Separate chapters treat the Paleolithic, Mesolithic, and Neolithic Ages. The second half of the book deals with the early civilizations in Mesopotamia, Egypt, and India, up to the appearance of writing. The mass of information in the book has not been compromised by the necessity for generalization. The reader is constantly made aware of such important problems as man's dependence on his climate and the influence of geographical features on civilization. The text is illustrated with a number of good maps and line drawings.

How the World's First Cities Began, by Arthur S. Gregor; illustrated by W. T. Mars (E. P. Dutton & Co., 62 pp., index, $3.75). The author of this slender volume is clearly an admirer of cities, which he calls "perhaps man's greatest invention." Increasing control over the environment is his criterion for man's progress. With a deprecating nod toward man the hunter, he eagerly recounts the steps in the march toward urbanization: agriculture, animal domestication, storage. Life in ancient Mesopotamia provides a focus for a detailed examination of the increase in populated areas. Irrigation, metal tools, increasing trade, slave labor, writing—all contributed to the concentration of people in favorably situated areas. In the final chapter, which boasts of the size of modern cities, the author might have done well to reconsider whether city life is man's greatest achievement. Has man's life been truly enriched by the city? Or is he now a prisoner in an environment of his own making? The book is illustrated with rather stylized drawings.

The Pygmies: Africans of the Congo Forest, by Sonia Bleeker; illustrated by Edith G. Singer (William Morrow, 137 pp., index, $3.25). Sonia Bleeker's account of the life of the Pygmies of the Congo's Ituri Forest portrays this people's dependence on and affection for their rain forest. Their food-gathering techniques and daily activities, and some of their beliefs and ceremonies, are described in careful detail. The Pygmies emerge as a well-regulated, perfectly adapted, cheerful people, whose lives have scarcely been touched by modern colonial intrusions. This book seems to be a simplified version of Colin Turnbull's *The Forest People,* without his sense of involvement and participation. The book is illustrated with undistinguished line drawings.

Indian Costumes, written and illustrated by Robert Hofsinde (Gray-Wolf) (William Morrow, 94 pp., index, $2.95). Clothing styles of selected North American Indian tribes, mostly of the West and Southwest, are the subject of this book. The book could be very useful as a reference, perhaps for Boy Scouts doing research for an Indian show; but its catalog style does not recommend it for casual reading. The author makes parenthetical

(Continued on page 4T)

Elizabeth B. Gould is a student of anthropology, and the wife of Dr. Richard Gould, Assistant Curator of North American Archeology, The American Museum of Natural History, New York City.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T-4T.)

IN THE NEXT ISSUE

Special-topic issue: Life in the City . . . The past, present, and future of cities . . . How a city "creates" its own climate . . . Crowded people . . . The plants and animals that share our cities . . . Controlling pigeon numbers.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Making Solids Disappear

Investigating solutions as suggested in this SCIENCE WORKSHOP article will stir your pupils' interest and curiosity about a process so common that we seldom think about it. You can help them to evaluate their findings, to develop further investigations as scientists do *(see "Suggestions" below)*, and to understand why solutions are vital to all living things *(see "Topics" below)*.

Suggestions for Classroom Use

• The investigations can be done in the classroom, or—even better—at home in the kitchen, where hot and cold water and the other needed materials and equipment are handy. Have each pupil write a brief description of each investigation and his findings, something like this: "Poured 2 fluid ounces of cool water into a clean glass. Added 1 level teaspoonful of white granulated sugar to water and stirred about 30 seconds. Waited 30 seconds to see if sugar settled to bottom of glass. It dissolved. Washed and dried spoon, then added more sugar. In the same way, added a total of 20 teaspoonsful of sugar to the water. Part of the 20th spoonful did not dissolve. Result: 2 fluid ounces of water dissolved 19½ teaspoonsful of sugar."

Explain to your pupils that these descriptions are not "written homework," to be turned in and graded, but scientific records for use in comparing their procedures and findings with those of others who have made the same investigation.

• If your pupils follow the directions for a particular investigation carefully, their findings should be *about* the same. By comparing their records of procedure with each other, your pupils may be able to trace small differences in their findings to differences or inaccuracies in measuring the amounts of solute and solvent, or to differences in the temperature of the solvent used.

Fluid ounces should be measured with a standard kitchen measuring cup, if possible, and level teaspoonsful with a standard kitchen measuring spoon (1 level teaspoonful equals ⅙ fl. oz.). The temperatures of the water can be measured with a common alcohol thermometer, but warn your pupils that the thermometer will break if placed in water hotter than about 110° or 120° Fahrenheit.

Pupils whose findings differ widely from those of their classmates should be encouraged to compare their procedures with those of other pupils, to seek an explanation for the wide difference in their findings, and to try the investigation again to see whether they get the same results.

If a number of pupils have independently made the same investigation in the same way and their findings differ only slightly, the class will probably agree that those findings can be taken as a useful description of the event they were investigating. Have your pupils try to make up a sentence that includes, or summarizes, the findings that seem most accurate. For example: "Two fluid ounces of 'cool' water will dissolve about 17 to 20 level teaspoonsful of white granulated sugar." (You might point out that 18 level teaspoonsful equals 3 fluid ounces, so the water dissolved about 1½ times its own volume of sugar.)

This raises the question of what is meant by "cool" water. Since your pupils have found that warm water dissolves more sugar than cold water, some may wish to repeat the investigation and find out how much sugar can be dissolved in water at a certain temperature.

The article also suggests finding out whether 4 ounces of water will dissolve twice as much sugar as 2 ounces of water at the same temperature. From the results of this investigation and the ones in the paragraph above, your pupils may be able to expand their general statement to something like this: "Water at ....° Fahrenheit dissolves about .... times its own volume of white granulated sugar."

This, of course, raises further questions: How much more sugar will a given amount of water dissolve when its temperature is raised, say, 10 degrees F.? Will 2 ounces of distilled water dissolve as much sugar as 2 ounces of faucet water at the same temperature? And so on.

By (1) summarizing their findings from each investigation in the article, (2) thinking of questions raised by each summary or making guesses (hypotheses) based on it, (3) figuring out ways to investigate these questions or guesses, and (4) revising each summary on the basis of their findings, your pupils could probably go on investigating solutions for the rest of their lives! And they might find the answers to some questions about solutions that scientists have not yet been able to answer.

Topics for Class Discussion

• *How would you describe a solution?* From the investigations in this article, your pupils might describe a solution as a mixture of a solid substance and a liquid, in which the particles of the solid substance can no longer be seen. *Are the particles of the solute spread out evenly in the solvent?* By tasting samples from different parts of a sugar solution, your pupils can guess that the sugar is distributed evenly in the water. *Are all solutions formed of a liquid and a solid?* No. Liquids can dissolve solids, other liq-

(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 September, Dctober, December through March; monthly November, April, May, 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. 10D24.

SUBSCRIPTION PRICES: In U.S.A. $1.15 per semester per pupil, $1.95 per school year (16 issues) in quantities of 1D or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $5.5D per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 1D or more subscriptions to the same address. Teacher's Edition $6.3D per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTIDN correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 1153D.

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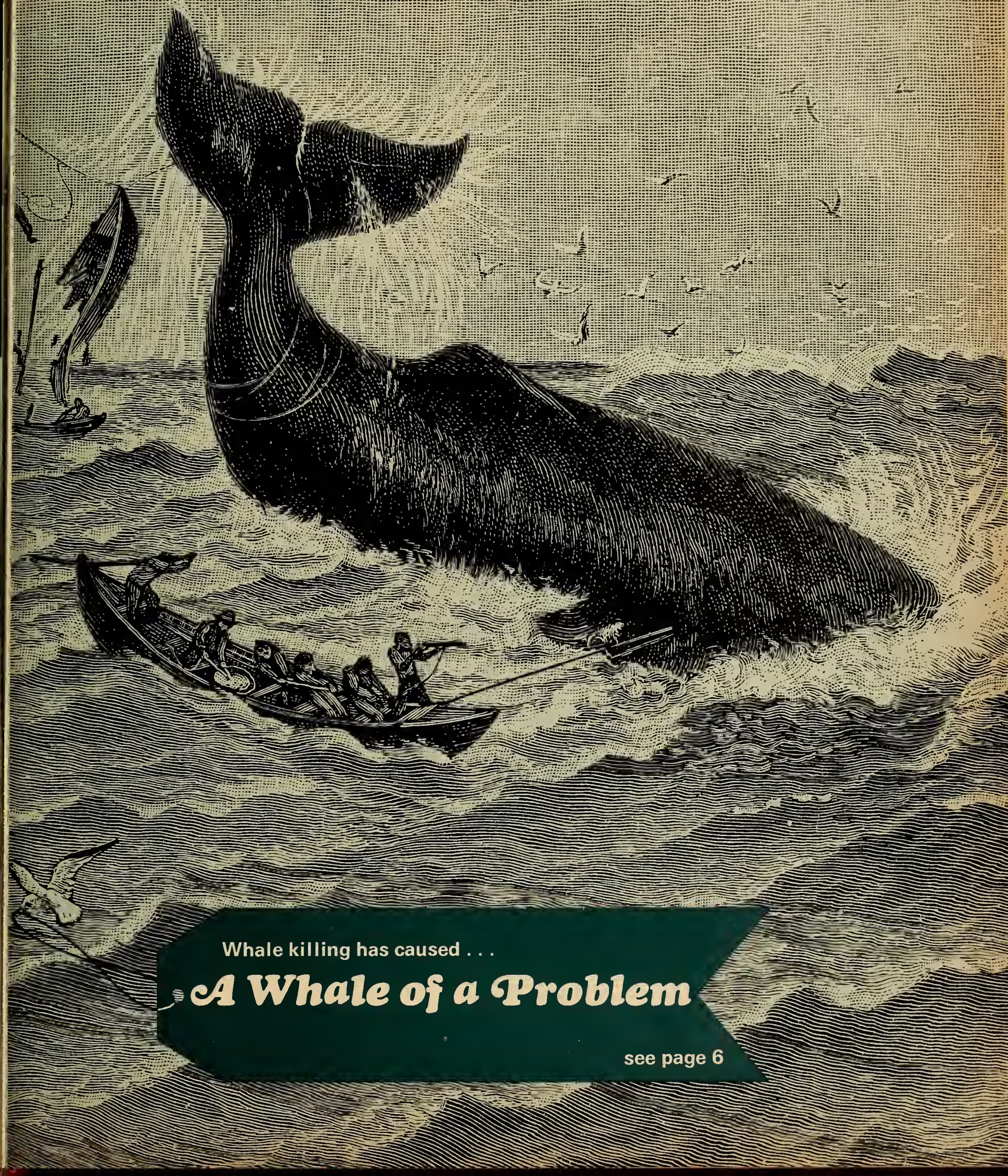
a cube of sugar vanish without touching it?

see page 2

MAKING SOLIDS DISAPPEAR



Whale killing has caused . . .

A Whale of a Problem

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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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A spoon is not a "magic wand," but waving one around in the right place will speed up the process of...

makin[g] SOLID[S]

by Robert Gardn[er]

■ Have you ever watched a spoonful of sugar disappear [in] a cup of hot tea? Or flavored crystals vanish as you st[ir] them into water to make a cool drink? When a solid di[s]appears in a liquid, we say that the solid has *dissolved* [in] the liquid. Chemists say that the *solute,* or solid substanc[e,] dissolves in the *solvent,* or liquid, to form a *solution.*

Do all solids dissolve in water? Does the temperature [of] the water affect the amount of solid that dissolves in i[t?] Can you separate the solute from the solvent once it h[as] dissolved? Will liquids other than water dissolve solid[s?] Does one dissolved solid interfere with the dissolving [of] another one? Here are some experiments that will help yo[u] find the answers to these questions.

Solids in Water

Use a kitchen measuring cup to pour equal amounts [of] water into two glasses. Two ounces (¼ cup) of water i[n] each glass will do. Now add one *level* teaspoonful of sug[ar] to one glass. (To get a level teaspoonful, use a card or ruler to sweep off all the sugar that is above the edges [of] the spoon.) Stir the water until all of the sugar crystals di[s]appear. Can you taste the sugar in the water?

How much sugar will the water hold in solution? Yo[u] can find out by stirring in one level teaspoonful after an[]other until the crystals will no longer disappear in the wate[r.]

Which will dissolve first, sug[ar] crystals packed together in [a] cube or the same number [of] crystals separated by mash[]ing a cube? Add equa[l] amounts of water to eac[h] glass and do not stir. Can yo[u] explain what happens?

DISAPPEAR

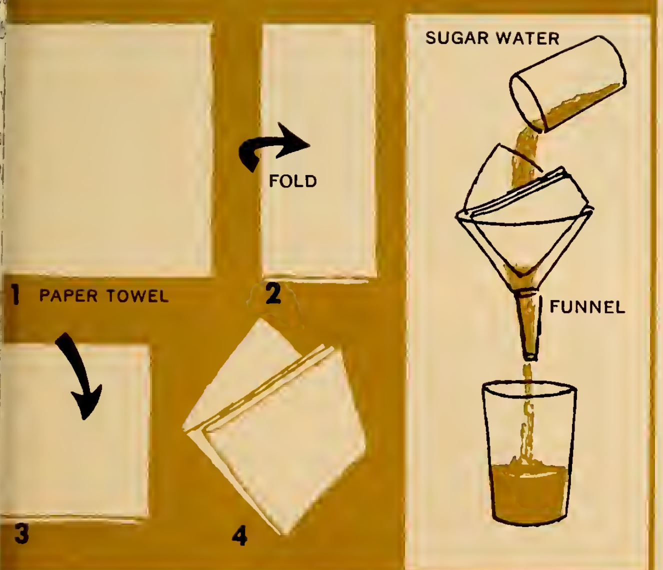
Now dissolve a level teaspoonful of salt in the other lass of water. (Use kosher salt if you have it, because iost other commercial salts contain added substances that iake the water a bit cloudy when the salt dissolves in it.) an you taste the salt in the water? Will two ounces of ater dissolve as much salt as sugar? More? Less?

When you have dissolved as much salt as possible, pour he solution into another glass, leaving the undissolved rystals behind. Do you think sugar will dissolve in this alt water? Try it and see. Will salt dissolve in water that as dissolved all the sugar it will hold?

Surely the more water you use, the more sugar or salt ou can dissolve in it. Will four ounces of water dissolve *wice* as much sugar or salt as two ounces of water will?

Try using hot water instead of cold water, and see if the emperature affects the amount of sugar or salt that a certain amount of water will dissolve.

ow To Make and Use a Filter

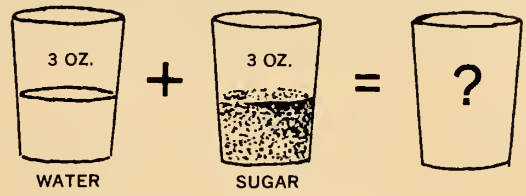


MORE INVESTIGATIONS

1. Will other liquids dissolve the same substances that water does? Try rubbing alcohol, cooking oil, and liquid detergent, for example. Try vinegar, too. (What happens when you add bicarbonate of soda to vinegar?)

2. Will water that has dissolved as much salt as it can hold dissolve still more salt if the water is heated?

3. If you add three fluid ounces of sugar to three fluid ounces of water, will you get six fluid ounces of sugar water? (Use a measuring cup to find out.) Can you explain your findings?



4. Dissolve as much salt as you can in a jar of water. Place a thermometer in the salt water, then put the jar into a freezer. Look at the thermometer every few minutes to see what happens. At what temperature does the liquid freeze? 32° Fahrenheit? Lower?

5. Does a level teaspoonful of sugar weigh the same as a level teaspoonful of salt? You have been measuring the *volume* of a solid that dissolves in a liquid. How could you change your measurements so that you could compare the *weights* of different solids that dissolve in equal volumes of water at the same temperature?

You might also try to dissolve other substances in water. Try bicarbonate of soda (baking soda), tooth powder, flour, starch, instant tea or coffee. You can probably think of other substances to try. Does the temperature of the water affect the amount of these solids that dissolves?

Separating Solids from Liquids

Are you sure that each of the substances you stirred into water is *dissolved?* If a solid is not dissolved, but is just *mixed* with the water, you should be able to separate the solid from the water with a *filter*. You can make a filter with a paper towel and a funnel, as shown in the diagram.

Try pouring the water containing the dissolved sugar or salt through a filter. Can you find any sugar or salt crystals on the filter paper? Does the water that passed through the filter still taste sugary or salty? Pour this water into a shallow dish or saucer and place it near a radiator, or in some other warm place, for a day or two, and see what happens.

Can you separate flour from water by pouring through a filter? How about tooth powder and water? (Be sure to use a new filter for each investigation.) ■

It's a bird...

It's a plane...

It's a sonic

Passenger planes that fly faster than sound will BOOM, instead of ZOOM, past us. Scientists are trying to find out whether we will be able to take it.

■ Have you ever heard a loud, sharp *Boom!* as a jet plane streaked across the sky above you? Perhaps not, because so far only military planes fly fast enough to make this noise, and they usually try not to make it where many people live. But near the bases where these planes take off and land, people often hear a *sonic boom,* as the noise is called.

The boom is caused by a single "super" sound wave that forms around an airplane that is traveling at a *supersonic* speed—faster than sound waves travel through the air *(see diagrams).*

The boom may startle you, but it probably won't damage your ears. If you are indoors, you may not hear much of a boom at all, but you will probably hear something else —the rattle of shaking walls, doors, and windows. The sudden change in air pressure as the giant wave passes the house makes walls *vibrate,* or shake, as a drumhead vibrates when you give it a hard beat.

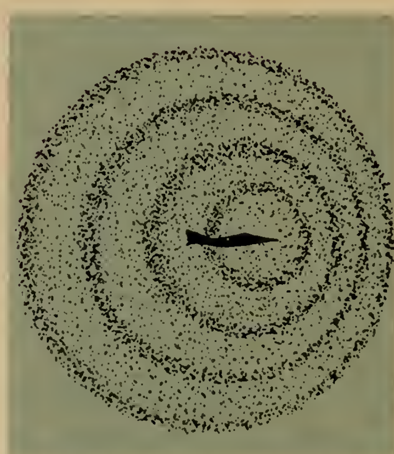
This vibration can break windows and cause other damage. The United States Air Force paid out nearly half a million dollars in 1967 for damage caused by sonic booms from its planes. In France, a sonic boom recently made an old farmhouse roof collapse, killing three people.

More and Longer Booms

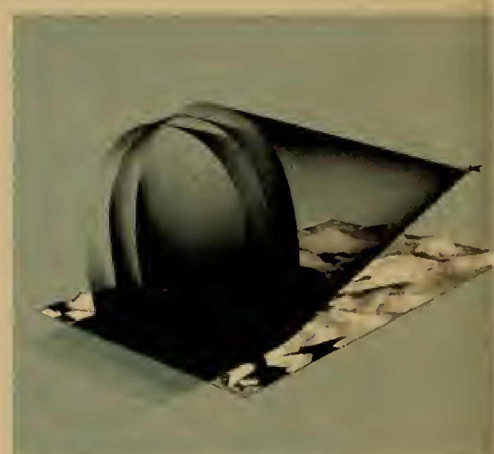
Now that giant planes are being built to carry passengers at supersonic speeds, scientists are trying to find out how sonic boom affects people, and what—if anything—can be done about it.

The new supersonic transports (SSTs) will be larger and will fly higher than the supersonic military planes. The sound of the SST's boom should last a little longer and

A sound wave starts, for example, when a firecracker explodes and *compresses,* or pushes together, the particles of air next to it. These particles bump into each other, then bounce apart, compressing the air particles next to them. In this way, the "push" from the explosion is passed along through the air at a speed of about 760 miles per hour. When it reaches the air at your ears, it gives your eardrums a sudden push and you hear a *BANG!*



A flying airplane is always compressing the air directly ahead of it, making a continuous series of sound waves. When the plane is traveling slower than sound waves travel through air, the waves outrun the plane and spread out in all directions as they move away from it. As long as these waves reach your ears, you hear a continuous, steady sound.



When a plane is flying at supersonic speed, it outruns the sound waves it makes, and they pile up in a single wave of compressed air. This wave is something like the water wave that forms at the *bow,* or front, of a speedboat. But the compressed air wave forms a giant cone in the air around the plane, as shown in the diagram. When the edge of this cone passes you, the air in it gives your eardrums a strong push and you hear a sonic *BOOM!*

Sonic booms from military planes may have caused recent damage to ancient dwellings such as these homes of prehistoric cliff dwellers at Mesa Verde National Park, in Colorado. Here and at other national parks, microphones and recorders have been set up to keep track of the number and strength of sonic booms reaching each area daily.

reach people in a wider path along the ground, but it should be a bit softer because the plane is farther away. If the SSTs are used to fly people across the United States, scientists believe that their sonic booms may damage millions of dollars worth of buildings and other property each year. And, depending on the routes these planes follow, people on the ground may hear from one to 50 sonic booms a day.

The question is, can people get used to these noises, as they have to the roar of jet engines and the rumble of heavy trucks, for example? Or will the louder and more sudden booms be too much for people to stand?

At Edwards Air Force Base, in California, scientists tested the effects of sonic boom on about 350 people. Some of them lived or worked at the base; others lived some distance away. All were at the base, either in houses or outdoors, during the tests.

Jet planes were flown over the base, sometimes at supersonic speeds so that they produced booms, and sometimes at slower speeds, so only the roar of their engines could be heard. The people were warned one minute before each plane came, and were asked afterwards how pleasant or unpleasant the sounds from the planes were to them.

The people who lived and worked at the base had heard sonic booms many times before. They were much less bothered by the booms than the people who lived farther away and had not heard as many. This suggests that people can get used to sonic booms. Some scientists have pointed out, though, that the people who worked at the base *had* to "get used to" the booms if they were to keep working there.

Louder and Louder Booms

The Federal Aviation Agency conducted a test in Oklahoma City, Oklahoma, to find out how people might feel about booms from civilian planes on regularly scheduled flights. For about six months, a plane flew over the area at supersonic speed at the same times, eight times each day.

For the first few weeks, the plane was flown so that its sonic booms got a little stronger each day. Then the booms were kept at the same strength for 15 weeks. Then the strength of the booms was stepped up even more during the last six weeks of the test. Early in the tests, in the middle, and again at the end, the people in the area were asked whether they thought they could "learn to live" with eight booms a day from passenger planes.

At first, about four people out of five thought they could get used to the booms. But by the end of the tests, only about three people out of five felt that way. And the number of people who said they definitely could not get used to the booms rose from one out of 20 to four out of 20. Scientists aren't sure, though, whether this means that people just got more irritated as the test went on, or that people who could stand the early booms were bothered more when the booms got louder.

The results of these tests, and of others that have been made, do not prove that people can't live with the added booms that SSTs will bring. But people are beginning to feel that "noise pollution" is just about as bad as air and water pollution. Some people think that the SSTs should only be permitted to fly over the oceans, where their booms would only reach ships. Meanwhile, engineers are trying to find ways to soften the boom, since they probably can't silence it completely if we must fly faster than sound ■

Boom from Above, Bellows Below

Planes booming overhead might disturb other living things besides humans. During the tests at Edwards Air Force Base in 1966, a group of high school students investigated how sonic booms affect farm animals. They watched different kinds of animals before each boom, at the time of each boom, and just afterwards.

The booms didn't change the behavior of the large animals much. Some horses jumped up and galloped, some cattle bellowed, but few cows being milked even raised their heads. The chickens seemed more frightened, and the booms may have made other birds produce fewer eggs.

Whale hunters have been so good at their job that some species of whale are in danger of dying out. Scientists are now studying whales to find out how to solve . . .

A Whale of a Problem

This scientific "gunman" aboard a whale-marking ship aims his special gun, ready to shoot an identifying mark into a blue whale.

by Robert Foy

■ A blue whale may weigh as much as 25 elephants and be almost one-third the length of a football field. You would think that a creature that size could take care of itself. But the blue whale has been no match for the cannon-launched harpoons of modern whale hunters. The blue whale and several other of the largest kinds *(species)* of whale have been killed in such large numbers that they are in danger of dying out. (Before modern weapons and steam-powered ships, whales had at least a fighting chance. *See cover.*)

Whales are hunted because they are useful to man in several ways. Whale oil is used to make margarine and soap. Whale meat is used for animal feed, and the rest of the carcass is ground up for fertilizer or poultry feed. The Japanese, who kill more whales than any other nation, consider whale meat a dinnertime treat.

Once many whale catchers roamed the Antarctic waters in search of these giant mammals. But so many of the whales there have been killed that the hunters are now going to other areas, such as the North Pacific. There, about 19,000 whales are killed each year. This area is home for many of the world's largest whales, including the sperm whale, now the most hunted species because of its large supply of oil.

Investigating Whales

Scientists like marine biologist Dale W. Rice have found the North Pacific a good place to learn about whales. Rice works at the United States Bureau of Commercial Fisheries' Marine Mammal Biological Laboratory, in Seattle, Washington. His job is to find out as much as he can about whales in the North Pacific—how many there are; their habits, travels, foods, diseases; and how often they reproduce.

What Rice and other United States scientists find out about whales is combined with information from Japan, Canada, and the Soviet Union. It is then studied by members of a scientific committee of the International Whaling Commission, who try to figure out what is happening to different whale species around the world. This information can be used to set limits on whale hunting so that no species will be killed off.

Rice is studying seven species of whale. They include the blue, finback, sei, gray, and humpback species from the baleen whale group. Whales of the baleen group have no teeth. Instead, they have rows of fringed bone called *baleen plates* that hang from their upper jaws *(see page 8)*. The baleen plates act like a strainer to trap millions of tiny sea creatures for the whale's food.

Rice is also studying the bottlenose and sperm whale species. They belong to the toothed whale group, having teeth rather than baleen plates. There are about 80 species of whale, but the ones Rice is studying are those that are in greatest danger of being hunted to extinction. Because each species has different habits and characteristics, each species must be studied separately.

Tales from Dead Whales

Rice gathers information about whales in several ways. He examines facts from other nations about whales. Sometimes he goes to sea to observe whales. He often goes to California whaling stations to examine whales killed by whalers. He tries to find out as much as possible about each whale.

Some of the largest whales Rice has examined have been blue whales. These sometimes weigh as much as 150 tons. They are the largest animals that have ever lived, as far as scientists know. But where once there were about 150,000 blue whales in the Antarctic waters, there are now fewer than 1,000. The whale catchers have done their job too well.

To learn about the food whales eat, Rice examines the stomach contents of dead whales. Sometimes the contents show the remains of *krill*—small, shrimp-like creatures that make up a large part of the diet of some whale species. Some whales, Rice has found, get along on a diet of small fish, usually anchovies. The chief food of the deep-diving sperm whale is the giant squid.

The scientists from the Seattle laboratory also try to determine the ages of dead whales. They count the layers of material in a whale tooth, just as rings are counted to date a tree *(see "Dating the Past," N&S, September 16, 1968)*. They count each tooth layer as one year *(see photo)*.

But scientists must use a different method to determine the ages of baleen whales, since they have no teeth. The method most frequently used is to remove a wax plug *(see photo)* from the whale's ear. Scientists count the number of layers, or *laminations*, of wax in the plug. The scientists

This ship is a Norwegian "floating whale processing plant." Dead whales are pulled up the rear passageway and then butchered aboard the ship.

Scientists counted the layers in this four-inch wax ear plug (above) and in this tooth, to find out the ages of the whales they came from. The tooth has 45 layers, and the plug has 20.

believe that each lamination of an ear plug probably means a year's growth in a baleen whale, but there is no positive proof. So they prefer to say that a baleen whale's age is a certain number of laminations. For example, they might say that a certain whale is nine laminations old. Rice has found some whales that are over 60 laminations old.

What "Bugs" a Whale?

Rice has found that whales are usually healthy, but that *parasites* sometimes trouble them. Parasites are organisms that live off other plants or animals and usually harm them in some way. Some parasites live on a whale's skin. The sei whale may have parasites in its liver that sometimes kill the whale.

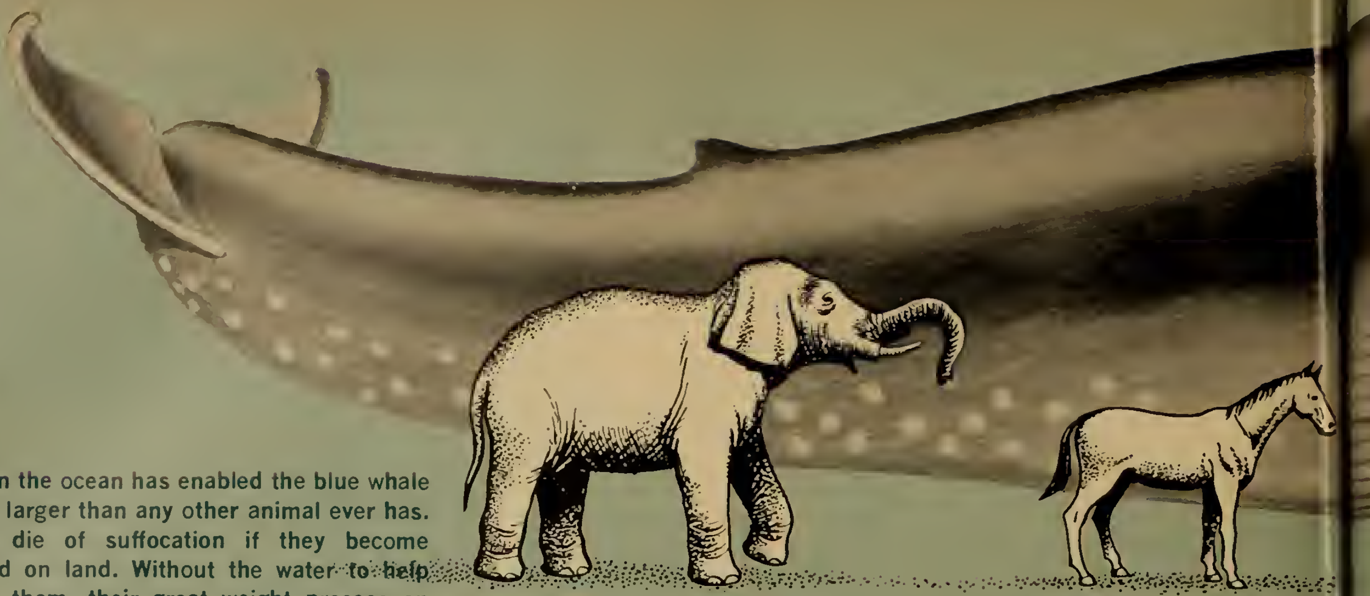
All large whales suffer from attacks by the sea lamprey. The lamprey is an eel-like animal with a toothed tongue and 125 horny teeth that help it hold tight to a whale while the lamprey sucks the whale's blood.

Rice and other scientists are especially interested in learning more about whale travels. "If we can learn where whales go and why," he explains, "we will be better able to decide how many of each kind can be killed each year without causing the species to die out."

Some species of whale travel between summer and winter homes. Rice and other scientists have found that there is more whale food during the summer in the cool waters of the North Pacific, where some species spend the summer. There they are hunted by whalers.

In winter, when food is harder to find in the northern seas, these whales travel to warmer waters farther south. There they breed, or bear their young. "Being born in warmer waters may give the newborn calves a better chance for survival," says Rice. But there is still a big mystery about just where the whales breed in winter. If

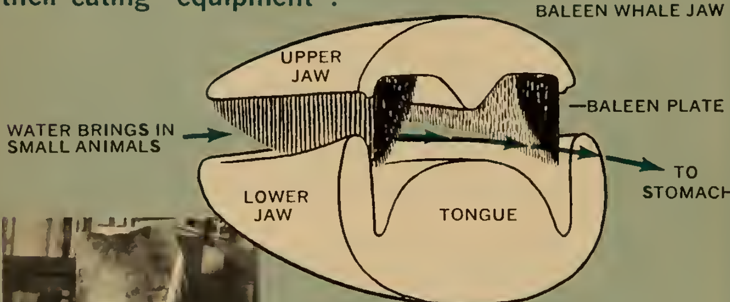
(Continued on page 10)



Living in the ocean has enabled the blue whale to grow larger than any other animal ever has. Whales die of suffocation if they become stranded on land. Without the water to help support them, their great weight presses on their lungs so the lungs cannot fill with air. Here you can see a 100-foot blue whale compared in size with some other mammals, including the smallest species of whale, about 5 feet long.

The Ways

Whales are divided into two large groups according to their eating "equipment":



Baleen whales have rows of fringed, horny plates, called *baleen plates*, hanging from their upper jaws. These plates trap tiny sea creatures for the whale's food. Unborn baleen whale calves have tiny teeth that disappear before they are born. This suggests that baleen whales once had teeth, but the teeth gradually disappeared as the whales came to depend on smaller creatures for food.

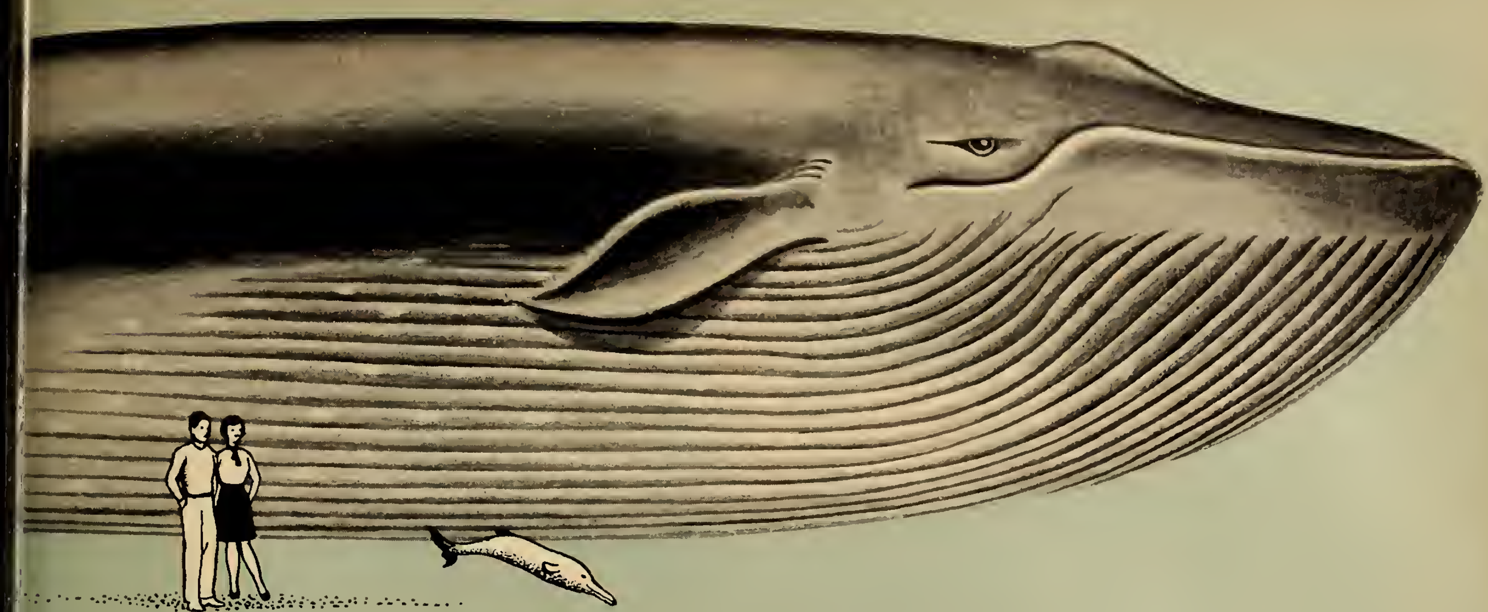
TOOTHED WHALE

Toothed whales use their teeth to seize food such as fish or other sea animals. They don't chew their food, and the teeth of a whale are all very much alike. (Many other mammals have different kinds of teeth to use for chewing or grinding.)

■ Whales are among the most mysteriou creatures in the world. Scientists hav only begun to study them thoroughly, a many things that people have believe about them are proving untrue.

Perhaps the greatest mystery abo whales is how they came to live in th water. For even though whales live amon fish, whales are not fish. They are mam mals, as are horses, dogs, and human Biologists believe that the ancestors whales lived on land, because the bodi of modern whales show traces of featur needed for land-living. The whale's a cestors probably had ears, four legs, an hair on their bodies. But something cause the whale's ancestors to begin living in th

SIDE VIEW OF WHALES AT SURFACE OF OCEAN

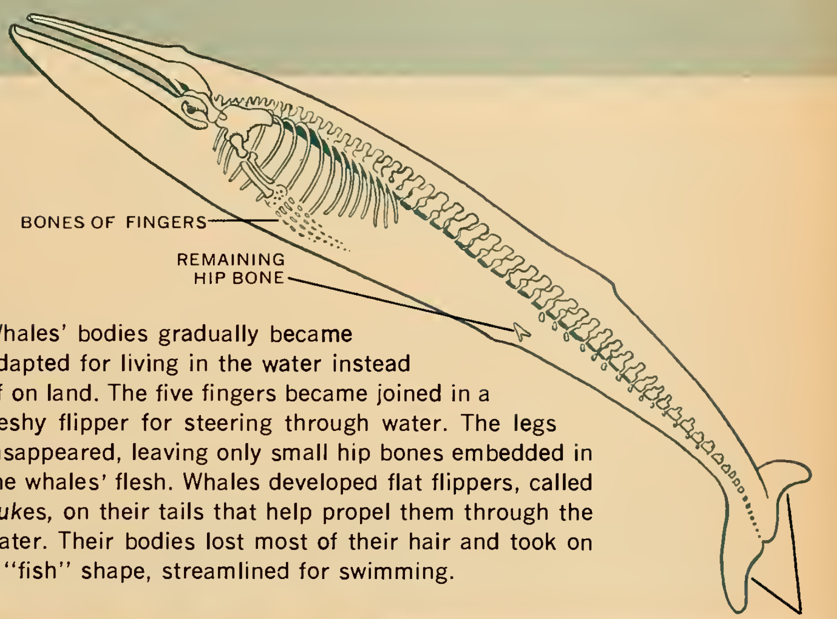


f Whales

ıter. Perhaps they could escape enemies ere; or maybe food from the water be- me easier for them to get than land food. or whatever reasons, over millions of ars whales gradually changed *(evolved)* :o creatures that live entirely in the ıter.

There are very few clues, such as fossils, how this happened. So scientists must ıdy the bodies of modern whales to try find out what their ancestors were like d how they evolved into the creatures e know today. In this WALL CHART you n see some of the characteristics, de- loped over millions of years, that enable hales to survive in the water.

—MARGARET E. BAILEY



Whales' bodies gradually became adapted for living in the water instead of on land. The five fingers became joined in a fleshy flipper for steering through water. The legs disappeared, leaving only small hip bones embedded in the whales' flesh. Whales developed flat flippers, called *flukes*, on their tails that help propel them through the water. Their bodies lost most of their hair and took on a "fish" shape, streamlined for swimming.

ıales take in air through openings in the tops of eir heads, called *blowholes*, which are connected their lungs. A whale closes its blowhole before *unding*, or diving. Some whales can stay under ıter for an hour or more without surfacing for fresh . The air in a whale's lungs gets warm and filled th water vapor. When the whale surfaces and lets is air out through the blowhole, the air is suddenly oled and the water vapor changes back to a liquid, rming the "cloud" that is called a *spout*. From is spout and the shape of the whale as it surfaces, ıalers can identify different species of whale.

Baby whales (calves) are born alive, like the young of most mammals. While the calf is developing inside the mother whale, it gets food from the mother through the *umbilical cord*, just as human babies do. It takes a whale calf from 8 to 17 months to develop in its mother, depending on the species of whale. After a calf is born, the mother nurses it, as do land-mammal mothers. This is how a baby gray whale looks after it has been growing inside its mother for about 2½ months. It is about 5 inches long.

scientists knew the exact locations, they could go there to count the newborn calves. This would help them to set future hunting rules for each whale species.

Marine biologist Dale Rice loads a nine-inch whale mark into a specially designed shotgun. Rice is a United States representative to the International Whaling Commission, which is made up of nations that have agreed to control their whale catches.

Tracing a Whale's Trail

One way scientists are trying to solve the mystery of whale travels is by marking whales. The whale "mark" is a pointed, stainless-steel tube about nine inches long that is fired from a specially designed shotgun into the back muscles of the whale. The mark has a number stamped on it, along with the request that it be returned to the Marine Mammal Laboratory in Seattle when it is found, together with information about when and where the whale was located. (Japanese, Russian, and Canadian marine biologists mark whales in a similar manner.)

When hunters kill a marked whale and butcher it, they find the mark. Some marks have been recovered in good condition after 25 years. When a whale mark is sent to the Seattle laboratory, Rice checks its number with the records. The records contain information about each marked whale, including when and where the whale was marked.

If the whale was marked in California waters and the mark was recovered in the far North Pacific, scientists can tell something about the whale's travels. Marks recovered in the same area from different whale species would show that the different species were mixing together.

Can the Whales Be Saved?

Since 1947 the International Whaling Commission has tried to save the great whales by setting limits on whaling catches in Antarctica. But most whale hunters have ignored the limits. Out of 12 species that could once be hunted for profit, only the sperm whale still exists in large numbers.

For 1968 and 1969, the countries that catch whales in the North Atlantic and Pacific waters have agreed to control their catches. Rice says that now more nations are becoming interested in whale research and in sharing information that scientists discover about whales. But it may be too late to save the great whales. Only if nations work together to control the killing and protect the whales for many years will the whales survive ■

■ For further reading about whales, see these books in your library or bookstore: **All About Whales,** by Roy Chapman Andrews, Random House, 1957, $2.95; **In the Wake of the Whale,** by John A. Barbour, The Macmillan Company, 1969, $3.95.

HOW DOES A WHALE "SOUND"?

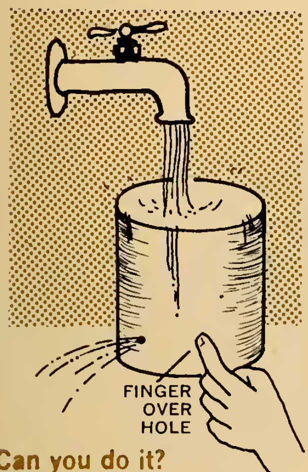
You can find out at The American Museum of Natural History in New York City. This photo shows the unfinished 94-foot model of a female blue whale hanging from the ceiling of the new Hall of Ocean Life. The photo was taken before the new hall opened in February. The whale is shown as if it were *sounding*, or diving after it had come to the surface of the ocean to breathe in air. The model took 2½ years to build and cost $200,000. It is made mainly of plastic foam and Fiberglas. The new whale will replace the Museum's old whale model, which was put on exhibit in 1908. Scientists later discovered that the old model was inaccurate because it did not "bulge" properly and its eyes did not stick out. The Museum is celebrating its 100th birthday anniversary this year.

Mystery Photo

Why are the letters of the road sign so much "heavier" in some parts than in others?

What will happen if?

Make two small nail holes near the bottom of a tin can. Hold your finger over one hole, and run water into the can fast enough for it to fill up and stay full, even though water is running out of one hole. Watch how far the water stream squirts out of the open hole.



What will happen if you take your finger off the second hole while keeping the can filled? Will each stream squirt the same distance as when only one hole was open, or will they both shoot out a shorter distance?

Can you do it?

Can you add more water to a glass that is already brim-full?

Fun with numbers and shapes

Remove 8 toothpicks so that 3 squares are left.

Submitted by Edward Siegel, Cleveland, Ohio

For science experts only

Where would you end up if you kept going northwest as far as you could?

Just for fun

Put some water, dishwashing liquid, and food coloring into a glass. Drop in an Alka-Seltzer tablet and watch what happens.

BRAIN BOOSTERS

by David Webster

ANSWERS TO BRAIN•BOOSTERS IN THE LAST ISSUE

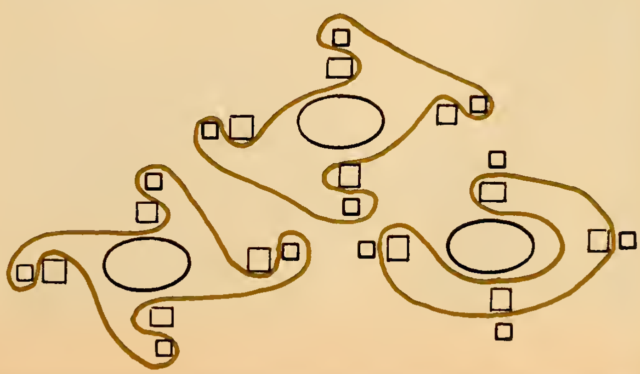
Mystery Photo: The lopsided pine tree is near the ocean. Strong winds blowing from the sea prevent the tree from growing normally. Where else might you find such a tree?

What will happen if? The wax drop at end B of each aluminum foil strip should melt first. Would a wax drop on a strip of aluminum foil ever melt if it were a foot away from the place being heated?

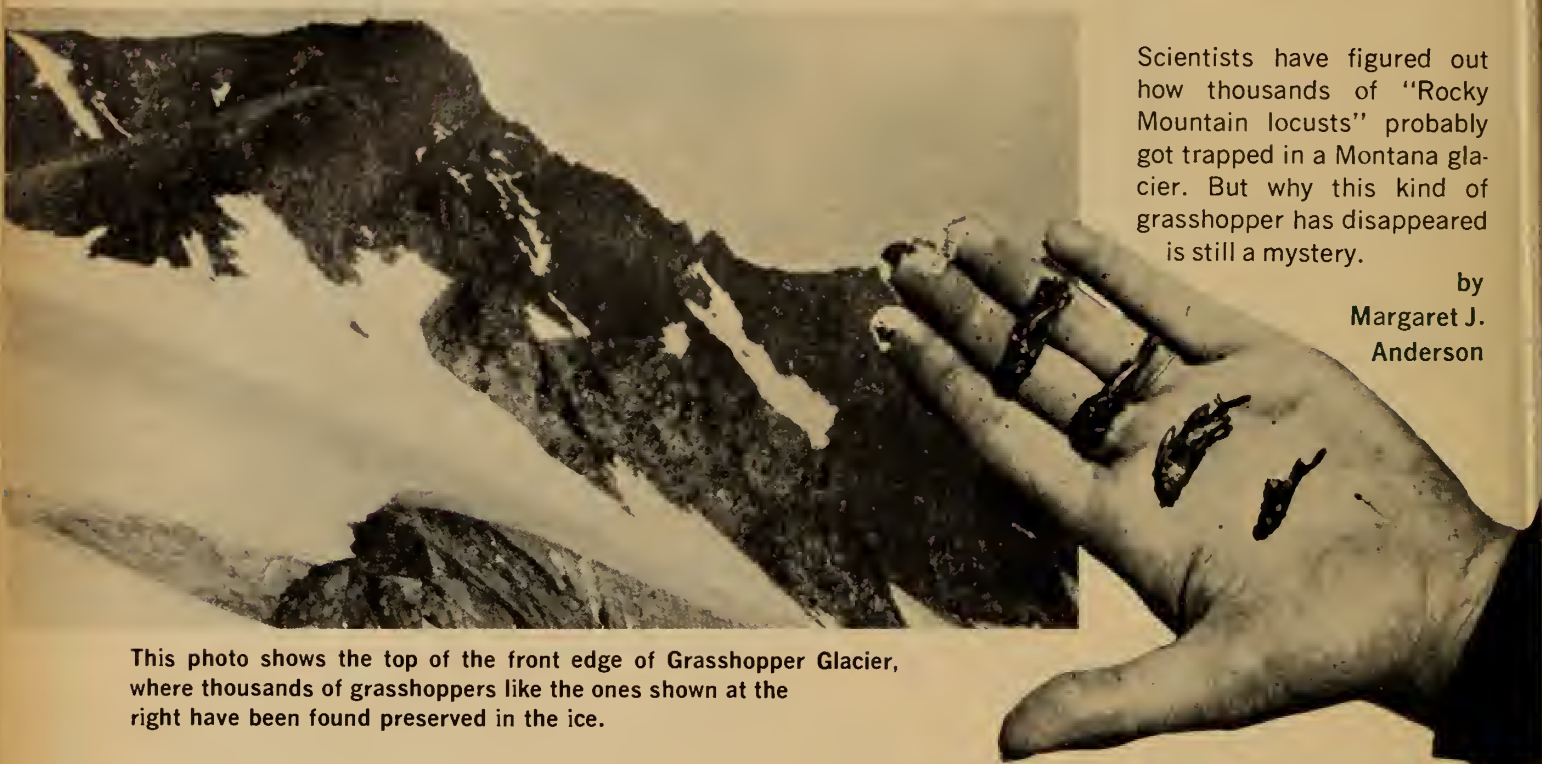
Can you do it? Here is how to make ice cubes of three different colors. Color some water with food coloring and fill the bottom third of an ice tray with it. When the water is frozen, add a second layer of different-colored water, and freeze the second layer. Then add a layer of a third color.

For science experts only: When it rained, raindrops collected on the helium-filled balloon. The weight of the water made the balloon fall to the ground.

Fun with numbers and shapes: Here are three ways to build a fence that will keep the people in the big houses away from the lake. Which way would be cheapest?



The Case of the Deep-Frozen Grasshoppers



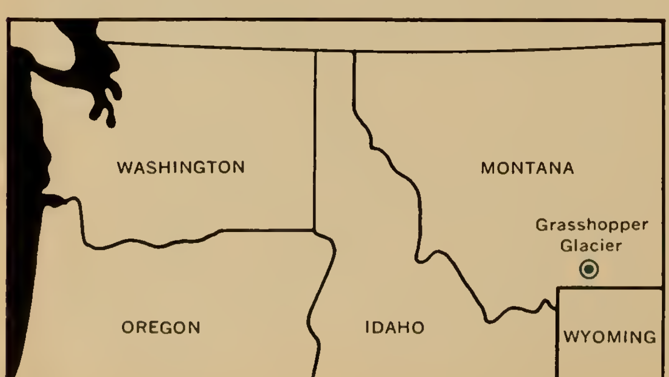
Scientists have figured out how thousands of "Rocky Mountain locusts" probably got trapped in a Montana glacier. But why this kind of grasshopper has disappeared is still a mystery.

by Margaret J. Anderson

This photo shows the top of the front edge of Grasshopper Glacier, where thousands of grasshoppers like the ones shown at the right have been found preserved in the ice.

■ High in the Beartooth Mountains of Montana, near the northeast corner of Yellowstone Park, there is a very unusual glacier. The bodies of thousands of grasshoppers are frozen in its ice. During the warm days of summer the face of the glacier melts, and birds and fish can feed on defrosted grasshoppers.

How did these insects get there, in a glacier 11,000 feet above sea level? How long have they been preserved in the ice? Have they been there for thousands, or hundreds, or just tens of years? And what is the name of this grasshopper? These are some of the questions that *entomologists,* scientists who study insects, have asked about the Grasshopper Glacier.



A Clue from Live Grasshoppers

The glacier has been known for more than 70 years, but because it is in a hard-to-reach place, not many scientists have studied it. One entomologist, Dr. J. R. Parker, who lives in Bozeman, Montana, has made several trips up there. He first saw the glacier in 1918, and cut some grasshoppers out of the ice. On a visit in 1931, when he was about a quarter of a mile from the glacier he noticed a smell of something rotting. When he reached the glacier he found piles of decaying grasshoppers, two to four feet deep, which had been uncovered by the melting ice.

When Dr. Parker visited the glacier on August 1, 1949, to collect more specimens, he found several hundred *live* grasshoppers scattered over the snow. He knew that grasshoppers could not have been living very close to the glacier, and from the way they were scattered about, he decided they must have arrived there by air. He gathered about 30 specimens before leaving to get down the mountain in daylight.

A few of these specimens were of two kinds (*species*) of grasshopper that were common on the lower slopes of the Beartooth Mountains. But most of them were of a species called *Melanopus rugglesi,* which had not been seen before in Montana or Wyoming. There were swarms of *rugglesi* in Nevada and Oregon, though, in 1949. They had been seen flying near the ground and at higher altitudes during the month of July. Could some of them have flown —or been blown—several hundred miles to Grasshopper Glacier?

Weather Bureau records showed that winds of 10 miles an hour or stronger had been blowing eastward from Oregon at altitudes of 10,000 feet and higher during the last few days of July, 1949. Scientists believe that these air currents could have carried high-flying insects from Oregon to Montana. High peaks on either side of Grasshopper Glacier funnel the wind across it, and the insects landed on the snow-covered ice, where they became too numbed by the cold to fly farther.

The grasshoppers found preserved in the glacier were not of the same species as those found alive on the snow. Still, it seemed likely that all had reached the glacier in the same way.

In the late 1940s, scientists had developed the carbon-14 method of testing the remains of plants and animals to find out how long ago they were alive (*see "Dating the Past,"* N&S, *September 16, 1968*). This test was used on the remains of grasshoppers cut from the ice at the glacier, and they were found to be fairly recent—probably less than 200 years old.

What Happened to *Melanopus spretus?*

Dr. A. B. Gurney of the United States Department of Agriculture studied the grasshopper remains and found that they belonged to a species called *Melanopus spretus.* And this brings us to a new mystery. This grasshopper is commonly called the "Rocky Mountain locust." A hundred years ago—from 1866 to 1877—there were tremendous swarms of these grasshoppers traveling mainly in areas between Canada and Texas, and from Wyoming and Colorado to Minnesota, Iowa, and Missouri, destroying farm crops and native plants wherever they went. It may have been during this time of dense flights that many of the grasshoppers were trapped in the glacier.

Then the numbers of Rocky Mountain locusts began to get smaller and smaller; the last live insect of this species was recorded in 1902. Just as the buffalo disappeared from the plains, this grasshopper vanished. Some scientists even wonder if it depended on the buffalo in some way. Perhaps the females laid their eggs in ground trampled by buffalo, or the young grasshoppers may have fed on dried buffalo manure. No one knows.

These flights of grasshoppers in the 1800s were nothing new. Since Biblical times "plagues" of grasshoppers have caused destruction throughout the world. Large swarms can block out the sunlight and turn day into "night." And when they land to eat, they leave the ground bare for miles around. The thing that puzzled scientists was that swarms could build up so suddenly—seemingly out of nowhere.

Then Dr. B. P. Uvarov, Head of the Anti-Locust Research Centre in London, England, explained this puzzle. He found that the insect leads a double life. It can live alone, as a *solitary* grasshopper, or it can live and breed in swarms. The strange thing is that when the solitary hoppers in an area grow in numbers, crowding together makes them more active, and somehow changes their body processes. And these changes, in turn, cause an individual insect's color to darken and the sizes of its body, wings, and other parts to change. Not all grasshopper species change in this way—only a few kinds, which are often called locusts.

Could the Rocky Mountain locust still be around in a different form, living as a solitary grasshopper? Will it someday swarm again? Or are the swarms trapped in the glacier the last examples of a vanished species? These are mysteries yet to be solved ■

These scientists are boring into the base of an ice cliff to blast out chunks containing long-preserved grasshoppers.

WHAT'S NEW

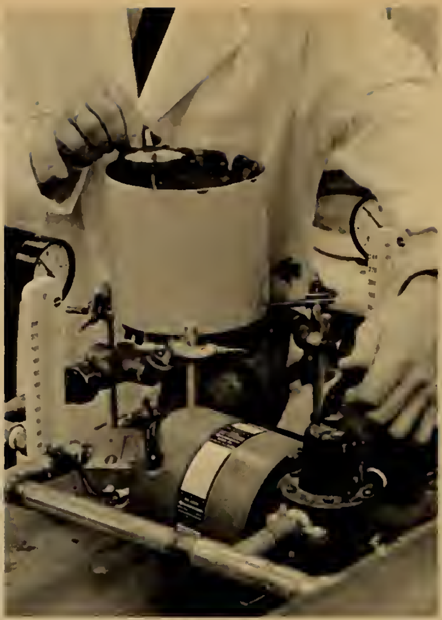
by
B. J. Menges

Insects that never touch land are being studied by scientists of the Woods Hole Oceanographic Institution, at Woods Hole, Massachusetts. These ocean-going insects are rare waterstriders called Halobates. Like the common waterstriders that you may have seen scurrying across the surface of ponds *(see "'Surfing' to Safety,"* N&S, *October 14, 1968),* the ocean-dwelling waterstrider is covered with water-repellent hairs and has six legs, two of which act as oars. With its sharp mouth, it pierces jellyfish and other marine animals and feeds on their body fluids.

These half-inch-long insects have always been hard to study. They spend their entire lives hundreds of miles from shore and move very fast. Recently, though, scientists invented a new kind of net that skims the striders off the ocean surface so they can be taken aboard a ship for study. But one problem remains. The striders move so fast that when they are put into an aquarium, they bump into the glass and kill themselves.

With no water to drink, an antelope called the oryx thrives in the hot deserts of Africa. Some small desert animals can also live without drinking. Some of them eat plants or other animals that contain water. Others can "manufacture" water in their own bodies, and they spend hot days in cool underground burrows. But the oryx does none of these things. Where does it get water? And how does it keep from overheating in the hot sun, or losing too much water by evaporation through its skin?

To answer these questions, Dr. C. R. Taylor, a zoologist at Duke University, in Durham, North Carolina, ran tests in a laboratory under desert conditions. At night, he reports in *Scientific American,* the usually dry desert grasses that the oryx uses for food take in moisture from the air So by eating at night, the oryx can get enough water. Then, during the hottest part of the day, the oryx can reduce the amount of heat its body produces, saving water that it would otherwise lose by sweating. The oryx is also adapted so that its body temperature can rise more than 10 degrees above normal without harming the animal's brain.



This miniature furnace *(arrow)* is no bigger than a two-pound coffee can, but it could still heat a nine-room house. The new furnace, developed by the Raytheon Company, of Lexington, Massachusetts, could use gas or other fuels to heat water or air in a home or factory, saving both space and money. As a test, the mini-furnace is now being used to heat the laboratory where it was developed.

"From wonderland to wasteland" may become the story of Florida's Everglades National Park. The problem is familiar: the desires of people versus the needs of nature. The park is a wildlife refuge—one-and-a-half million acres of natural swamp containing a large variety and abundance of plants and animals.

The Everglades' very existence depends on a constant water supply from the north. For thousands of years water has come from an area beyond the park's boundaries. This area is now being drained for use in farming and building, as well as for a huge airport. "It took hundreds of thousands of years to create the Everglades," says Brooks Atkinson, a writer for *The New York Times.* "Now men have the ability, facilities, and the will to destroy it in less than a century."

Unidentified flying objects (UFOs) are nothing to worry about, according to a team of scientists headed by Dr. Edward U. Condon of the University of Colorado, at Boulder. The scientists recently completed a two-year study of the subject for the United States Air Force. More than 12,000 "sightings" of "flying objects" have been reported to the Air Force in the past 21 years. Dr. Condon's committee investigated many of these reported "sightings," and found common explanations for most of them. While some remain unexplained, the scientists found no evidence strong enough to make them think that UFOs might be spacecraft from another world. They said there was no reason to believe that further investigation of UFOs would add anything to scientific knowledge.

Several scientists have criticized the committee's work and conclusions. But a panel of scientists set up by the National Academy of Sciences to review the Condon committee's report has approved of its methods and supported its conclusions.

One of the "master chemicals" of life has been "manufactured" in the laboratory by two teams of scientists working separately. Scientists at Rockefeller University, in New York City, and others at Merck Sharp & Dohme Research Laboratories, in Rahway, New Jersey, both succeeded in making *ribonuclease,* one of the enzymes in our bodies.

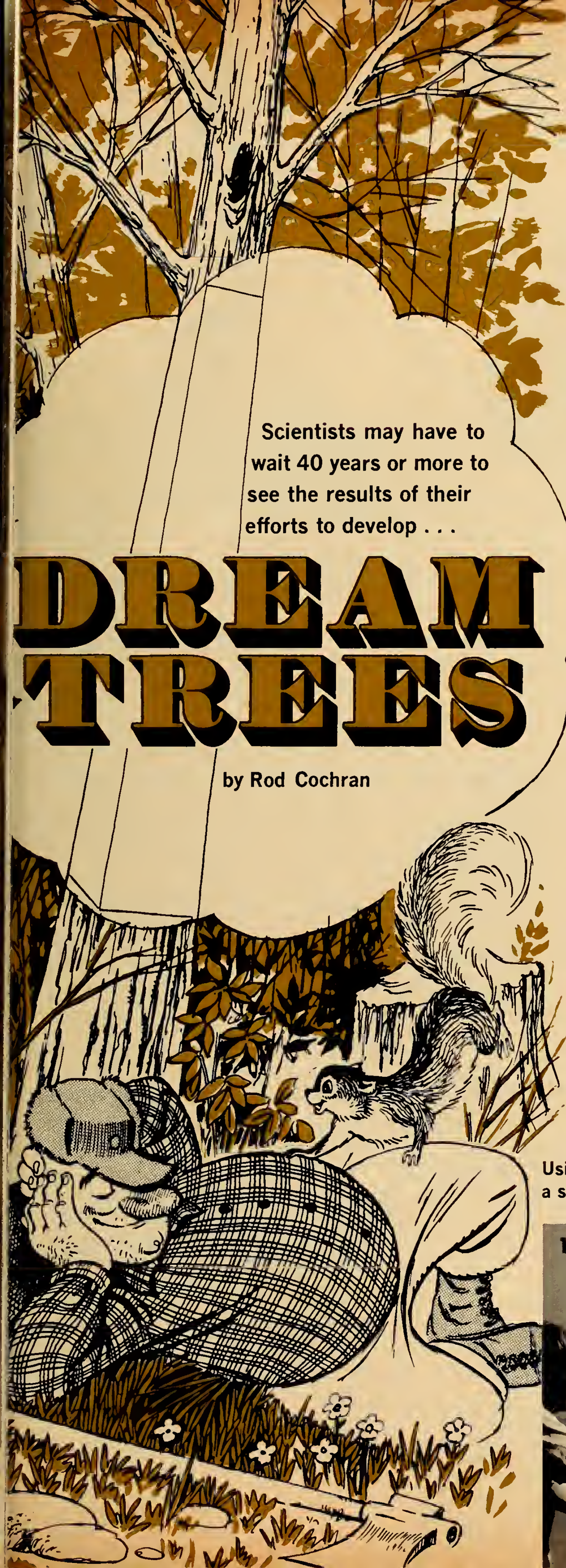
Enzymes help our bodies to work in many ways. Some change the food we eat into substances that are needed for building our body cells; others change food into energy for muscle movement. Ribonuclease affects the way almost all of our body cells work.

Because enzymes help control our body processes, they could be very useful in medicine. An enzyme called *dextrinase,* for example, has been reported to be helpful in fighting tooth decay. So far, though, enzymes have not been used very much in medical treatment, partly because scientists could not get enough of the enzyme needed. If enzymes can be produced in laboratories, it will help solve that problem.—R.J.L.

Scientists may have to wait 40 years or more to see the results of their efforts to develop . . .

DREAM TREES

by Rod Cochran



■ It is said that a forester once dreamed of a "perfect" tree —the stem was straight and did not taper, it had no limbs or bark, and it was square-sided. The forester must have smiled in his sleep, for the sight of acres of such trees would be a pleasant one—at least for lumbermen, carpenters, furniture makers, and others who work with lumber.

The rest of us can be thankful that trees will never be like that. But trees *are* being changed by man. Farm crops and fruit trees have been improved so that they produce more and better food. And scientists are trying to develop trees that yield better lumber.

This search for "better" trees is going on at the State University of New York College of Forestry, at Syracuse, and at other forest research centers throughout the world. Dr. Gerald R. Stairs is directing the tree improvement work at Syracuse.

Taking eastern white pine as an example, Dr. Stairs explained, "We would like to develop faster-growing trees that are straight and *self-pruning*—that is, their lower limbs should die and drop off as the trees grow. The trees should be able to resist attacks by insects and diseases, and to grow well in a variety of climates. Finally, the trees should produce high-quality wood that can be used in a variety of ways."

The Search for "Superior" Trees

To develop such trees, scientists at the College of Forestry begin by looking for healthy, straight, self-pruning trees in the wild. They take small samples of wood from these living trees. By examining and testing the samples, the scientists can select the fastest-growing trees with high-quality wood.

The scientists then collect small branches from the tops of these special trees (called *superior* trees). These branches, which will grow seed-bearing cones, are collected either by climbing the trees or by shooting limbs off with a rifle *(see Photos 1 and 2)*.

The branches are then attached to other trees by a

(Continued on the next page)

Using a rifle with a telescopic sight, a scientist is able to shoot a small branch from the top of a 100-foot-tall pine.

Tc graft a branchlet to a living tree, a slit is cut in a tree branch and the branchlet is put part-way into it *(Photo 3)*. The two are then bound together *(Photo 4)* so that the branchlet receives food and can keep growing.

Dream Trees (continued)

method called *grafting (see Photos 3 and 4)*. The scientists watch the growth of each grafted branch to see if it does as well as they expected. If so, seeds from the cones of the grafted branch are used to start growing a crop of young trees. The growth of these seedlings is also noted, and compared with the growth of seedlings from the seeds of "average" trees. In this way, the scientists are able to test the quality of the seeds and seedlings without waiting 40 years or more for when the trees would be big enough to be used for lumber.

Breeding Better Trees

When the branches from the superior trees develop flowers, the scientists have another chance to produce trees that will yield better lumber. Usually the flowers of pine trees are pollinated by grains of pollen carried by the wind. However, by putting protective bags over the pine flowers, the scientists keep this from happening. They then pollinate the flowers *(see Photo 5)* with pollen grains they have selected. They might, for example, use pollen from one superior white pine tree to pollinate the flowers of another. Or they might use pollen from a Himalayan white pine to pollinate the flowers of an eastern white pine. The seeds that develop from the flowers will then produce trees that have characteristics of both parent trees.

"We're definitely making headway," says Dr. Stairs. Scientists at the College of Forestry have found Norway spruce trees that grow twice as fast as normal. The wood of these trees is also better for making paper than that of their slower-growing relatives. The scientists have also had success in developing white pine trees that are better able to resist a disease called blister rust.

So far, the men studying white pine have been unable to produce trees that are "self-pruning," though they have grown trees that have smaller-than-normal limbs. If trees that quickly lose their dead lower limbs can be developed, much of the lumber from such trees will be free of knots *(see Photo 6)*—a woodworker's dream ■

A plastic bag put over pine flowers keeps pollen in the air from reaching them. The flowers can then be pollinated with pollen selected by scientists. Photo 5 shows pollen grains being forced inside the protective bag.

The knots you see in the board on the right are the remains of limbs that died and stayed on the tree. When trees lose their dead lower limbs quickly, the result is more knot-free lumber, like the board on the left.

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

uids (alcohol in water), or gases (air in water, carbon dioxide in soda pop). Gases can dissolve other gases, vaporized liquids, and certain solids. And some solids can dissolve certain liquids, gases, and other solids (sterling silver is a solution of copper in silver). A chemist defines a solution as a *homogeneous* (uniformly distributed) mixture of two or more substances whose amounts may vary.

To go into solution, the particles of a substance must break up into *molecules* (the smallest particles of a substance that retain all of its characteristics), or in some cases into pieces of molecules (called *ions*), before they can become distributed homogeneously among the molecules of the solvent.

When particles *larger than the molecules* of a particular solid are mixed evenly through a liquid or gas, the mixture is called a *suspension.* (Tiny particles of soil, sand, or clay are usually suspended in river and ocean water; dust particles are usually suspended in the air.) A suspension can also be formed of two liquids that will not dissolve each other; this kind of mixture is called an *emulsion.* (You can make a *temporary* emulsion by shaking a spoonful of cooking oil into a jar of water. The oil breaks up into tiny drops spread through the water, but they soon rise to the surface and join together again. To make a *permanent* emulsion, mix some soap or detergent with the oil and water before shaking. The detergent helps the water molecules "stick" to the drops of oil and hold them in suspension.)

• *Is "homogenized" milk a solution?* Partly. Milk is mostly water with calcium and other chemicals *dissolved* in it and with butterfat *suspended* in it. Since butterfat is a liquid, milk is also an *emulsion.* "Homogenized" milk is treated to keep the drops of butterfat (cream) in suspension instead of rising to the top as they do in "nonhomogenized" milk.

• *Why are solutions vital to all living things?* The cells that make up a plant or animal need a constant supply of food, which the cells change into energy and "building materials." The water entering a plant through its roots carries "food" dissolved out of the soil to the plant cells, then removes waste materials from the cells, in solution. An animal's body fluids, including blood, are mostly water. They carry food in solution from the animal's stomach to its cells, and carry wastes away for disposal. Fish get the oxygen they need to live from air that is dissolved in the water.

• *Water is sometimes called "the universal solvent." Can you guess why?* Water dissolves more substances than any other known solvent does. "Pure" water is almost impossible to find in nature; even rainwater usually has some air and impurities from the air dissolved in it. Water that passes over or through the ground dissolves many substances from the soil or rocks, often carrying them in solution to the oceans.

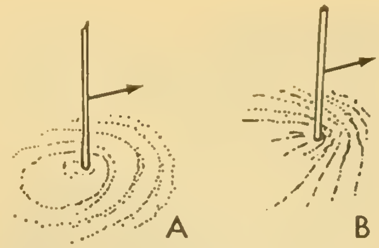
Water will not dissolve oil or grease, though. A different solvent must be used to remove a grease spot from your clothes. Soap or a detergent *emulsifies* oil or grease *(see above)* so they can be washed away from greasy dishes.

Activity

Your pupils probably found that salt can be recovered from solution in water by letting the water evaporate. Can they think of a way to get pure water from a salt solution? (Boil the solution in an open pan and hold a cool pie tin above the pan. The water boils off as water vapor, leaving the salt behind, and the vapor cools when it touches the pan, forming drops of pure, *distilled* water.) Can your pupils guess why this is an expensive way to get drinking water from the ocean for a whole city? (It takes a lot of fuel to distill enough water.)

It's a Sonic Boom!

To show your pupils how sound waves pile up in a shock wave around a plane flying at supersonic speed, move a stick through a pan of water *(see diagrams).* Moved slowly, the stick sets up waves that move out from it in all directions through the surface



water (A). Moved faster (B), the stick catches up with its waves and piles them up in a single V-shaped "shock" wave. Point out to your pupils that if the stick were a submarine traveling very fast underwater, its shock wave would take the form of a *cone,* just like the shock wave of compressed air that forms around a supersonic plane *(see diagram on page 4).*

You might explain to your pupils that the speed of sound through the air varies with the temperature of the air. (Cold air particles move slower than warm air particles, so they don't pass a wave of energy along to their neighboring particles as rapidly.) At high altitudes, the cold air reduces the speed of sound to between 600 and 700 miles per hour. The new SSTs are designed to fly about three times that fast.

Dream Trees

Plant breeding is becoming increasingly important as a means of improving both the quantity and quality of wood and of wood pulp, used for making paper. Most people think of plant breeding only in relation to food plants, or to flowers.

Hybrid corn is a classic example of what humans have achieved by breeding plants. Although corn had an ancestor or ancestors among the wild grasses, there are no wild corns today. The corn we know is "man-made." Partly by trial and error, partly by design, men have selected corn plants and bred them so that the resulting hybrid seeds would produce plants with characteristics of both parents.

The first aim of plant breeders was simply to produce more corn per plant. In Illinois, an average acre of land produced 40 bushels of corn before the introduction of hybrid plants; now the average yield is 100 bushels. Present day hybrids have higher resistance to diseases and insects than the early

(Continued on page 4T)

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

hybrids, and can be grown in colder climates.

Using such hybrid plants and fertilizers, farmers in the United States and Canada have produced huge (but temporary) surpluses of food. Elsewhere in the world, however, plant breeders are engaged in a frantic effort to produce rice, wheat, and other grains to keep pace with the rapidly growing population. Their aim is to develop plants that produce more food of better quality; for example, rice that contains a greater amount of protein. Improved varieties of rice and wheat are already being grown in parts of Asia, but some food experts doubt that even this "green revolution" will be enough to prevent widespread food shortages and starvation during the 1970s.

For more information about reproduction in plants and animals, see the March 27, 1967 issue of *N&S*.

Brain-Boosters

Mystery Photo. The sign painted on the road is intended for drivers, who view it at a slant from their cars. If you hold the picture sideways and at a slant *(see diagram)*, you can see the sign as

an approaching driver would see it; the letters will appear normal and the sign will be easier to read.

Your pupils might enjoy looking for signs like this along the road, or trying to draw a similar sign themselves.

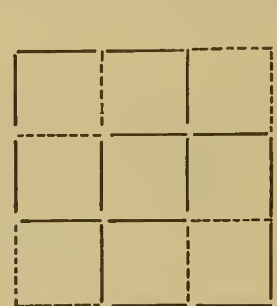
What will happen if? If you have a sink in your classroom, you can demonstrate that water will squirt equally far from two (or more) holes at the same level in a tin can as it will from one hole.

Point out that the weight of the water that is pushing water out of each hole is not the weight of all of the water in the can above the holes, but only the weight of a column of water having the same diameter as the hole and extending from the top of the hole to the surface of the water. So if the can is held level and each hole is the same distance from the top, the water pressure at each hole is the same. (Ask your pupils to guess which hole will squirt water farther if one hole is higher than the other.)

As long as the can is kept filled, the water pressure at each hole remains constant. If the can is allowed to drain, however, the pressure will decrease at each hole, squirting the water less and less far until the pressure drops to zero.

Can you do it? Your pupils can use a straw or medicine dropper to add water very slowly to a glass that is already brim-full. It is possible to make the water pile up a little higher than the sides of the glass. *Surface tension (see "What Makes a Drop?",* N&S, *Oct. 14, 1968, page 3T)* holds the water together and keeps it from spilling over the sides of the glass.

Fun with numbers and shapes. Distribute some toothpicks and let your pupils try to find a way to remove eight toothpicks from the design shown, leaving three squares. Here is a way to do it:



Can your pupils find other ways to solve this problem? Can they make up similar problems of their own?

For science experts only. Use the classroom globe to show to your pupils that if you kept going northwest as far as you could, you would travel in a spiral path until you reached the North Pole.

Just for fun. When you have some time at the end of a day, let the children try to guess what will happen if they try the project suggested, basing their guesses on what they know about water, dishwashing liquid, food coloring, and Alka-Seltzer, and the effects that some of them have on the others. After they have made their guesses, let them try it and see. What happens if they add food coloring of another color after the bubbles begin forming?

Recent Books on Anthropology . . .
(continued from page 1T)

remarks about the symbolism of particular design motifs or about superstitions connected with the wearing of certain garments, and wisely takes into account the modification of dress styles after the arrival of Europeans. The text is illustrated by many well-done line drawings of figures, details, and designs.

Search for a Lost City: The Quest of Heinrich Schliemann, by Sam Elkin; illustrated by Lee Ames (G. P. Putnam's Sons, 94 pp., index, $3.49). This is a biography of the unorthodox nineteenth-century excavator of the ancient city of Troy. Told in a breathless journalistic style, the legend of the Trojan War springs to life and captures the reader's imagination as it must have Heinrich Schliemann's. His life is a study in contradiction: the shrewd businessman who is part romantic poet; the enthusiastic but naive archeologist who is scorned by scholars. Obsessed by the thought of discovering Troy, and taking Homer's *Iliad* as literal truth, Schliemann dug through numerous layers of the Trojan city and retrieved enormous treasure. Although he failed to understand much of what he discovered, and his methods were often unscientific, the story of Schliemann's dream-come-true is a fascinating interweaving of truth and fiction.

Finding Out About the Past, by Mae Blacker Freeman (Random House, 76 pp., $1.95). The best feature of this book is its inclusion of many fine photographs of archeologists at work and of the objects of their searches. The book is aimed at a very young audience (up to fifth grade, perhaps), but it does not spark the imagination as this subject might. The book describes ancient sites chosen more or less at random by the author, and tells about some of the treasures discovered. It then talks about the archeologist at work, dating and recording methods, and the preservation of recovered material. The account of an expedition lacks excitement; the reader is made aware of the *things* that are found, but feels no involvement with the people whose cultural remains are being uncovered. Also the author has failed to mention the importance of laboratory work—analyzing and cataloguing the collections to make them intelligible and useful to other scholars.

nature and science
TEACHER'S EDITION

VOL. 6 NO. 14 / MARCH 31, 1969 / SECTION 1 OF TWO SECTIONS

"The City Stinks, Let's Clean It Up"

by Gerald Schneider

■ Each child is a product of his heredity and environment. A person's biological heritage is received through sperm and egg. His cultural heritage comes from tradition, social institutions, circumstances, and interaction with the physical environment. Small wonder that children raised in cities may grow up with little empathy or concern for wild nature.

Gerald Schneider is Outdoor Program Specialist at the national headquarters of the Girl Scouts of the U.S.A., in New York City.

WIDE WORLD PHOTOS

Traditional teaching of nature and conservation assumes that the pupils already value nature. But to city children whose environment is like this, a tree seems useless, a forest a frightening place.

Nature study must seem trivial to most urban adults. They're probably preoccupied with problems of money, taxes, crime, and just getting to and from jobs each day. Conditioned for the worst, they often calmly tolerate smog, crowding, architectural ugliness, and other environmental evils. Their apathy is the bane of conservationists and others who are striving to preserve and improve man's environment.

There's some hope for city youth, however. Even the slum child can learn to love nature and a healthy environment. But to accomplish this, traditional approaches to nature and conservation education must be modified. A child's cultural heritage must first include a recognition and love of nature and conservation *in cities.*

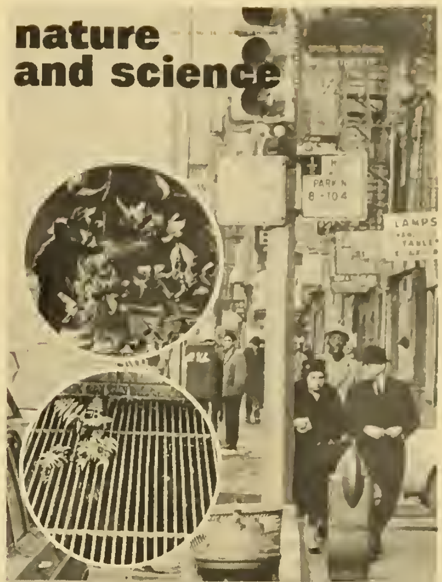
Explore the Environment

Awareness of environment is fundamental. Many city children travel between schoolroom and home televisions without seeing the land they pass through. They may be knowledgeable about Vietnam, black power, and such, but often don't realize that the air around them is polluted. Their environmental awareness must be awakened. How?

Focus on problems that affect their everyday lives: waste disposal, water supply, pollution, housing, parks. Let them probe the problems, study them firsthand, and suggest cures and solutions.

Have them observe the environment of their neighborhoods or school areas.

(Continued on page 4T)



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T – 4T.)

IN THE NEXT ISSUE

SCIENCE WORKSHOP investigations into birds' feeding habits, what makes plants bloom when they do, and the trajectories of falling objects . . . How scientists are studying the dream process.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

City Climate

A modern city, or metropolitan area, is a gigantic monument to man's ability to change the natural environment for his own purposes. But like most man-made changes to the natural environment, a city also changes the environment in ways that men have not foreseen—ways that make life in the city less pleasant and even harmful. Air and water pollution, overcrowding, noise, and traffic jams are a few of these undesirable changes in the environment. Hotter, cloudier, and wetter climates may be another, as the article on page 12 points out.

Do your pupils think a city's tendency to change its own climate is as serious a problem as, say, the pollution of its air or the jamming of automobile traffic in its streets? Probably they don't. But if they think about what causes the city's climate to change, they will see that these problems are all related. For example, slowly moving automobiles pour more heat and hot gases into the air at a particular place than faster moving cars do, helping to pollute and heat the air, and thus affecting the weather there.

The effect of a city on its climate may not seem very important *now*, especially to people who don't live in cities. Air and water pollution didn't seem very important, either, until scientists began to find that pollution affects people and all other living things, and that the effects of pollution are often felt far away from its source. And now that pollution has become bad enough to make us want to do something about it, we find that the job will cost billions of dollars and take a tremendous amount of work.

Some scientists suspect that if cities keep growing in size and number without cutting down the amount of heat and other pollution they pour into the atmosphere, they could affect the climate of the whole continent. So your pupils can see that the kind of climate a city makes for itself may be important to *them*, no matter where they live.

Topics for Class Discussion

• *How is* climate *different from* weather? "Weather" is a general word for the atmospheric conditions (air temperature and pressure, relative humidity, wind speed and direction, cloud cover, and precipitation) over a particular part of the earth's surface *at a particular time*. "Climate" is a general word for the kind of weather a place has *over a long period of time*.

• *Do the shapes and materials of natural areas of the earth's surface affect their own climates?* Yes. A forest, desert, mountain range, or large body of water, for example, each helps to make its own climate. (The climate of an area also helps to make the shape and materials of the earth's surface there, through erosion by water and wind, for example, or by favoring the growth of vegetation.) The climate in a natural area may change, but usually very slowly, over thousands of years.

• *Has man begun only recently to affect his own climate?* Ever since men began clearing forests to plant crops, and to build cities, he has been changing the shape and materials at the earth's surface, and thus helping to make his own climate. The biggest change, however, began with the Industrial Revolution *(see page 2)*, when men began to burn fuels to power machinery, pouring heat, gases, and smoke particles into the atmosphere over cities at an ever-increasing rate. And as a city grows into a metropolis, it tends to change the climate over a wider and wider area.

Activities

• By holding one hand a few inches below a lighted incandescent light bulb, your pupils will find that their skin is warmed, just as it is by the sun's rays. If you use a clear bulb, they can see that the light, and apparently the heat, both come from the heated wire.

Does the air carry heat from the filament to their hands? To find out, hold a sheet of glass or clear plastic between the bulb and hand. Their skin will still be warmed, but not the glass or plastic that separates the air next to the bulb from the air next to the hand. Using the other hand, they can test the air at the edges of the glass to make sure that heated air is not coming around it to their hand. This shows that whatever it is that carries "heat" from the filament (or the sun) passes through a transparent substance such as glass or the air without heating up the substance very much.

• Have a pupil hold his hand near the bulb but shaded from it *(see diagram)*, then close his eyes. Fold a sheet

of aluminum foil several times to make it rigid, then reflect light from the bulb to the hand. Can the pupil tell from the warmth of his skin when "heat" is being reflected from the foil? Have a pupil do the reflecting. Does the bottom of the foil get warm when the rays are hitting it at a slant? How about when the foil is held so the rays fall straight down on it? This will demonstrate the heating effect of the sun's rays as they reach the earth at different

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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. 6 NO. 14 / MARCH 31, 1969

SPECIAL-TOPIC ISSUE
LIFE IN THE CITY

nature and science

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Editor for this issue: Laurence P. Pringle

PICTURE CREDITS: Cover, street scene and top circle, United Press International, bottom circle, George Resch, from Fundamental Photos; pp. 2-3, Photo Researchers, Inc.; pp. 4, 8-9, 12-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, photo by Bough, from Fundamental Photos; p. 5, Joan Whitney, from Black Star; p. 6, UPI; p. 7, top left, Wide World Photos, top right, UPI, bottom, Leo Vials, from Frederic Lewis; p. 10, artwork by Joseph M. Sedacca; pp. 10, 11, photos from *The New York Times;* p. 16, photo by David Webster.

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

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Challenge o[f the Cities]

More and more people are living in or near cities. But is it "living" when people have to put up with traffic jams, crowding, polluted air, and dirty, noisy streets?

■ Suppose you had the job of planning and building a city. How would you go about it?

One thing is certain. There are probably no cities in the United States that you would want to use as an exact model for your new city. Nearly everyone agrees that today's cities are a mess.

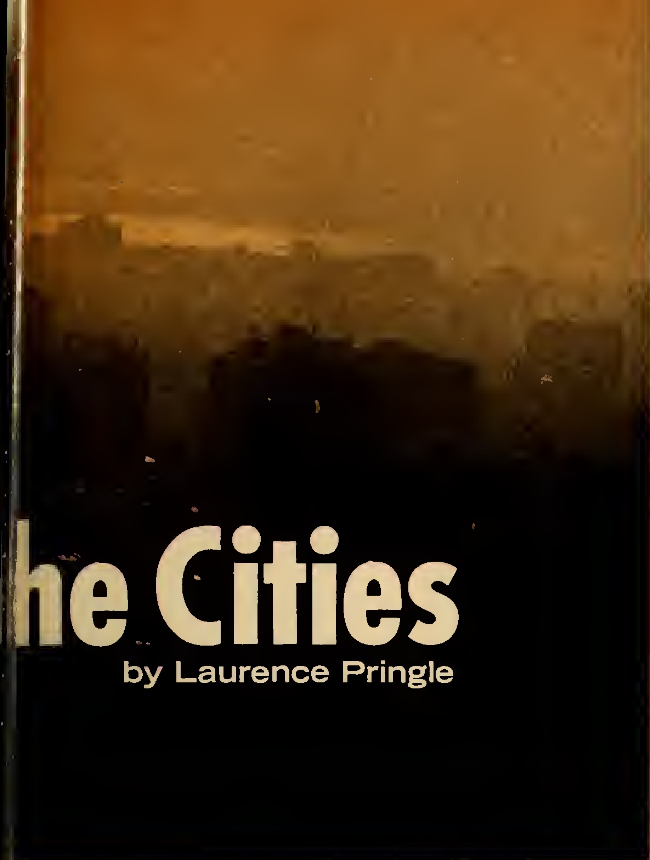
The air is polluted with wastes and noise; often nearby waters are polluted too. More and more highways are built—and then jammed with more and more automobiles. Those people who can afford to, usually escape to the suburbs. That leaves mostly poor people in the cities' centers. Taxes collected from these people don't provide enough money to solve all of the cities' troubles.

This article tells about some of the problems of cities, and some ways in which they might be solved. Other articles in this special issue tell about how crowding in cities may affect people, how cities "make" their own climate, and about some of the living things that share cities with humans.

In the Beginning . . .

Once there were no cities. Men lived in small, roving bands, or in villages. The first cities began about 5,500 years ago, in what is now Iraq. Since then many cities have been born. Some have died, some have grown to great size. Still, for thousands of years only a small part of the world's population lived in cities.

About 100 years ago, however, the proportion of the human population living in cities began to increase. The



he Cities

by Laurence Pringle

ain reason for this great change was the Industrial Revolution. There were new sources of power, such as the steam igine. Men no longer had to depend mostly on their own uscles and those of other animals. Better farm machinery, tter ways of raising crops and preserving foods, and tter means of transportation meant that fewer people ere needed on farms. Many people moved to cities, where ey found jobs in factories.

This was the start of the industrial city. It began in Engnd and has since spread all over the world. About one ird of the earth's population now lives in or near such ties.

After the 1960 census, some people claimed that the nited States had become "a nation of cities." The Census ureau reported that nearly 70 per cent of all Americans ved in city *(urban)* areas.

By "urban," however, the Census Bureau meant any ttlement having more than 2,500 people. Actually, in 960, nearly half of the United States population lived in nall towns or in rural areas. About 32 per cent of the opulation lived in cities of 50,000 people or more. Anther 21 per cent lived in suburbs around these cities. lthough the 1970 census will probably show an increase the urban share of the population, the United States is ill far from being "a nation of cities."

Looking ahead, however, it seems that the urban share f the population will continue to increase. People are still aving farms to settle in or near cities. City dwellers are till moving to nearby suburbs. Modern highways and automobiles have made it possible for suburbs to be built several miles from a city's center. But the differences between "city" and "suburb" have become blurred as the suburbs closest to cities become more densely settled.

The result is a new kind of human settlement—the *metropolis* (from the Greek words for "mother" and "city"), or *metropolitan area.* With people able to travel quickly several miles between home and work, the modern metropolis can be 100 times larger in area than the biggest cities that existed before the Industrial Revolution.

Bigger Is Not Better

A city usually grows by accident. It begins as a little village just like many others. But its location—beside a harbor, along a river or railroad route, near some cheap source of power—makes it an important center of trade or manufacturing. So a city grows, usually without any particular plan. Even a city that was planned, such as Washington, D.C., was designed long before the automobile was invented, and before surrounding suburbs made it a metropolis.

The sprawling, unplanned growth of metropolitan areas is a source of many of their problems. Take the New York City metropolitan area for example. According to a group of city planners who studied it recently, the New York City region covers 6,900 square miles in three states. In 1960, this metropolis had over 16 million residents.

Within the New York metropolis there are 550 separate governments, including cities, towns, villages, and boroughs. Many of these communities have common problems of water supply, pollution control, garbage disposal, parks, schools, and libraries. Problems such as these might be solved more easily and cheaply if the needs of the whole region were planned for. Instead, communities often tackle these problems by themselves.

Even when communities work together, the troubles of the metropolitan area may get worse, not better. For example, the word "transportation" often seems to mean only "automobile" to government agencies in charge of planning for transportation needs of metropolitan areas. Many highways, bridges, and tunnels have been built to handle automobiles, while railroads and other *mass transit* systems have received little financial help. So rail service gets steadily worse. Some railroads that used to carry many commuters have gone out of business. And in the centers of many cities, automobiles are causing traffic jams, parking problems, and polluted air.

People like the convenience of driving to and from work. One flaw in mass transit systems of buses, subways, or railroads is that they must follow fixed routes. In a sprawling metropolitan area, there are bound to be many

(Continued on the next page)

The sounds of traffic and of continual building and repairing make cities noisy. So far, little is known about how the noise of cities affects the people living there.

people who do not live along a mass transit route. These people often choose to drive their cars.

A group of engineers at the Massachusetts Institute of Technology, in Cambridge, has a plan that could convince people to leave their cars at home—or not to have cars at all. A person wanting a ride would simply make a phone call, giving his address and destination. A computer would then send the information to the nearest "mini-bus," which would pick him up. These 10-passenger buses, run by electricity, would each have a small territory to cover and no fixed route to follow. After picking up a few passengers, the buses would get onto an electric-powered "guideway" that would speed the buses downtown *(see diagram)*. The M.I.T. engineers say that this system could provide the convenience of personal travel with the speed of mass transit.

Such a system could be working in a metropolis by 1975. But it probably won't be. The governments of a central city and of its surrounding suburbs would have to provide great sums of money, and agree to spend it on mass transit instead of more highways for autos. There seems to be little chance of that happening.

A Nice Place To Visit, But . . .

During the next 30 years, the population of the United States may grow by 100 million people. And despite the dirt, noise, danger, and other unpleasantness of cities, most of those millions will live in metropolitan areas. The cities and their surroundings will change tremendously as homes, schools, factories, and other structures are built or replaced to meet the needs of the rising population.

Will the resulting cities be better or worse places in which to live? Finding ways to make them better is a huge and costly job. Only in the past few years have scientists and engineers begun to really study ways of making cities more livable. There are still many questions to answer.

What are the effects of air pollution and noise on people? When do street noises stop being just a background sound and begin to get on people's nerves? How much of a metropolis should be left as parkland and other open space? Should the outward growth of metropolitan areas be halted, and better use made of the space within the metropolis? How can housing be built for great numbers of people that will still give them quiet, private, living areas?

Answering questions like these—and doing something about them—is the great challenge of the cities ■

■ Look for these books about cities in your library or bookstore: **Planning Our Town,** by Martha Munzer, Alfred Knopf, New York, 1964, $3.95; **Under the City,** by David Lavine, Doubleday & Company, Inc., Garden City, New York, 1967, $3.50; **Becoming a City,** by Margaret Uroff, Harcourt, Brace & World, Inc., New York, 1968, $3.75.

In one plan designed to solve city traffic problems, people would be picked up at their homes (and returned) by electric "mini-buses" that would then travel downtown on an electric "guideway." Individual electric cars could also use the "guideway." In the downtown area *(right)*, people could also travel in capsules on tracks running along the fronts of buildings.

Our attempts to reach to the moon and beyond may someday yield great benefits. But more important, perhaps, will be how successful we are in . . .

The Quest for Inner Space

by R. J. Lefkowitz

■ *A pale grey light filters through the window, and somewhere an alarm goes off. You yawn and start to roll over, but your kid brother is in the way. You roll the other way, and bump smack into a wall. You slide down off the bed and look out the window, but you can't really tell what kind of day it is because the brick wall of the building just a few feet away blocks out all the sunlight anyway.*

Downstairs, you bump and jostle your way through the crowded streets, then get into a bus with so many people already in it that it looks like a cartoon. But the squeezing and squashing aren't funny, and by the time you struggle your way to the door at your stop and shove your way through the throng of people waiting to get on, you feel so closed-in that you just want to scream. . . .

Maybe you're lucky. Maybe you don't share a bed in a tiny room in a crowded apartment in a big, crowded city. Maybe you live in a nice roomy house in the country or in a suburb, surrounded by lots of trees and grass. But many people in the United States today live in cities. Some cities are less crowded than others, and some people live in less crowded parts of cities than others do. Still, there are millions of people in this country who often feel as though they just don't have enough "breathing space."

Scientists, like many other people, are now wondering what effects too little space may have on people, and what can be done to give people the space they need. One way they have tried to find out is by studying the effects of crowding on other animals besides humans.

Raging Rats and Dead Deer

In 1947, a scientist named John Calhoun began a 14-year study of rats in an old stone barn near Rockville, Maryland. Dr. Calhoun wanted to find out what would happen to the rats if their numbers were allowed to increase while the rats were kept in a confined space.

He found that as more rats were born, and the rat numbers increased in the pens he had built, the rats' behavior began to change. Fighting broke out among the male rats. The female rats either stopped bearing young or stopped caring for their young and building nests for them. Some of the adult males ate the young, even though there was other food available; and

(Continued on the next page)

many rats died of disease. It seemed as though crowding had produced *stress* in the rats—a kind of "nervousness" that changed their behavior and made them less healthy.

If Dr. Calhoun had let his experiments continue, the rat situation would probably have reached a "crisis," after which enough rats would have died of disease or from fighting so that the remaining rats could live normally.

This sort of thing seems to have happened on James Island, a tiny piece of land in Chesapeake Bay, off Cambridge, Maryland. Four or five Sika deer had been brought to the island in 1916. There were no predators on the island to kill the deer, and by the late 1950s the herd numbered about 300. Then, from 1958 to 1960, nearly 200 of the deer died. They hadn't starved to death, and there was no evidence that any disease had spread among them. It seemed that the deer numbers had been high enough to produce stress, which caused changes in the animals' bodies that killed the animals.

No one knows whether crowding can have the same effects on humans as it has on some other animals. But many scientists believe that crowding in our cities may be making some people less healthy, or may be causing emotional problems in some people. Some scientists believe that high crime rates may be partly due to crowding, and that crowding may be one of the things that has helped to cause riots in our cities. Certainly crowding is helping to make a great many people unhappy.

Of course, not everyone in a city feels so crowded. If a person has enough money, he can "buy" the space he needs in even the most crowded city. He can live in a large home or apartment, and can get from place to place in a private automobile, rather than on a crowded bus or train. Other people, however, are forced to live together in small spaces, where they are in constant contact with each other.

You probably know yourself what it's like to be in a place where people keep bumping you. Imagine what it would be like to be in that situation nearly all the time, hardly ever having a chance to be alone.

But do large numbers and small spaces always mean "crowding"? Perhaps not. When Dr. Calhoun was performing his experiments with rats, he found that about 150 rats could live well together in a quarter-acre pen. But if the space were divided up into pens two feet square, it could hold 5,000 healthy rats in pairs. What seemed to matter most was not how much *total space* a rat had, but how much space "of its own" it had, where it could move around without bumping into another rat.

Your Own Space

People aren't rats, of course; but each of us seems to need a certain amount of space to call his own. It may be just a small "bubble" of space that separates us from other people as we go through our everyday activities, or it may be a room or a part of a room at home. Perhaps a city's apartment buildings could be built with these human needs more in mind.

Years ago, apartment buildings were built one right next to another, with no space in between for trees and grass.

In many cities all over our nation, there are large families that can afford only one or two rooms in which to live.

Too Close for Comfort

Do you have to be "elbow-to-elbow" with other people before you feel "crowded"? Or do you begin to feel cramped even before another person comes close enough to touch you? People seem to need a "bubble of space" around themselves that keeps other people "at their distance." You probably can't measure your own "bubble of space," but you can try finding out how close you can get to another person before he or she begins to feel crowded.

While you are having a conversation with a friend, take a small step forward. If your friend doesn't move, take another step toward him a few moments later. How many steps can you take in this way before your friend begins moving backward? What happens if you lower your voice, as though you were telling your friend a secret? Or if you raise your voice, as though you were talking to a large group of people? Does your friend change the distance between you according to the way you talk? Does a member of your family try to keep the same distance from you as your friend does?

If you have some friends who come from other countries, you might try the experiment on them and see whether they behave the same way as people born in the United States. People from Germany and England, for example, tend to stand farther away from one another while talking than Americans do; Japanese and Arabs tend to stand closer together than Americans. Do you think that a person who was born in one country, but who lived a long time in another country where people "spaced themselves" differently, would change the way he felt about spaces between people? Can you think of a way to find out?

Buildings like these *(left photo)* house many families, but often make people feel "closed-in" and "pushed-together." "Habitat," the experimental community built for Expo '67 in Montreal, Canada, shows another way to house many families in a small area *(top photo)*. The way that the apartments are fitted together gives each one its own terrace, and makes people feel as though they have more privacy.

Now many builders are using large land areas to put up tall buildings that often take up less than one fifth of the land. But people who live in the buildings often complain that the rooms are too small, the corridors too narrow, the ceilings too low. And the open space around the buildings is taken up by concrete walks and parking lots; or, where there is grass, it is often fenced off so that no one can walk or play on it.

Perhaps a builder could buy a little less land, and use a little more of it for his buildings. With the money saved on land, he could build underground or rooftop parking lots, leaving more of the land available for recreation. And perhaps he could build thicker walls that would block out sound better, so that people wouldn't feel sometimes as though their neighbors were right in their own apartment.

Many people believe that the problem of crowding can only get worse as more and more people pour into our cities. But that may or may not be true. We may not be able to stop people from moving into the cities, or from having children, but perhaps we can find ways of using space and building homes that won't crowd people, and that won't make people *feel* as crowded as they do now ■

A normal workday crowd in a big city.

nature and science | WALL CHART | *March 31, 1969*

How To Survive in the City

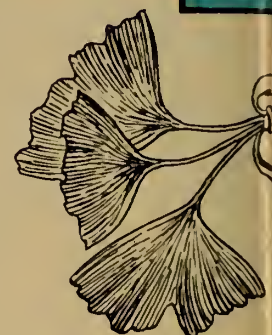
■ Whenever humans move into an area and build homes, towns, and cities, the wild animals begin to disappear. Their living places (*habitats*) are destroyed. In time, you might think there would be nothing but people—and their pets—living in the city world of concrete, close-packed buildings, and polluted air.

If you look around in a city, though, you'll find many kinds of animals and plants living there. Some of them, like rats, have followed man and shared his living places for centuries. Others are species that once lived wild in the area where a city was built. All of these organisms have some characteristics that enable them to survive in cities. Some of them may live nowhere else.

The drawings on this WALL CHART show some common plants and animals that live in North American cities. If you look in vacant lots and other open spaces in cities, you will find small plants such as dandelions, ragweeds, and plantains. Mammals such as raccoons and opossums often live at the edges of cities. See what other kinds of life you can discover in your city.

—LAURENCE PRINGLE

TREES



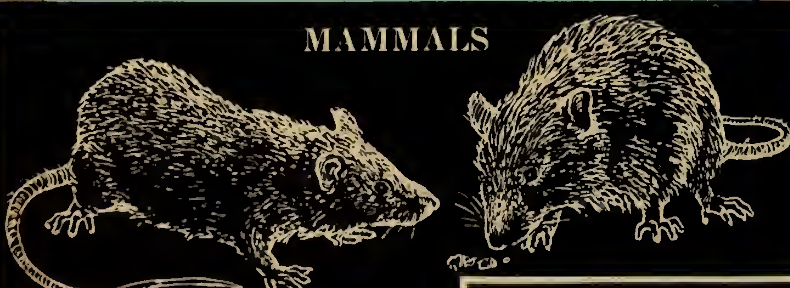
Fan-shaped leaves mark the ginkgo, another tree brought to North America from China. It is called a "living fossil," since it has been on earth for at least 100 million years, and has changed little in that time. It is able to resist most tree diseases and grows well along city streets.

About 75 kinds of eucalyptus have been
from Australia to California. They ha
names as blue gum, red gum, and red i
The leaves curl up on hot days, losi
moisture to the air; the big taproot gro
into the soil. In ways like these eucalypt
do well with little water.

The London plane tree is a *hybrid*—a tree produced by breeding the American sycamore with the Oriental plane tree. It is better able to resist disease and to live in cities than either of its "parent" trees.

The ailanthus, or
heaven, was first br
North America from
1784. It grows quick
most any kind of soil
or shade, and thrive
dust and waste gase
air. Its seeds have
that are twisted like
propellers; even a ligh
carries them a long w

MAMMALS

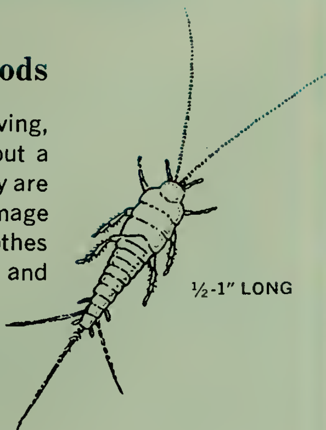


Rats depend on people for most of their shelter and food, and people seldom disappoint them. Rats are wary, curious, and quick to learn. Traps and poisons may reduce their numbers, but they reproduce quickly and can survive as long as they find garbage and other wastes for food, and places to nest and hide.

House mice can climb, jump, and swim well, and can survive on all sorts of food, including glue and soap. Females begin breeding when they are only 40 days old, and can have about six young a month.

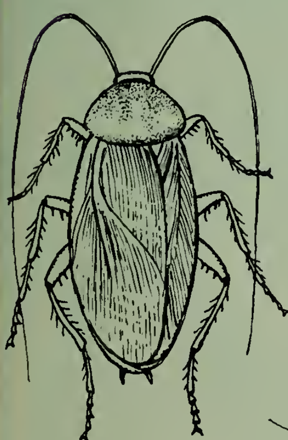
INSECTS and other arthropods

Silverfish are quick-moving, scaly, gray insects, about a third of an inch long. They are active at night, and damage books, wallpaper, and clothes by eating glue, paste, and starch.

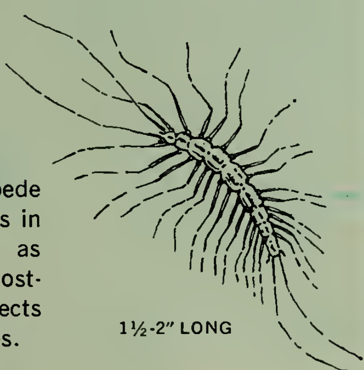


½-1" LONG

½-1½" LONG



Like rats, cockroaches find the cities of man much to their liking. They hide in cracks and crevices by day, then come out and feed on garbage and unprotected food by night. They are quick-moving insects, and have flattened bodies that can squeeze through small openings.



The house centipede *(not an insect)* lives in damp places such as cellars. Its food is mostly spiders and insects such as cockroaches.

1½-2" LONG

5-6" WING SPAN

The cynthia moth was brought to North America from Asia in 1861. Its caterpillars *(larvae)* prefer to eat the leaves of the ailanthus tree, so this big moth is found mostly in eastern cities where this tree grows.

BIRDS

10" LONG

Nighthawks are not hawks but resemble them as they fly in the evening sky above cities, catching flying insects. Outside cities, they nest in open fields or on gravel. In cities they find the same sort of conditions on the rooftops of many buildings.

The brown and red house finches are as common in some western cities as house sparrows are in the east. They eat the same kinds of food, and nest in bird houses and in crannies of buildings.

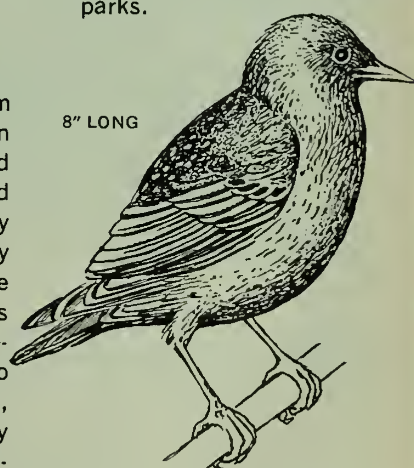
6" LONG

6" LONG

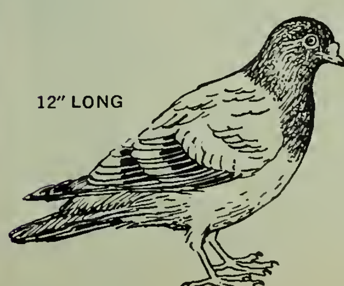
Brought to North America from England in 1850, house sparrows now live in most cities of the continent. They are weaver finches, not sparrows. They eat such food as grain and bread crumbs, and often compete for food with pigeons on sidewalks and in parks.

Starlings were brought from Europe to New York City in 1890. They have now spread over almost the entire United States. Starlings eat many kinds of food, and swarm by the thousands at city garbage dumps. Flocks of starlings roost on city buildings, especially in the wintertime. To chase away these noisy flocks, city officials sometimes play recordings of a starling's distress call.

8" LONG



12" LONG



Pigeons raise young almost all year round in many cities. People feed them grain and bread, and pigeons also find plant seeds in parks and crumbs on sidewalks. Nests are built on window ledges of buildings. Because of their design, many new office buildings offer few nesting places for pigeons.

Too many pigeons is the problem. Poisons and traps aren't the answer. And you can't get rid of all the roosting places. But a solution may have been found.

the pigeon predicament

BY BARBARA DAVIS

■ Cities often have as many pigeons as people. And while there are those who like pigeons and want to feed and protect them, other people are trying to get rid of them. Pigeons dirty streets and buildings. They may carry diseases that can spread to people. They annoy some people with their cooing and wing-flapping.

This plastic owl was supposed to keep pigeons away from a New York City bridge by scaring them. It didn't work, for the pigeons weren't frightened at all.

Health department officials have used one method after another to reduce the number of pigeons. One way is to use pinwheels or other objects that might frighten the birds (*see photo*). But they do little good. The birds usually get used to them, or else move to a nearby building.

Poisons and traps have been tried, but people who like pigeons object to the killings. And poisons and traps may hurt other kinds of birds. Besides, as long as food and living space remain, other pigeons soon replace those that are killed.

One sure way of reducing the numbers of an animal is to destroy the place where it lives (its *habitat*). This works for some animals, such as mosquitoes that breed in swamps, but not for pigeons. It would be impossible to destroy all the pigeon-roosting places, from tenement buildings to the mighty heights of cathedrals.

The pigeon problem is similar to those studied by *wildlife biologists,* who often have to try to increase or decrease the numbers of wild animals. And it is a wildlife biologist, Dr. William Elder, a Professor of Zoology at the University of Missouri, at Columbia, who may have found an answer to the pigeon predicament.

Nuisance Numbers

The ancestors of city pigeons lived on hills and cliffs

near the Mediterranean Sea. Their gradual spread around the world has been the result of man's providing food and cliff-like buildings. Dr. Elder knew that many other birds, such as starlings, had increased to nuisance numbers because man had made habitats for them. He wondered if some kind of *birth control* might be a good way of reducing the numbers of nuisance birds. Dr. Elder began to search for ways to stop birds from laying eggs, or to stop eggs from hatching.

From reading about the work of other scientists, Dr. Elder learned of many chemicals that might control bird births. Some were substances that had been tried on animals as part of the search for cures for the disease called cancer. These chemicals had lowered the animals' *fertility*, or ability to have young. Dr. Elder also learned that some insect-killing chemicals had affected the fertility of birds that ate the insects. He read of many other substances known to affect fertility. He hoped that out of all these chemicals, one would reduce bird births without killing the adult birds or making them sick.

Success—in the Laboratory

Dr. Elder began testing the effects of the chemicals on pigeons kept in laboratory cages. The pigeons were given food pellets that had been sprinkled with one or another of the chemicals. Some chemicals were given to pigeons for as few as seven days, others for as long as 50 days. After each tryout, the pigeons were given regular food pellets (without the chemicals added) for several months. During these months, Dr. Elder watched to see whether the chemical being tested prevented egg-laying, how long it worked, and whether it made pigeons sick.

Some of the chemicals did nothing. Some made the birds weak. Others stopped the pigeons from laying eggs, but *only* while they were being fed the special pellets.

After four years of tests, a chemical that had the right effects was found. Its manufacturer called it SC-12937. When fed to female pigeons for about two weeks, it stopped them from laying eggs for about six months. How SC-12937 works in the pigeon's body is still not known, but it may keep the pigeons from making egg yolk.

Success—on Street Corners

SC-12937 had succeeded in the laboratory. Next, in Missouri, a graduate student of Dr. Elder's counted the number of eggs laid by pigeons fed SC-12937. There, too, SC-12937 seemed to work. Fewer eggs were laid after the chemical was given, and those that were laid failed to hatch.

The next step was to try the chemical on wild city pigeons. Dr. Elder supplied the food—wheat soaked in SC-12937. The American Society for the Prevention of Cruelty to Animals chose the testing sites — three New York City street corners known to have large pigeon flocks.

For 10 days in April (just after the breeding season had started) and 10 in September (near the end of the breeding season), grain with SC-12937 was scattered at two of the corners (*see photo*). The third spot received regular wheat. It was the *control* for the experiment—the normal condition with which the other sites could be compared.

From May through December, the pigeons at each street corner were counted at least once a week. The people counting the birds also recorded how many pigeons were adults and how many were young. (Young pigeons, unlike the adults, have no white spots above their bills.)

The total counts didn't tell much, for the numbers changed a lot just from day to day. But in December, there were fewer *young* pigeons than there had been at the beginning. The birds that had been young in May had become adults. Apparently, fewer pigeons had hatched.

Dr. William Elder (in the light-colored coat) watches as wheat treated with SC-12937 is scattered at one of the New York City test sites.

This birth control chemical is now being used in some European cities. But reducing pigeons by birth control chemicals alone is slow work. The chemicals only reduce the number of pigeons that are hatched and not the number of adults living when the chemicals are given. Pigeons usually live about five years, so waiting for the adult birds to die is a long wait.

To reduce pigeon numbers quickly, Dr. Elder has suggested that first some adult pigeons might possibly be killed. Then, SC-12937 or another birth control chemical can be given several times a year, for several years, throughout an entire city. In this way, the numbers of pigeons can really be reduced ■

Peeking at Pigeons

The private lives of pigeons are a mystery to most of the people with whom they share a city's sidewalks. If you would like to learn more about these birds, here are some tips on things to watch for.

- One way to get a close look at pigeons is to go where a flock comes to eat (or put out some grain or bread crumbs yourself, if there is no law against it in your city).

Do the birds "fight" over the food? Do some individuals seem to be "bosses," always getting their way? What do pigeons eat that *is not* provided by humans? Where do pigeons get water?

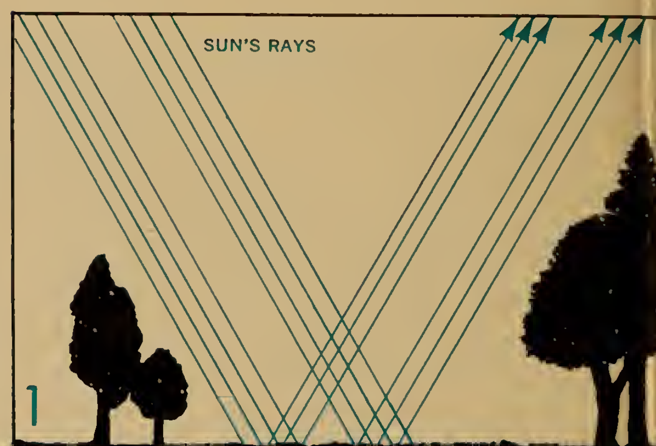
- Pigeons make most of their cooing sounds during the mating season. You may hear them make other sounds, especially when they are frightened. Watch a male pigeon seek a female during the mating season. It usually doesn't recognize a female by sight, so it keeps approaching both males and females, cooing loudly. (The loud cooing helps to identify the pigeon as a male to other pigeons.) If the bird approached is another male, or a female that already has a mate, it drives off the male by pecking and beating its wings. When a male approaches a female that has no mate, the female usually just tries to edge away from the male. Watch to see paired birds "billing"—when the female puts her beak inside the open beak of the male to take some partly-digested food.
- Where do pigeons build their nests? How high above the ground? What are the nests made of? (Field glasses might help here. Or try to find a pigeon that is building its nest and watch to see what materials it carries.) Do pigeons let other pigeons come near their nests?
- During the long breeding season you may be able to see pigeons keeping their eggs warm, eggs hatching, and *squabs* (baby pigeons) growing up. Do the male and female birds share the job of sitting on the eggs? The eggs usually hatch in the morning, about 18 days after they are laid. What happens to the broken shells? Watch the parents feeding the young. The adults "cough up" a partly-digested cheese-like substance, called "crop milk," which the young then take from the adults' beaks. When the squabs are older, the food they are given is not digested so much. The squabs are usually ready to leave the nest four weeks after hatching. You can watch them exercise their wings, and if you're lucky, you may see their first flight from the nest.

■ The weather reports broadcast by big-city radio stations remind us daily that a city is usually warmer than its suburbs and the open country around it. Scientists who studied the climates of cities in the United States and England found that a city also tends to have more cloudy days, more fog, more *precipitation* (rain or snow), slower winds and less sunshine than the countryside around it.

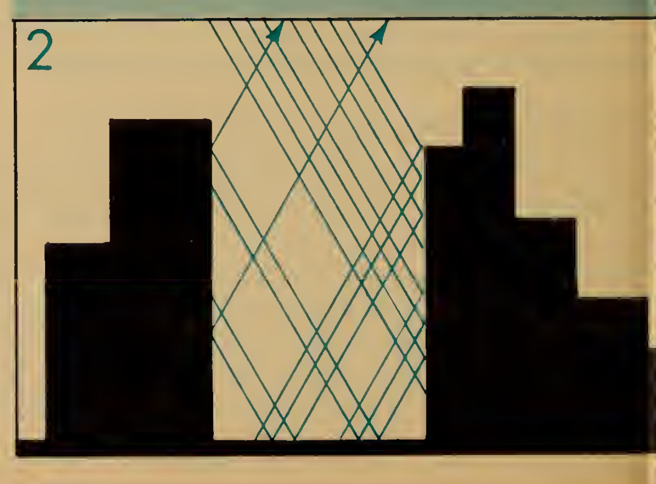
The city itself causes these differences in climate, according to Dr. William P. Lowry, an Assistant Professor of Biometeorology at Oregon State University, in Corvallis. In *Scientific American* magazine, Dr. Lowry described how a city and the flat or gently rolling country around it produce such different climates.

Heat from the Sun's Rays

In the morning, Dr. Lowry pointed out, the sun's rays reach the city and the surrounding country at a low angle. In the country, most of the rays are reflected from the ground back into the atmosphere, leaving very little heat in the soil (*see Diagram 1*). Only the rays that strike th



During most of the day, the sun's rays strike the earth at a slant. In the country, most rays are reflected from the ground back into the air (*Diagram 1*). City walls reflect the rays to other walls and streets, which absorb heat from the rays (*Diagram 2*).



"You can't do much about the weather," people often say. But scientists have found that building cities and living in them changes the weather quite a bit, because...

A CITY MAKES ITS OWN CLIMATE

[s]ides of trees and other plants leave much heat there.

In the city, though, most of the sun's slanting rays strike [th]e sides of buildings, leaving some of their heat there and [th]en bouncing off toward other buildings or streets that [a]re also heated by the rays (*see Diagram 2*). The rock-like [m]aterials that make up buildings and streets *absorb,* or [so]ak up, heat much faster than soil does. The air gets most [o]f its heat from contact with solid surfaces, not from the [s]un's rays as they pass through the air. So the city air is [w]armed up faster than the country air.

Around noon, when the sun's rays reach the earth at a [s]teeper angle, the country ground absorbs more of their [h]eat. The country and city have about the same tempera[t]ures then. Later, perhaps, rain will fall. In the city, the [w]ater quickly runs off the ground through drainpipes and [s]ewers. In the country, most of the water stays on the [g]round or near its surface. As the water evaporates, it [c]ools both the land and the air.

In the afternoon, the sun's slanting rays again warm [t]he city more than the countryside. As the sun sets, the [c]ountry ground rapidly loses its heat to air that rises and [m]oves away as cooler air moves in to replace it.

In the city, the first surfaces to cool off at night are [s]treets and rooftops. If many rooftops are at the same [l]evel, a layer of cool air may form over them and block [t]he warmer air near the ground from rising and moving [a]way. By dawn the city will probably still be four or five [d]egrees warmer than the country around it.

The Heat That People Make

On a workday, the city's air is warmed even more by the heat, smoke, and gases from stoves, furnaces, cars, trucks, and buses. The center of the city becomes what weather scientists call a "heat island." The hot air from this area rises and spreads out over the whole city.

The air from the heat island contains particles of dust and smoke that hang over the city and reflect light from the sun, making the sky appear hazy. At night, when the air cools, moisture from the air may collect on the particles and form fog.

Unless wind blows the particles away, or rain washes them out of the air, the haze gets denser each day. It cuts off some sunshine from the city, and people may burn more fuel to make up for the lost heat. This pours still more smoke, gases, and heat into the air.

Dr. J. Murray Mitchell of the United States Weather Bureau wanted to be sure whether people's activities in cities affect the city's climate. Studying weather records, he found that a city will have a heat island whether it is located on flat or hilly land. He also found that a city is warmer on weekdays, when most people are working, than on Sundays. In addition, he found that as a city's population grows, so does the size of its heat island and the difference in temperature between the heat island and the areas around it.

Today more and more people are moving from the country into our cities. The cities themselves are spreading out into the countryside around them. And in some places whole new cities are being built or planned. Weather scientists are wondering whether this will cause changes in the climate of our whole continent, and they are studying the climates of cities to find the answer ■

Some Things To Think About

Some engineers have suggested that new cities be enclosed in a huge dome of plastic that would let the sun's rays pass through it, but not snow or rain. The engineers say that a dome two miles across could be built.

Can you think of some things that would have to be changed to keep the air in such a domed city from getting too warm and polluted with exhaust gases and smoke particles? Might such changes improve a city's climate even if the city were not enclosed in a huge dome?

If giant air conditioners could keep the air in such a domed city at a comfortable temperature and free of polluting gases and particles, do you think the city would change the climate of the country around it? Can you explain why?

MALE AND FEMALE LOOK ALIKE

AUSTRALIAN

THE "CITY SLICKER"

Cockroaches like what people eat, so city life is right up their alley. These slippery insects roamed the earth before dinosaurs did, and they may outlast us all.

by Alice Gray

MALE AND FEMALE LOOK ALIKE

AMERICAN

■ If there is a city insect, it is the cockroach. Although it came originally from the tropics, the roach has traveled all over the world as a stowaway.It even thrives in the Arctic (in heated buildings). Every large city swarms with roaches, and urban housewives usually aren't entirely free of them for very long.

It is misleading to speak of "the roach," as though there were only one. In fact, there are about 3,500 kinds *(species)* in the world. Most of them are outdoor insects in the tropics. Only a few kinds of roaches live indoors. About half a dozen are at home throughout the continental United States. (Alaska has only one species; Hawaii, being tropical, has many more species that do not occur on the mainland.)

International Insects

The most widespread of these pests is the German roach, a pale tan species about half-an-inch long when fully grown. (Germans call this insect the French roach!) The American roach, a chestnut-brown species an inch-and-a-half long, is almost as common. The broad, dark brown, short-winged kind is called the oriental roach in the United States and the black beetle in England. (It is not really black, and not a beetle!)

The Australian roach is like the American, but a little smaller, with a yellow streak on the "shoulder" of each front wing. The brown-banded roach resembles the German, but the female has short wings. The gray- brown Madeira roach is bigger than the American. It lives only in cities visited by ships from tropic ports.

Although many roaches are named for places from which they supposedly came, the names may all be mistaken. Possibly all the common house roaches began in Africa, but that is far from certain. They have lived with man so long and have been so widely spread in the belongings of traveling people that their original homes may never be known. The German roach may well have come from Asia before history began. Whatever their origin, roaches have lived in cities as long as people have. Before that they shared the huts of villagers and the caves and tents of even earlier men. Not that they care much for people. They just like what people have to eat.

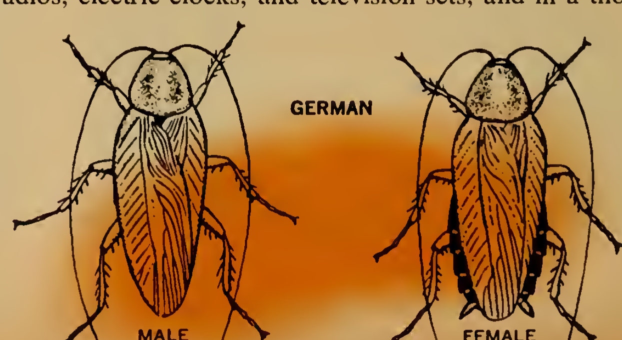
Roaches, like people, are *omnivores*—eaters of both plant and animal food. But roaches eat a greater variety of foods than most humans. Plant or animal, living or dead —anything that will stand still and be eaten is food for roaches. However, they much prefer moist, soft substances, such as garbage.

They drop their own wastes wherever they happen to be feeding. Many human diseases are caused by "germs" that can pass uninjured through the digestive system of a roach. The insects may spread infection by picking up "germs" in the sewer and leaving them in the kitchen. Polio and typhoid fever are among the diseases roaches may carry. However, no one has yet proved that roaches have ever played an important part in the sudden spread of any disease.

Why Roaches Keep in Touch

You have only to look at a cockroach to know that it lives in crevices. It is flat and slippery, with strong pushing spines on its legs and long, thread-like antennae that "smell" the outside world before the insect leaves its shelter.

Roaches are *thigmotactic* — they can rest quietly only when in contact with something. The more surfaces of its body a roach has touching something, the more secure it seems to feel. House roaches hide by day in cellars and closets, behind and under articles of furniture, inside radios, electric clocks, and television sets, and in a thou-



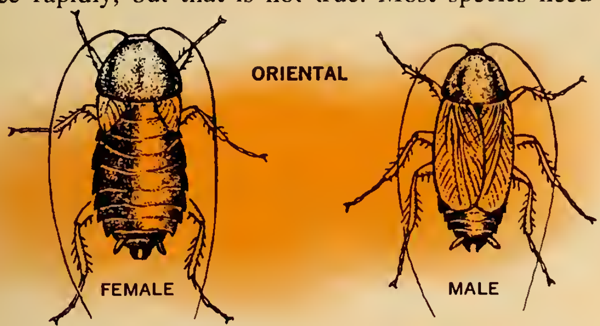
GERMAN

MALE FEMALE

sand crannies that a housekeeper never thinks to examine.

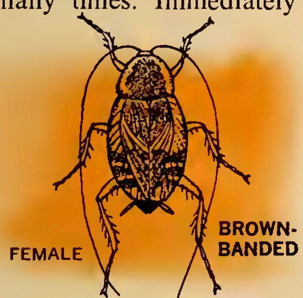
At night they come out and search for supper and a drink of water. Roaches need a lot of water, unless their food is very wet. This is why they are so much more likely to be seen in the kitchen, bathroom, or laundry room than in a bedroom or living room. Because so many places offer shelter to roaches, it is very hard to reach all of them with an insect-killing poison *(insecticide)*.

Since roaches are so abundant, people think they reproduce rapidly, but that is not true. Most species need at least a year to produce a new generation of adults. The number of young produced by one female roach in her lifetime is not great when compared with many other kinds of insects.



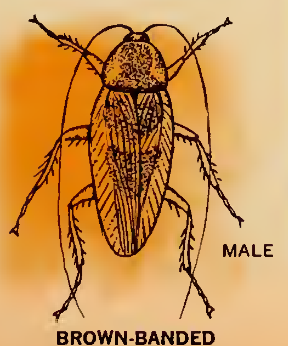
You may have seen a female roach with her egg capsule protruding from the rear of her body. The capsule looks like a tiny purse. Some species carry the capsule inside their bodies until the eggs hatch and the young are born alive.

The young roaches look like adults, except that they have no wings. During their growth they shed their skins many times. Immediately after shedding, the insect is milk white. People who see a roach in a new skin are likely to mistake it for an *albino*—an animal that stays white all of its life, even though that is not the usual color for its species. But if you keep the roach for half a day, you will see it gradually change to the normal color.



Even though most people dislike them, roaches are of a very old and distinguished family. Three hundred million years ago, they were the most common animals on land. They have changed very little since then. In the time of the dinosaurs, they were already as old as the dinosaurs would be now if they still existed. A family so tough and so adaptable is likely to be with us a while longer. Perhaps the last living creature on the earth will be a roach ■

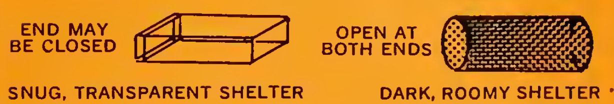
March 31, 1969



Investigations with Cockroaches

Cockroaches are good laboratory animals, easy to get and to care for, little enough to keep in a small space but large enough to handle and to watch without using a magnifying glass. (But be sure to get your parents' permission before bringing roaches into your home.) If you watch captive roaches carefully, you will see them doing things that will suggest experiments. For instance:

- If there are hiding places in their cage, roaches will stay hidden all day and come out to feed at night. What happens if you keep the insects always in darkness or always in light? Do they stay on their usual schedule? If not, how long does it take for their schedule to break down, and how soon does it come back when you expose them to the normal cycle of light and darkness? If you find that the roaches stay on their usual schedule, see whether you can change their hours of hiding and hunting by changing the hours of light and darkness.
- Roaches hide in dark crevices. Which is more important to the roach, the darkness or the tight fit? If you offer the insects a snug shelter made of transparent plastic, and a dark, roomy shelter that is round so that only the roaches' feet can touch any surface, which will they choose?



- Does a roach have a special "home" to which it returns every morning? Give your roaches several identical hiding places, such as small boxes. Mark the insects with numbers painted on their backs in waterproof ink so that you can tell them apart. Examine each box every morning to see which roaches are in it.

The better you get to know your roaches, the more questions you will ask yourself about them, and the more experiments you will be able to think of to help you answer your questions.

Taking Care of Captive Roaches

A gallon mayonnaise jar from a restaurant will make a fine cage for roaches. Cut out the center of the lid and put in a piece of wire screening, cut to fit. Give the insects a crushed paper towel in which to hide. Feed them dry cat food crushed to powder. Make them a drinking fountain out of a small, wide-mouthed bottle or test tube. (Just fill the bottle with water and plug it tightly with a wad of wet cotton, so that the water will not run out when you lay the bottle on its side. The roaches can squeeze the water out of the cotton when they need it.)

For experiments that need space, a glass fish tank is good. It must have a tight screen cover. A band of vaseline about an inch wide just below the inside top edge of the tank will help to keep the roaches in.

brain boosters

prepared by **DAVID WEBSTER**

MYSTERY PHOTO What are these?

WHAT WILL HAPPEN IF...

. . . you let a glass of milk stand in your room for two weeks? You probably know that it will get sour. But what will it look like? Will it still be white? How else might it change? Try it and find out. Look at the milk every day to see what happens. You might try keeping it longer than two weeks to see if any more changes take place.

CAN YOU DO IT?

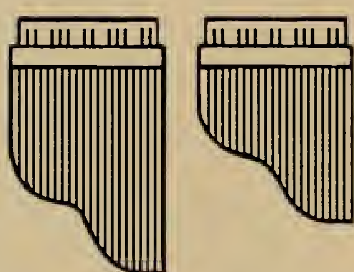
If an egg is dropped into water it will sink. What can you do to make it float?

JUST FOR FUN

Make a pinhole in a small piece of paper. Hold the paper about an inch from your eye, and look through the hole. At the same time, hold a pin by the point with your other hand so that the pinhead is between the hole and your eye. If you move the pin up, it should look as though it is coming down from the top. Which way does the pin seem to go when it is moved from left to right?

FOR SCIENCE EXPERTS ONLY

If the length of a piano string determines the pitch of the sound it makes, how can pianos of different sizes have the same notes?



FUN WITH NUMBERS AND SHAPES

What is the weight of a fish that weighs 10 pounds plus half its weight?

Submitted by Helen Norton, South Harpswell, Maine

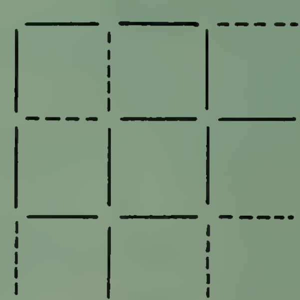
ANSWERS TO BRAIN·BOOSTERS IN THE LAST ISSUE

Mystery Photo: The sign painted on the road is usually viewed from a slant by the driver in a car. Hold the picture sideways and at a slant (*see diagram*), and the letters should look more normal.

Can you do it? If you use a soda straw or medicine dropper to add water very slowly to a glass that is already brim-full, you can make the water pile up a little higher than the sides of the glass. Can you guess why the water doesn't spill over?

For science experts only: If you kept going northwest as far as you could, you would travel in a spiral path until you reached the North Pole.

Fun with numbers and shapes: Here is a way to make 3 squares by taking away 8 toothpicks.



What will happen if? Water from a filled tin can will squirt out just as far from two holes as it does from one. What would happen if you made three or four holes at the same level?

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

angles throughout the day.

• Have your pupils place directly beneath a lighted bulb a stone or piece of concrete of fairly even thickness, and a shallow glass or plastic bowl filled with earth to the same thickness as the stone. After half an hour or so, have them find out whether the bottom of the stone is warmer than the soil at the bottom of the dish. (They may be able to tell by touch; if thermometers are used, they should be shaded from the light.) Your pupils can tell that heat is *conducted* away from the surface of a rock-like material faster than from the surface of the soil. Could this explain why rock-like materials can hold more heat than unpaved ground does?

• Putting one's hand in the air above a heated radiator demonstrates how the air gets heat from warm surfaces (such as the earth, water, and city walls and streets that have absorbed "heat" from the sun).

• It might be well to explain that the sun (or the bulb filament) does not radiate *heat*, but certain *waves of electromagnetic energy* called *infrared waves*. These waves are longer than light waves, so we can't see infrared "light"; but they are shorter than radio and television waves *(see "Seeing Things in Different 'Lights'" and preceding box, "Send Signals by Radio,"* N&S, *March 18, 1968).*

Infrared waves, like light waves, pass through transparent substances and are reflected from the surface of opaque substances (especially from surfaces that are light-colored or shiny). But whenever they strike the tiny particles of substances called *molecules,* the infrared waves lose some of their energy to the molecules. This makes the molecules vibrate faster than before, which explains why the skin is heated by infrared waves that strike it *(see "Exploring Heat and Cold,"* N&S, *Nov. 1, 15, Dec. 6, 1965).* The faster the molecules jump around, the more they bump into each other and lose some of their energy, which is radiated from the substance in the form of "new" infrared waves. These waves have less energy than the infrared waves radiated by the sun, so they are more easily absorbed by other substances — even transparent substances such as glass or air.

HOW TO TRAP COCKROACHES

If your pupils want to try some of the investigations with cockroaches (on page 15), they may have some trouble catching these wary insects. They can make a roach trap like the one shown here, using a half-pint bottle with a

screw cap. The best cap is the two-piece kind—a flat cover with a screw rim to hold it in place. You use only the rim. If you can't get that, cut most of the top out of an ordinary lid with a pair of tinsnips. You will also need a scrap of window screening about as big as half a sheet of letter paper, to make the funnel part of the trap. (Screening lets the smell of the bait in the trap reach the insects.)

Roll a piece of paper into a cone. Fit the cone into the mouth of the bottle. Adjust it until the cone's point reaches about half way to the bottom of the bottle while the top fits the mouth tightly. Fasten the paper in this shape with sticky tape, then draw a pencil line around the cone at the top of the jar. Press the cone flat and cut it open along one fold. Trim the top about half an inch above the pencil line. Then use this pattern to cut your screening, with about half an inch extra at the side to allow for overlap.

Roll the screen into a cone and fasten it with staples, or sew it shut with a big needle and a piece of string. Cut off the tip to make a hole big enough for a roach to get through. Fit the funnel into the jar and turn the very top down over the top of the jar. Screw on the cover to hold it in place. Bait your trap with a piece of very ripe banana or a little stale beer on a scrap of paper towel. Lay the trap on its side against a wall behind or under something in the cellar, or wherever you know that roaches live. (If you don't know where there are any, ask the manager of a supermarket or school cafeteria for permission to put the trap in a back room.) Leave it overnight. To care for the roaches you catch, see "Taking Care of Captive Roaches," on page 15.

Brain-Boosters

Mystery Photo. The metal globes shown stockpiled in a Navy yard are used as floats for a mine net.

What will happen if? When left at room temperature for a long period, milk will separate into a thick, white curd at the top of the container, and watery, clear whey at the bottom. The milk is decomposed by the action of microorganisms that are always present in the air. Encourage the children to find out what happens to other liquids when they are allowed to stand uncovered and out of the refrigerator. Fruit juices and soups are some liquids they could try.

Can you do it? Adding salt to a glass of water will increase the water's density enough to enable it to float an egg, which is only slightly denser than water *(see "How Dense Are You?",* N&S, *Sept. 30, 1968, pages 10 and 2T).*

Can your pupils find other liquids that are dense enough to float an egg without having anything added to them? Can they find other substances besides salt that will make water dense enough to float an egg? Sugar, instant coffee, powdered milk, and soap are some substances they could try.

Fun with numbers and shapes. Some of your pupils may try adding half of 10 to 10 in order to solve this problem; but this yields 15, which is not correct. The fish's weight is made up of half its weight plus half its weight. If a fish weighs 10 pounds plus half its weight, 10 pounds must be half the weight of the fish. The fish, then, must weigh 20 pounds.

For science experts only. The pitch of a piano string is determined by its thickness, as well as by its length. A large piano has thinner strings than a small piano, in order to compensate for the greater length of the strings.

Your pupils can test this by stretching rubber bands of different thicknesses to the same length and comparing the pitch of the sounds they make
(Continued on page 4T)

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

when plucked.

Just for fun. Distribute some pins and let your pupils try this. (Caution them to hold the pin head-up, and not to poke themselves in the eye.) When the pin is brought upwards, the head of the pin interrupts a light beam coming down from above *(see diagram).* In

like manner, each point along the shaft of the pin interrupts this beam first as you move the pin upwards, making it appear as though the pin is moving downward. (The pin is so close that your eye cannot focus on it.)

"The City Stinks . . ."
(continued from page 1T)

Is there enough parking space? Are more trash barrels and garbage cans needed on streets? Do buildings need repair? Does the air smell, or blanket everything with a layer of soot? What kind of plants and animals live in homes, vacant lots, parks, along streets? Encourage city children to take pictures of attractive and ugly spots in their community. Perhaps they'll want to develop a photo exhibit of contrasts to display in school or in the public library.

Once accustomed to seeing their surroundings from a new perspective, they're likely to see how the city environment affects them. A teenage girl said: "I'm seeing the city like it is for the first time." An eleven-year-old boy, after completing an environmental survey, said: "The city stinks, let's clean it up."

Get Them into Nature

Fun and adventure in the outdoors is important. Love of nature and a healthy environment comes from favorable experiences, not from speeches, sermons, or textbooks. Values are caught, not taught.

Take a city nature hike. Visit stores, pet shops, parks, zoos, museums, factories, waterfront areas, sewage treatment plants. Children can remove their shoes and socks in parks and feel the cool grass on their feet. Can they get permission to climb a tree? Is there a park pond where children can feed fish, ducks or geese?

Outdoor activities for city youths are often best kept unstructured, light, and open-ended. The children will learn something on their own, and best of all, discover that nature has *value* for them. The fun of infrequent outdoor experiences can be ruined by burdensome emphasis on fact memorization and note-taking. And words are no substitute for direct involvement with plants and animals.

I once watched a university professor lecture to a class of nine-year-olds in an arboretum. It was a rare trip outdoors for this inner-city group. The professor dryly explained the role of insects in flower fertilization, using a beautiful orchid as an example. Only a few children clustered around the professor could actually see what he was doing with the orchid. Others in the class stood around looking aimlessly at the ground.

Suddenly a girl in the class turned to her teacher and said: "Can we smell the flowers?" "Shh," replied the teacher, "the professor's talking. We can't waste time smelling flowers."

How sad, I thought. The whole lesson was a waste of time for most of the children. If only they had smelled the flowers. Perhaps they might want to grow flowers in their drab classroom. Some children might have developed a love of flowers and returned to the arboretum to learn more about them. Instead, I overheard one youth saying to another as they left the arboretum: "Who gives a ____ about flowers anyway."

On another occasion, I watched a class of ninth-graders from the city visiting a nature center. It was also a rare chance for these children to get outdoors. Most of their time at the center, however, was spent indoors making leaf spatter-prints, viewing slides of birds, and listening to a lecture on the "web of life." They were completely listless and looked bored.

Meanwhile, through the window, I could see a gray squirrel and two robins on the lawn. A tiger swallowtail butterfly fluttered near a hedge. And the beginning of a self-guiding nature trail was visible and inviting.

The class boarded a bus and left the center without having had any real outdoor contact. Worse yet—the center operates under federal funds provided for "innovative and exemplary" outdoor education programs!

Projects Can Help

Love of nature and a healthy environment comes from *meaningful involvement in projects to improve the living conditions of plants and animals in the city.*

Even simple beautification projects, such as planting flower seeds and tending them in flower boxes, have meaning. They can leave children with favorable impressions that lectures can't duplicate.

The city child can plant shrubs near homes, around schools, and in parks (with permission). Shrubs are not only attractive in themselves, but provide food and cover for wildlife. Trees can be planted, also. They give shade, seclusion, beauty, and protection from the wind. Birds and other animals may rest, nest, or roost in them. The affection of children for shrubs, trees, or flowers they planted themselves is a wonderful thing. And it may carry over to nature at large, as children build and maintain animal feeding stations, birdhouses and birdbaths. You can seek advice on these projects from park department officials, naturalists at a local museum, and conservation department employees.

Beware of using the term "conservation" too soon. It's difficult to get even experts to agree on what conservation means. You can study environmental problems without mentioning the abstract term "conservation."

Once a city child is made aware of his environment and its problems, and has had opportunities for outdoor fun, he may be ready for more traditional nature and conservation teaching. But if the child hasn't first gained an appreciation of nature and its relation to his environment, your further efforts are doomed ■

nature and science
TEACHER'S EDITION
VOL. 6 NO. 15 / APRIL 14, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Swinging Birds

When people see a bird, tree, or other organism, their first question usually is: "What is it?" Today that question is usually easy to answer, thanks to an abundance of illustrated field guides that help identify all sorts of living and non-living things.

There are two other questions that are much more important to ask, though, and not nearly so easy to answer. One is "What does it do?" Books and magazines give information about an animal's food, mating habits, and other characteristics. And knowledge about adaptations, such as the behavior and bill size of birds mentioned in this article, answers part of the question "What does it do?" But a person must know quite a bit about nature in order to be aware of an organism's role in its environment, and of how the creature affects and is affected by other organisms. This is the study of *ecology,* a science that has become critically important as humans learn how their actions are helping to destroy their own life-giving environment. *(See these articles in recent issues of* N&S*: "Tale of the Torrey Canyon," Feb. 3, 1969; "A Whale of a Problem," March 17, 1969; "Challenge of the Cities," March 31, 1969. Also see the Special-Topic issue, "Spaceship Earth," April 1, 1968.)*

"Big Bills, Little Bills," on page 4 of this issue, attempts to answer another difficult question: "How did it get that way?" The answer, most scientists believe, is evolution through natural selection.

About 100 years ago Charles Darwin and Alfred Wallace proposed the theory of natural selection. Darwin had studied and raised domestic animals for many years. He knew that no two animals are exactly alike, even animals with the same parents. He also knew that animals could pass along their different characteristics to their offspring. A strain of animals with a certain characteristic—such as sheep with especially thick wool—could be developed by breeding only animals that had that characteristic.

Reproduction is the key to natural selection, since anything that increases the chances of reproduction also increases the chance that a characteristic will be passed on to the next generation.

When people think of natural selection, they often picture a "struggle for existence," with the swiftest animals and the fastest-growing plants always succeeding and passing their characteristics on to future generations.

But a plant or animal may be vigorous and unusually successful in competing for food, space, or other needs, and still not be able to reproduce itself as well as other, less vigorous organ-

(Continued on page 2T)

IN THIS ISSUE

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

● **Mystery of the Swinging Birds**
Your pupils can investigate the feeding habits of birds. The article tells how these adaptations may have evolved through the process of natural selection.

● **Brain-Boosters**

Make Flowers Bloom When You Want Them
By underexposing plants to light each day, your pupils can make them bloom early.

Way-Out Ways to the Moon
A cover and WALL CHART show how science-fiction writers of the past envisioned trips to the moon.

● **How High? How Far?**
With a marble and a simple ramp, your pupils can investigate the trajectories of objects moving through space.

How Do We Dream?
Scientists don't know yet, but this article tells how they are trying to find out.

IN THE NEXT ISSUE

SCIENCE WORKSHOP investigations of shadows, insects that are active at night . . . Article and WALL CHART on biological controls . . . New theories about dinosaur mobility . . . Index to Volume 6.

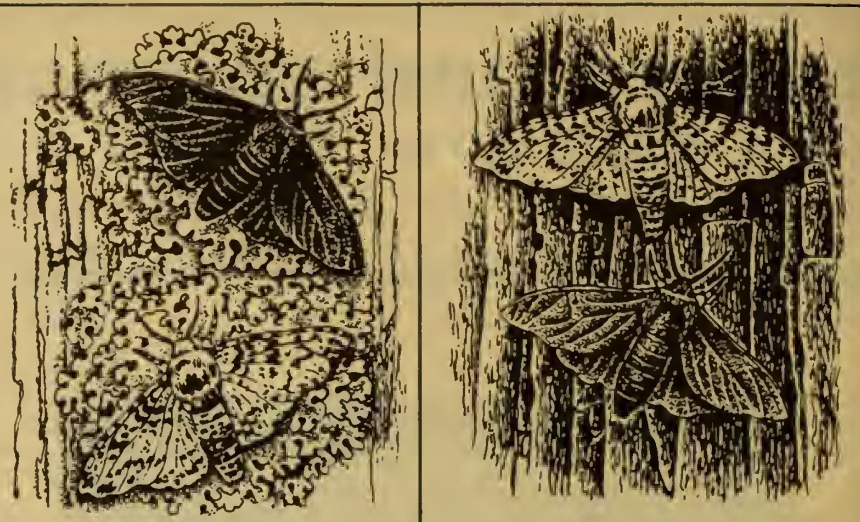
Using This Issue...
(continued from page 1T)

isms. Natural selection depends on the ability of organisms to produce offspring. Only through successful reproduction can characteristics such as swiftness be passed along. This fact helps account for the great variation in means of reproduction found among plants and animals. (This point is illustrated in the *N&S* WALL CHART, "Six Ways to Success," advertised in *N&S*, Sept. 30, 1968, page 4T.)

Evolution is going on all the time. Usually it takes thousands or millions of years for noticeable changes to take place. Sometimes, however, evolutionary changes happen in a fairly short time, and we can actually see the results.

One example is the changes that often take place when a population of mosquitoes is sprayed with an insecticide such as DDT. Most of the mosquitoes are killed when the area is first sprayed. A few survive—those individuals that have the ability to resist DDT. They live to reproduce offspring that also are able to resist DDT. Eventually, if DDT is sprayed year after year, a new population of DDT-resistant mosquitoes will evolve. (Another example of rapid evolution is shown in the drawings on this page.)

Rapid evolutionary change like this is most likely to happen in a species having *sexual* reproduction, rather than *asexual* reproduction. The first life on earth, perhaps two billion years ago, probably had asexual reproduction. These one-celled organisms reproduced by *fission*—the division of their genetic and cellular materials—with each half becoming an individual of the same kind. In asexual reproduction the offspring are identical "copies" of the parent, unless a genetic change called a *mutation* occurs.



ABOUT 1850 — TODAY

Before 1850, most of the peppered moths near Manchester, England, were pale in color. Their speckled appearance concealed them from their enemies as they rested on light-colored tree trunks in the daytime. But as soot and smoke from industries coated the trees, the pale individuals were more easily seen than darker moths. Through natural selection the peppered moth became a dark species; today the pale forms are rare except in rural areas.

Asexual reproduction is still common in many groups of plants and animals; some organisms have both sexual and asexual reproduction. The methods are similar in that a parent organism contributes a part of itself to a new individual. The main significance of sexual reproduction is that it promotes genetic variability. In sexual reproduction the offspring cannot be identical "copies" of their parents, because the offspring have inherited characteristics from *two different* parents. Sexual reproduction *maximizes* variation in a species; asexual reproduction keeps variation at a minimum. (For more information, see the special issue on reproduction, *N&S*, March 27, 1967.)

How High? How Far?

By investigating the trajectories of marbles launched from a simple ramp, your pupils can find out that the path described by any object moving through space depends on: (1) its initial speed and direction *(velocity)*; (2) other forces applied to it in flight (rocket thrust or air resistance, for example); and (3) gravitational forces caused by nearness to other bodies.

Since Galileo first investigated trajectories (with ramps and balls), knowledge of the subject has been used mainly for military purposes. You might point out to your pupils, however, that such knowledge is equally necessary for guiding a projectile such as the Apollo spaceship into orbit around the earth or to the moon, and for plotting the path of a heavenly body, such as a comet. (Most scientific discoveries can be used for either constructive or destructive purposes; it depends on which purposes we consider more important.)

Suggestions for Classroom Use

Have your pupils do the first investigation in the classroom, by simply rolling a marble off a desktop and releasing another marble at the height of the desktop as the rolled marble leaves the desktop. With a little practice they can do this well enough to tell by the sound of impact that (1) both marbles travel through the same vertical distance in the same period of

(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 September, October, December through March; monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. 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. 6 NO. 15 / APRIL 14, 1969

Before going
to bed tonight,

see page 13

HOW DO WE DREAM?

this as "far out" as the
AY-OUT WAYS TO THE MOON
hown on page 8?

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 EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **EDITORIAL ASSISTANT** Alison Newhouse; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

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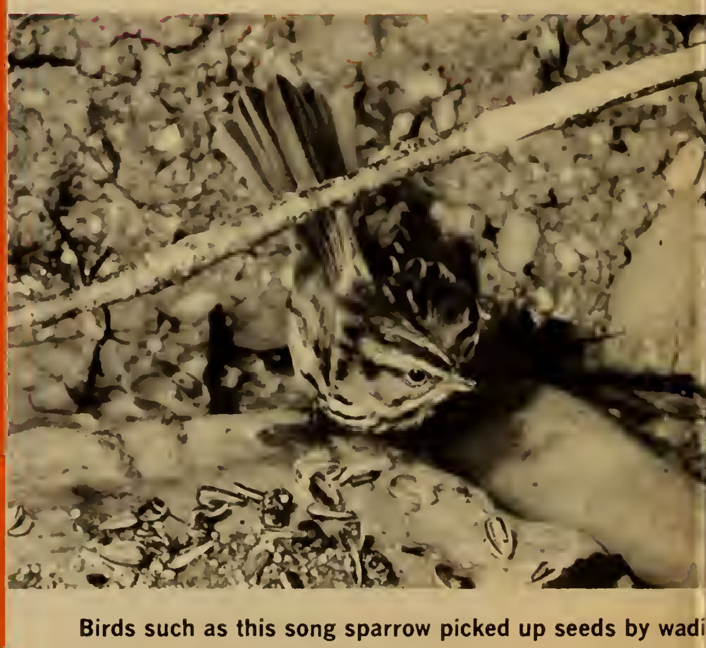
Mystery of the Swinging Birds

by Martin A. Slessers



Birds such as this song sparrow picked up seeds by wadi[ng] into the stream or landing on a rock.

Why did some birds wade into the stream to get floating seeds, while others swung from sticks and scooped the seeds from the water?

Wings spread wide, this tufted titmouse swung down from a branch and grabbed a seed, then flew away with it.

■ Like many people interested in birds, I have a bird feeder at my home in Maryland. Nearby there is a small stream where birds come to drink and bathe.

One day I saw a sunflower seed fall into the stream and float in the shallow water that bubbled over the gravel and rocks. A tufted titmouse, which was drinking at the stream, noticed the seed. Immediately the bird flew to a stick that hung about four or five inches above the water. As soon as the seed was beneath the stick, the titmouse swung around like a trapeze gymnast, caught the seed in its beak, then flew away with it.

In a short while, the bird was back on the stick, watching the bubbling water. I threw in another sunflower seed, and the titmouse caught that one, too.

Soon I had two titmice and three chickadees picking up floating seeds this way. Later, a cardinal and two song sparrows joined in. But they did not perch on the stick,as the titmice and chickadees did. They waded into the shallow water and fished the seeds out. So did the slate-colored juncos that joined the flock.

Why Not Wade?

The behavior of these birds puzzled me. I asked myself: "Why did the titmice and chickadees perch on a stick to catch a seed from above, while the other birds picked up the seeds while standing in the water or on the bank?" It seemed so much simpler to get the seeds the way the sparrows, cardinal, and juncos did. The water was very shallow, and all of the birds liked to bathe in it. So why this fuss of sitting on a branch, waiting, and then bending down, stretching their necks and feet to the utmost, and swinging around the stick, or diving down to catch the seed?

Unable to explain these different kinds of behavior, I decided to try some investigations. First, I put a piece of bark with seeds on it beneath the stick, so the birds could land on the bark and get the food without using the stick or wading into water. To my surprise, the titmice and chickadees still used the stick. They landed on the bark or in the shallow water only when another bird was on the stick, or when the seeds could not be reached from the stick. The sparrows, cardinal, and juncos continued to eat by standing on the bark or in the shallow water.

Then I realized that chickadees and titmice are somehow related to each other, and so are sparrows, cardinals, and juncos related to each other. By searching for information in nature magazines and books, I learned that chickadees and titmice belong to a family of birds called *Paridae*. Sparrows, cardinals, and juncos belong to the finch family, or *Fringillidae*.

Food Shapes a Bird's Life

I also learned that the type of food the birds usually eat and the place where they get the food affects their behavior. Sparrows, cardinals, and juncos, for example, eat mostly seeds that they find in fields and brushy clearings. To crack these seeds, they need strong and heavy bills. They also need bigger muscles and heavier bodies than birds such as chickadees.

Titmice and chickadees, on the other hand, feed mostly on insects (adults, young, and eggs) that they find on trees and brush. As they search for food, they poke into every crevice or crack in the bark of tree trunks, branches, and brush. They leap from branch to branch, swinging around twigs or hanging upside down.

Over many thousands of years, birds of the *Paridae* family have slowly changed *(evolved)* so that they have lighter bodies and more delicate bills than sparrows, cardinals, and other finches. They cannot open seeds the

(Continued on the next page)

INVESTIGATIONS

- Place a stick less than half-an-inch in diameter across a stream, puddle, or birdbath. Below the stick you can put a large leaf, a flat stone, or a small board with sunflower seeds and other kinds of seeds on it. Watch to see which kinds of birds land on the stick to pick up the food, and which land on the flat surfaces or in water to take or eat the food. If a bird such as a chickadee lands on one of the surfaces or in water to pick up food, try to find the reason it did so. (Are the seeds too far from the stick?)
- Change the height of the stick and observe how far (in inches) a chickadee or other bird can stretch its body to reach the seeds. Watch to see what other movements the birds make when picking up food. Use binoculars if you have them or can borrow them.

way the finches do. Instead, they use one or both feet to hold a seed against the branch on which they are perched. Then the birds hit the seed several rapid blows with their bills, until the seed opens.

The photographs I took of the feeding titmice and chickadees made me realize how quickly they move. I had to use electronic flash lights as brief as 1/10,000 of a second in order to "stop" their movements on film.

The differences that I noticed between the two groups of birds came about through a process called *natural selection.* How it works is explained in "Big Bills, Little Bills," below ■

Big Bills, Little Bills

Each new plant or animal that is produced inherits a "set of directions" from its parents. No set of directions is exactly like another. This is why no two plants or animals have exactly the same characteristics, such as size, shape, color, or ways of behaving.

Even among the earliest, very simple life on earth, each individual plant or animal was different from other individuals of its kind, or *species*. When two of these individuals mated, each of their offspring inherited characteristics that made it different from its parents and from the other young. In this way, as generation followed generation over millions of years, plants and animals became different from their simple ancestors. The change in characteristics of a group of plants or animals through time is called *evolution.*

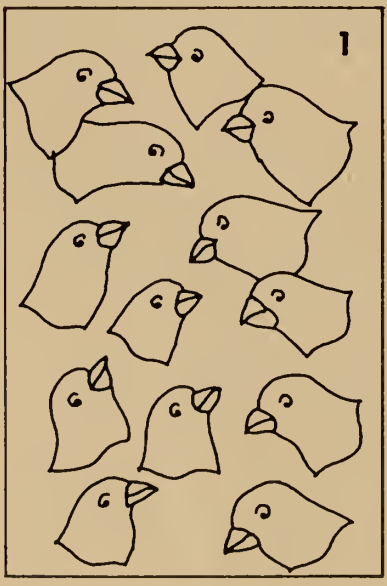
Scientists believe that evolution is guided by a process called *natural selection*. This process takes place as animals (or plants) reproduce and pass some of their characteristics on to their offspring.

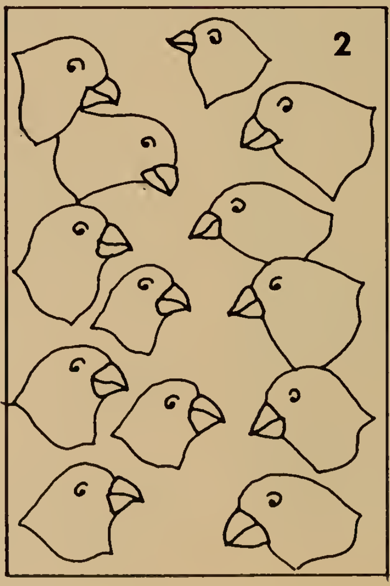
Here is how natural selection might work in a population of birds: Suppose the birds had bills that enabled them to eat both insects and seeds fairly well *(Diagram 1)*. But they lived in an area where seeds were abundant and insects were becoming scarce. A few individuals might have bills that were a bit heavier and stronger than most—better suited for cracking seeds. Their bills might increase their chances of surviving long enough to have young. And the characteristic of a stronger bill would be passed on to their offspring.

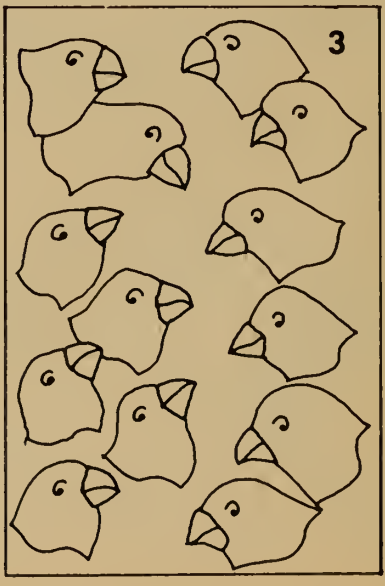
Those birds that had bills better suited for catching insects might not survive as well in that particular area. Fewer of them might live to reproduce.

In each generation, more and more of the birds in that area would have bills suited for cracking seeds *(Diagram 2)*. And whenever a bird was born that had a stronger, heavier bill—even better for cracking seeds—it would have a greater chance of surviving long enough to have offspring. In this way, after thousands of years, the birds would have evolved so that they all had bills suited for cracking seeds *(Diagram 3).*

What do you suppose would happen if seeds gradually became less abundant and insects plentiful? Would the entire bird population die out? Remember, even if all of the birds had big bills suited for cracking seeds, some individuals would have somewhat smaller bills than others, which might enable them to catch insects, to survive and have young, and to pass on their characteristics to their young. The variations among individuals would make it possible for the birds to survive, and to evolve to meet the new conditions.

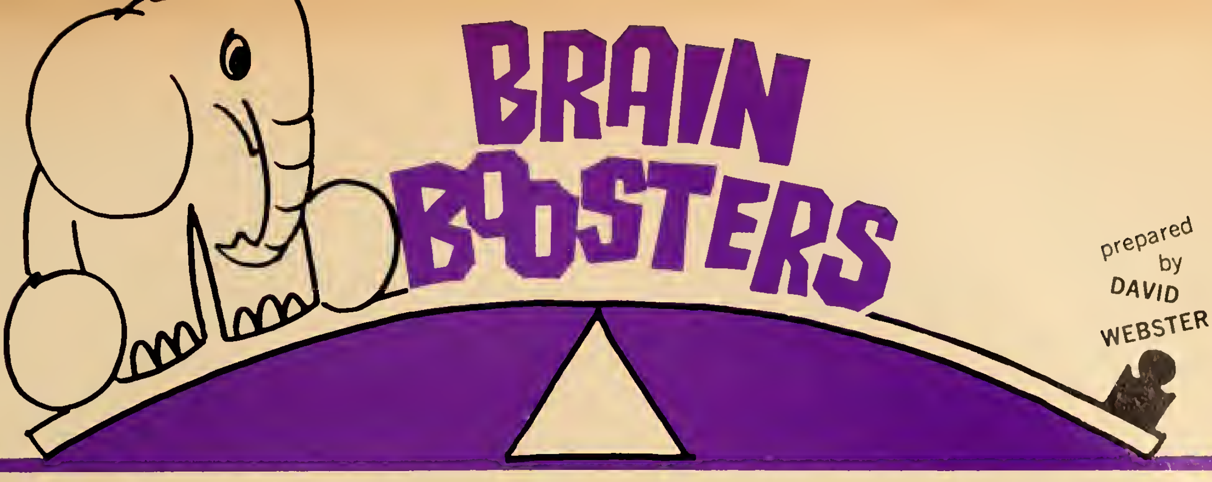




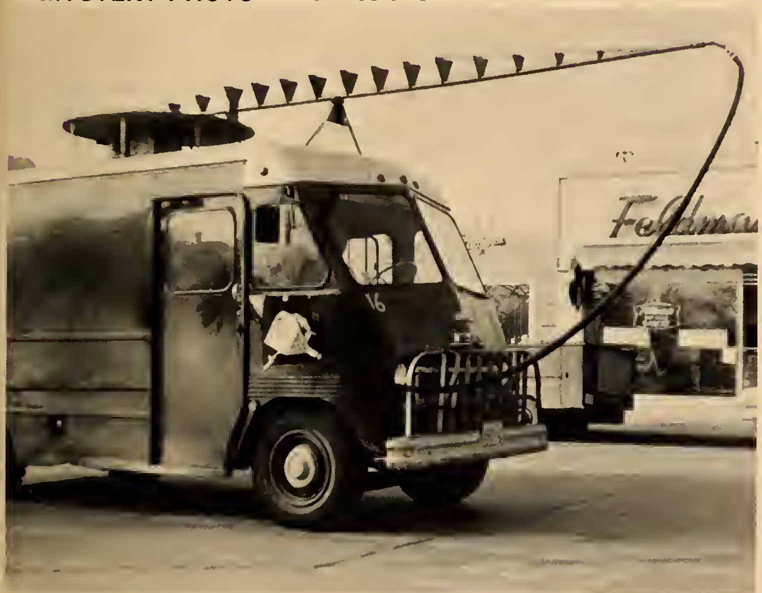


BRAIN BOOSTERS

prepared by DAVID WEBSTER



MYSTERY PHOTO What does this truck do?

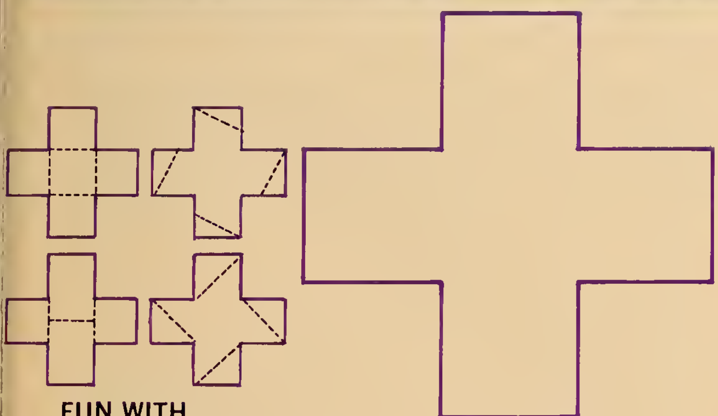


JUST FOR FUN

Put an uncooked egg in the kitchen sink and let the water from the faucet run on it. The egg should stay under the stream of water by itself. What other objects will stay under the faucet? What objects get pushed aside by the water?

WHAT WILL HAPPEN IF . . .

. . . a bottle half-full of pancake syrup is placed on its side on a tilted board? Try it and see.



FUN WITH NUMBERS AND SHAPES

How can you cut the cross into pieces that can be fitted together to make a square? (Trace the cross on paper, cut it out, then cut it up into pieces.) The diagrams show four ways you could try. Only one of these ways will work. Can you find some other way?

FOR SCIENCE EXPERTS ONLY

Is the shadow of a bird flying 100 feet above the ground bigger, smaller, or the same size as the bird?

CAN YOU DO IT?

Hold 15 straws in your mouth and put them into a glass of water. Can you drink any water?

Submitted by Larry Oberdick, Painesville, Ohio

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

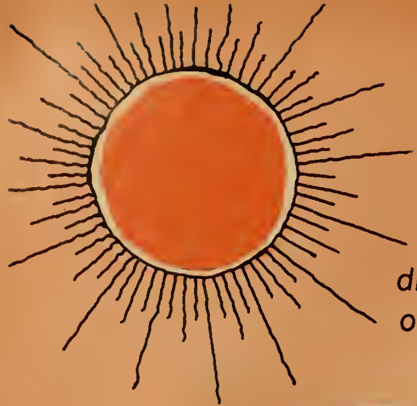
Mystery Photo: The mountain of metal globes was photographed in a Navy yard. The balls are used as floats for a mine net.

What will happen if? When milk is left out of the refrigerator for a few weeks, it usually separates into a thick, white *curd* at the top, and watery, clear *whey* at the bottom. What other liquids will separate when they are not refrigerated?

Can you do it? One way to make an egg float is to add salt to the water, making the water more dense. What else could you put into the water to get the egg to float?

Fun with numbers and shapes: A 20-pound fish weighs 10 pounds plus half its weight.

For science experts only: The pitch of a piano string is determined by its thickness, as well as by its length. The longer strings in large pianos are thinner than the corresponding strings in small pianos. Tightening or loosening a string also changes its pitch. Does tightening make a string sound higher or lower?



You can give certain plants different amounts of daylight and...

MAKE FLOWERS BLOOM WHEN YOU WANT THEM

by Richard M. Klein

■ Have you ever wondered why crocuses bloom only in the springtime, black-eyed Susans flower only in midsummer, and chrysanthemums bloom in autumn? Most of us can make lists of plants that bloom only in the spring, or the summer, or the fall. Many important food crops, such as spinach, sugar cane, soybeans, and wheat, are in flower at only one special time during their growing season.

Botanists, too, have wondered about this striking ability of plants to "know" just when to flower. The biggest advance in our understanding of flowering was made almost by mistake. In 1920, two scientists working for the United States Department of Agriculture, in Maryland, were trying out breeding experiments on a new, giant variety of tobacco. The plants grew to be about 10 feet high, but they never formed flowers. When the scientists, Dr. Willard Garner and Dr. Harry Allard, transplanted cuttings from the plants into a greenhouse, the plants developed flowers in the winter.

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

The two scientists decided to see if they could find out why this kind of tobacco didn't flower in the late summer like most other kinds of tobacco. They first tested the effects of different strengths (intensities) of light, and different temperatures, but the plants did not flower. Then they tried to see if the amount of water, or the minerals in the soil, or combinations of these caused the tobacco to flower. All of their experiments failed.

One Last Experiment

Simply because they didn't know what else to do, they decided to change the number of hours per day during which the plants received light. This is really an easy thing to do. The "day" length can be increased by turning on electric lights over the plants. The day length can be shortened by covering the plants with light-tight covers.

Drs. Garner and Allard found that as long as the tobacco plants received the number of hours of light that is common in the summer, no flowers developed. But when the day length was about as short as it is in the winter, flowers developed even on very small plants of giant tobacco. The scientists called this kind of tobacco a *short-day* plant.

In another series of experiments, the two scientists planted many soybeans. They planted some in the early spring, some in late spring, some in early summer, and some in late summer. They thought that by this method they would be able to have flowering plants for their experiments all during the year. To their amazement, all of the soybean plants flowered at exactly the same time—in the early fall. It seemed that soybeans, like the giant tobacco plants, were short-day plants.

What about Summer-Blooming Plants?

Drs. Garner and Allard wondered if plants that normally flower in the middle of the summer (when the days are long) might also be affected by the length of the days. They tried to make some summer-flowering plants bloom in winter by giving them a long day-length. For several months, the plants were placed under lights from dusk until late at night. Sure enough, the summer-flowering plants bloomed in winter. The scientists called the plants *long-day* plants. These plants include beets, lettuce, black-eyed Susans, and potatoes.

Finally, the scientists found that some other kinds of plants would flower any time that they were big enough. Called *day-neutral,* these plants do not require any particular day length to start blooming. Tomatoes, dandelions, corn, and a number of tropical plants, such as oranges and mangoes, are day-neutral plants. They form flowers at any time of the year.

Scientists throughout the world became interested and excited about these discoveries. They began experiments of their own to learn more about how day length affects plant flowering, or "photoperiodism" (*photo* = light; *period* = time). They discovered that not all plants of the same species have the same day-length requirements for flowering. Some tobacco varieties, for example, are long-day plants, while others are short-day plants, and still others are day-neutral. The scientists also found that most plants have to be above a certain minimum size and have to be growing well before they will bloom. When you grow plants in poor soil, or in very cold or hot temperatures, even giving them the proper number of hours of light per day will not cause the plants to bloom.

Knowledge about photoperiodism of plants is being used to delay or speed up the blooming of certain flowers in greenhouses. For example, poinsettias, which normally bloom in September, are kept under long-day lighting until shortly before Christmas. Then they are exposed to the normal winter day-length, and bloom in time to be sold for Christmas. The same procedure is used in greenhouses where vegetables are grown for the winter market ■

For more information about plants and plant experiments, look for these books in your library or bookstore: **Play with Plants** (1949, $2.78) and **Plants That Move** (1962, $2.95), both by Millicent Selsam, William Morrow and Co., New York; **Discovering Plants, A Nature and Science Book of Experiments,** by Richard M. Klein and Deana T. Klein, Natural History Press, Garden City, N.Y., 1968, $4.50.

INVESTIGATION

Here is a summer research project on photoperiodism you can try. First, buy seeds of one or more short-day plants and seeds of one or more long-day plants from a garden store or seed company. Some short-day plants that can be grown in pots are cosmos, amaranthus, and dill. Four good long-day plants are the dwarf shasta daisy, petunia, dwarf French marigold, and moss campion.

Plant about two dozen seeds of a short-day plant in each of two large clay pots filled with soil. Label each pot with the name of the plant and the planting date. Also start two pots of a long-day plant, and label them. Follow the directions for planting that are on the seed package. The seeds will germinate and form seedlings in about a week to 10 days. Record the date when the plants appear above the soil. Water the pots every few days, but don't overwater them.

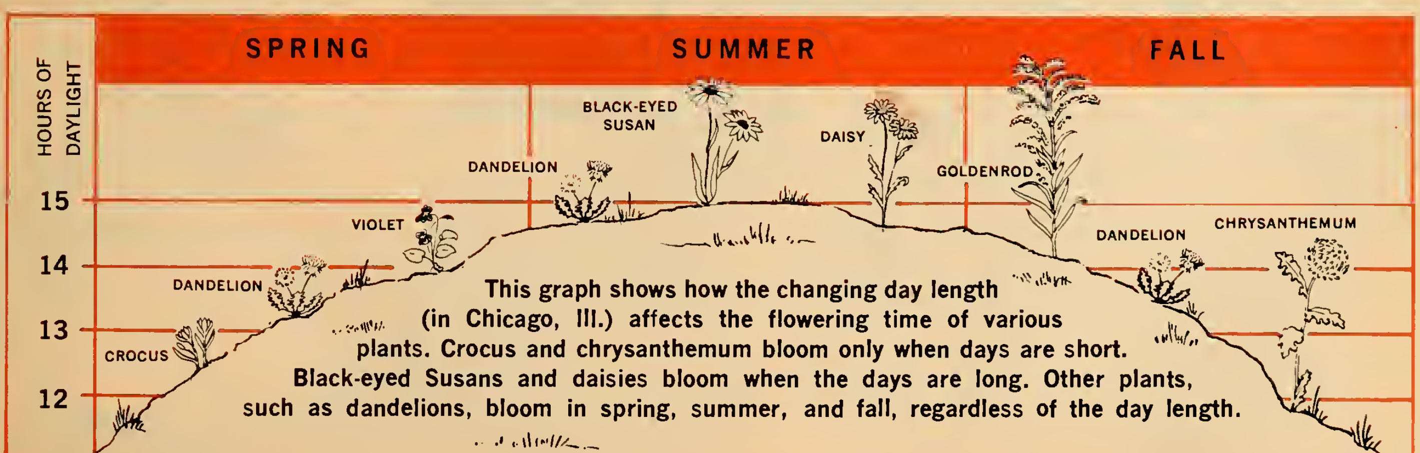
When the young plants are about two inches tall, pull out any that are very small or very large so that you will have 10 plants of the same size in each pot. Keep all of the pots in a place where they receive as much sunlight as possible.

When the plants are about four weeks old, you can start your investigation. Remember that the summer days in North America are long days, averaging about 15 hours of sunlight a day from June through early August. This means that the short-day plants will not normally flower until the days become short in late August or September. To cause them to flower in the middle of the summer, you must reduce the number of hours of light they receive each day.

To do this, take a cardboard box tall enough to cover one of the pots completely. Make sure that it is light-tight by binding all of the edges and seams with black tape. Use the box to cover one of the pots of short-day plants and leave the other pot—the "control" plants—exposed to long days. Cover the experimental pot at about 5 or 6 o'clock each evening and remove the box each morning between 7 and 9 o'clock. This must be done every day for at least 10 days to two weeks.

After the plants have been covered and uncovered for about two weeks, flowers will appear in another two weeks or so. Did the "control" plants exposed to long days (the uncovered pot) form any flowers? Will they form flowers if you leave them growing into the early fall?

The two pots of long-day plants that you left in the natural long days of summer should flower. Can you think of a way to stop them from flowering? What would happen if you covered one pot with a box so that the plants received only about nine hours of light each day?



This graph shows how the changing day length (in Chicago, Ill.) affects the flowering time of various plants. Crocus and chrysanthemum bloom only when days are short. Black-eyed Susans and daisies bloom when the days are long. Other plants, such as dandelions, bloom in spring, summer, and fall, regardless of the day length.

Way-Out Ways to the Moon

Going to the moon may seem like a fairly new idea, but it isn't. For at least 1,800 years, writers have been dreaming up ways to reach the moon—ways that mixed a little science with a lot of imagination.

Some writers pinned their hopes on natural forces. For example, about 160 A.D. a Greek writer named Lucian described a ship being lifted to the moon by a whirlwind. In 1621, the English dramatist Ben Jonson wrote that a Greek philosopher named Empedocles leaped into a volcano, and the smoke "whift him up to the moon."

Bird power was also popular among writers as a means of reaching the moon. In Francis Godwin's *Man in the Moon*, published in England in 1638, the hero trained wild birds to carry him through the air. They took him to the place where they "hibernated"—the moon.

This Wall Chart shows some of the most "way-out" ways to the moon described by writers of the past. Can you explain why none of them would have worked?

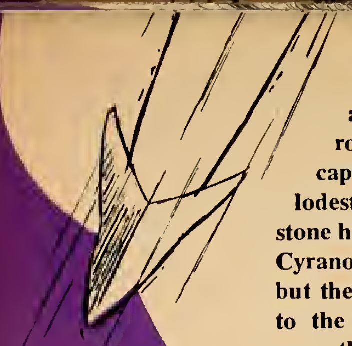
—Roger George

In *Voyage to the Moon*, published in 1650, the French writer Cyrano de Bergerac told how he strapped bottles filled with dewdrops to his body one night, then rose with the dew as the morning sun beamed down on him. To keep from rising past the moon, he broke some of the bottles — and fell back to earth. (Cyrano's many ideas for getting to the moon were included in the famous play about him written by Edmund Rostand.)

The Persian poet Firdausi wrote in 1010 that a king had four eagles captured, fed on meat to make them strong, then tied to the base of a throne. When the king sat on the throne and

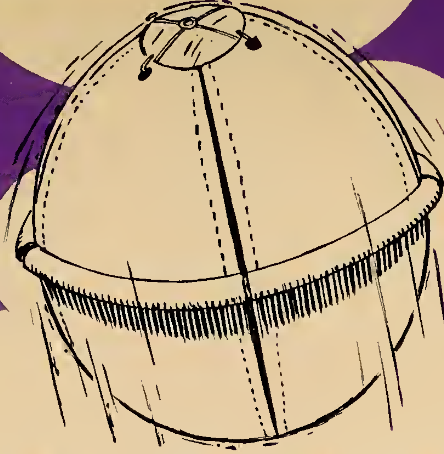
to earth.

Cyrano also suggested



sule shaped like a compass needle and made of thin iron, he would throw a *lodestone,* or magnetic rock, into the air. When the capsule was drawn up to the lodestone, he would throw the stone higher, and so on to the moon. Cyrano's ideas were written in fun, but the one he claimed carried him to the moon (*see cover*) showed more than a spark of promise.

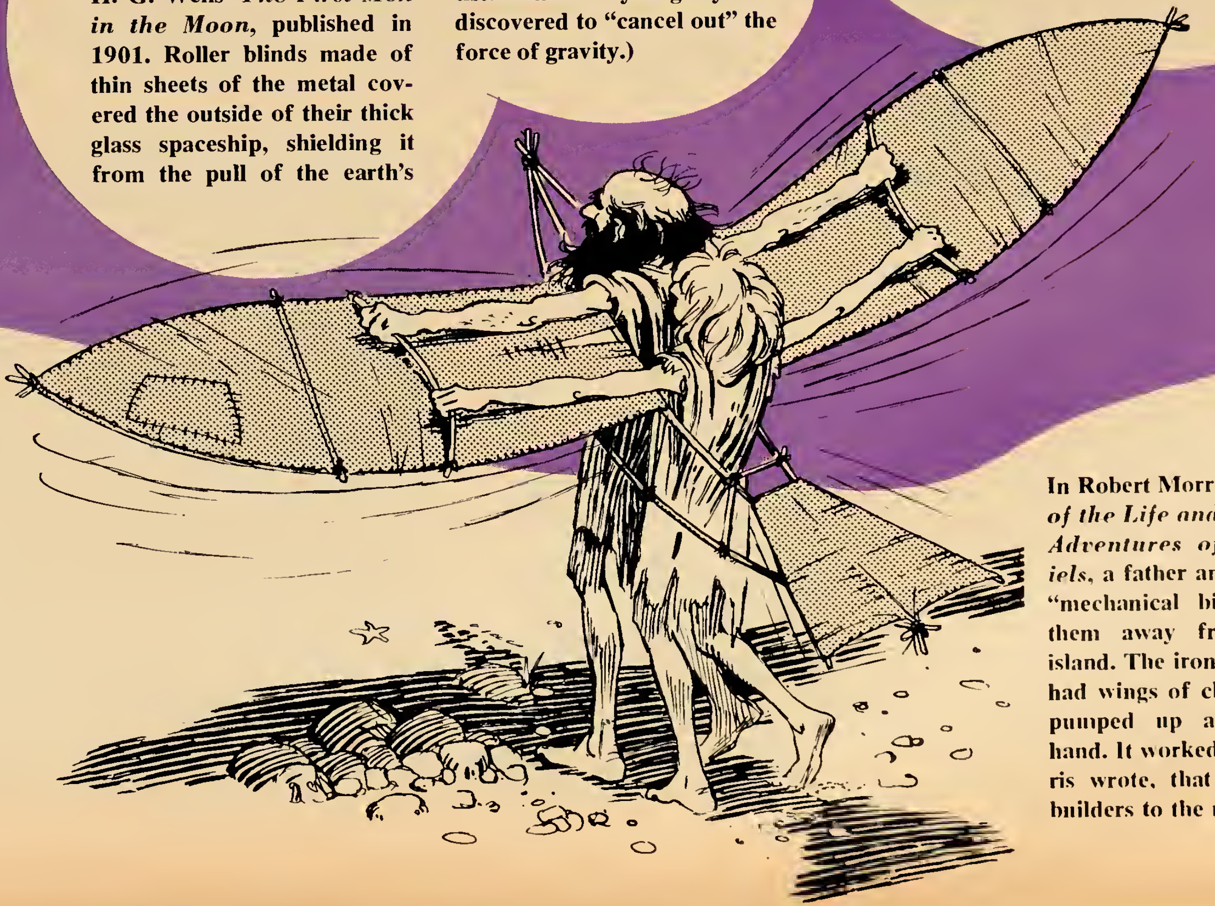
the eagles got tired and the throne dropped back to earth.



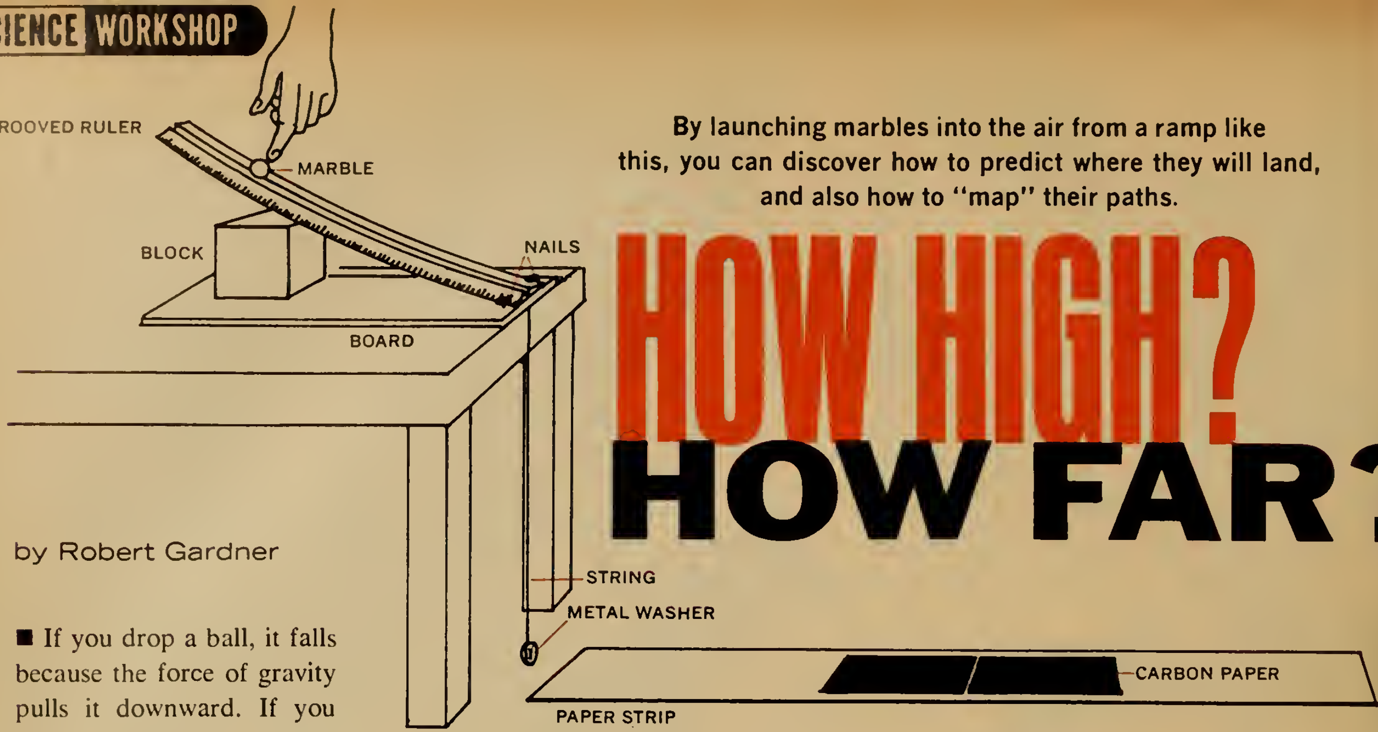
In 1670, an Italian philosopher-scientist named Francesco Lana proposed a boat with four large, hollow, metal globes attached. Pumping the air out of the globes would make the boat lighter than air and lift it moonward. However, he couldn't find a metal that was light in weight and yet strong enough to keep from collapsing when air was pumped out of the globes.

A metal that blocked the pull of gravity helped two men to go to the moon and back in H. G. Wells' ***The First Men in the Moon,*** published in 1901. Roller blinds made of thin sheets of the metal covered the outside of their thick glass spaceship, shielding it from the pull of the earth's gravity. An open blind on top exposed it to the pull of the moon's gravity. (Some scientists think a way might yet be discovered to "cancel out" the force of gravity.)

In Jules Verne's novel, ***From the Earth to the Moon,*** published in 1865, a 10-ton spaceship carrying three men was shot moonward from a 900-foot-long underground cannon. Padded couches protected the men from the shock of launching, and "water buffers" shielded the ship from the heat of air friction. The ship circled the moon and returned safely to the earth. (The cannon, oddly enough, was placed in Florida, near what is now called Cape Kennedy!)



In Robert Morris's *Narrative of the Life and Astonishing Adventures of John Daniels,* a father and son made a "mechanical bird" to carry them away from a desert island. The iron-ribbed "bird" had wings of cloth that were pumped up and down by hand. It worked so well, Morris wrote, that it carried its builders to the moon.

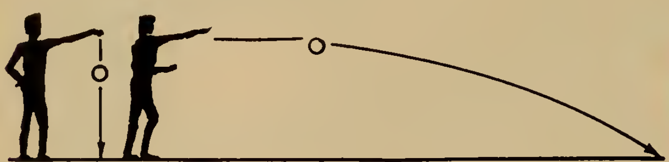


By launching marbles into the air from a ramp like this, you can discover how to predict where they will land, and also how to "map" their paths.

HOW HIGH? HOW FAR?

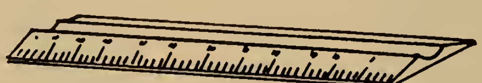
by Robert Gardner

■ If you drop a ball, it falls because the force of gravity pulls it downward. If you throw a ball, gravity also pulls on it; but while the ball is being pulled downward it is also moving away from you, so its path looks something like the one shown below.



If you throw a ball straight outward at the same time someone else drops a ball from the same height, which ball will hit the ground first? Here's a way to find out, and also to investigate the *trajectory*, or path, of an object that is launched into the air.

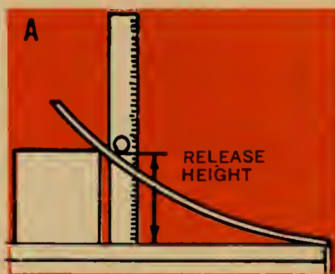
First build a ramp so that you can launch marbles or small steel balls in a horizontal direction. You will need a plastic ruler that has a groove running down the middle, from end to end *(see diagram)*. You can buy one at a



variety or stationery store. The groove will keep the ball or marble moving along the center of the ruler. You will also need a small board, several nails with broad heads, a hammer, and a block of wood. The diagram at the top of the page shows how to make a launching ramp.

Using the Ramp

Let a marble or a steel ball roll down the incline. What kind of path does it follow after it leaves the ramp? Try it again, but this time, at the instant the ball leaves the ramp, drop another ball from the same height as the end of the ramp. You may have to practice a while before you are able to drop the second ball at exactly the same time the other ball leaves the ramp. Do both balls land at the same time? Do you hear one "thud" or two as they hit the floor? Will it make a difference if the marble or steel ball that you drop is heavier or lighter than the one that comes off the ramp?



Let a marble roll down the ramp from different heights. Does this affect the distance that the marble travels in the horizontal direction? Can you explain why?

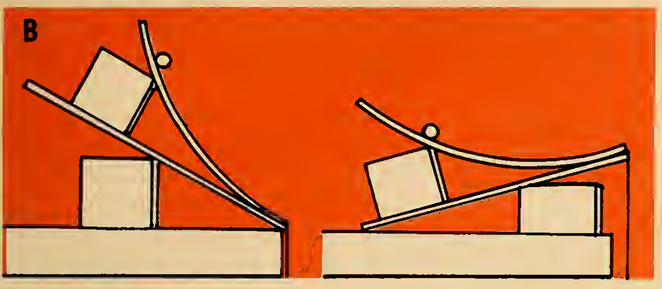
You can use a ruler to measure the height from which you release the marble, as shown in the diagram. To measure the distance it travels horizontally, hang a plumb bob (a washer on a string will work nicely) from the front edge of the board. Then tape a strip of paper to the floor and lay a sheet of carbon paper on the strip, carbon side down, to mark the spot where the marble lands. (If you have no carbon paper, you can ask someone else to watch closely and mark the place where the marble hits.) Measure the distance from that point to the plumb bob to find the horizontal distance that the marble or ball traveled during its fall.

If you double the height, does the horizontal distance that the ball travels also double?

Keep a record of the horizontal distances the ball travels when launched from different heights. A good way to do this is to make a graph like the one at the right. For example, suppose a ball released from a height of 4 inches on the ramp traveled a horizontal distance of 20 inches. You would mark an X on the graph where the line from the 4-inch mark at the side of the graph crosses the line from the 20-inch mark at the bottom *(see X on graph)*.

After you have *plotted,* or recorded, the results of four or five launches from different heights on the graph, draw a line connecting the centers of the Xs. What does it look like? Can you use the line on the graph to predict how far the ball will travel horizontally when launched from heights you haven't yet tried? Make a prediction for a particular height, say 3½ inches or 5 inches, then test it by launching the ball from that height.

Do you think that raising the launcher higher from the floor will change the horizontal distance the ball travels? To find out, place the launcher on a box on the edge of the table.



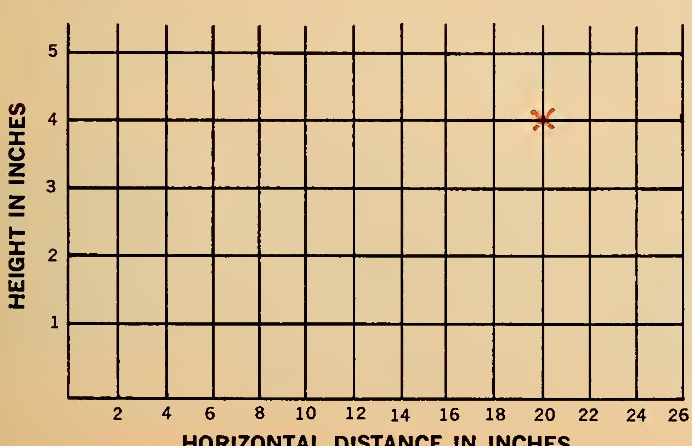
Use a block to tilt the ramp up or down.

Try tilting the ramp up or down, as shown above. (When the ramp is tilted, measure the launching height from the point where the ball is released to the level of the point where the ball leaves the ramp.) How does tilting the ramp affect the horizontal distance the ball travels? Do you think it changes the shape of the ball's path through the air?

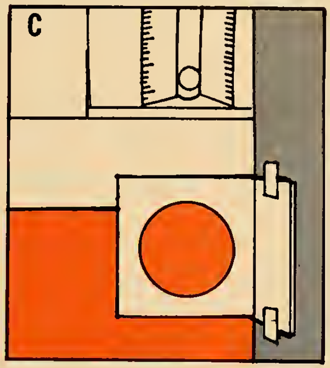
Mapping a Trajectory

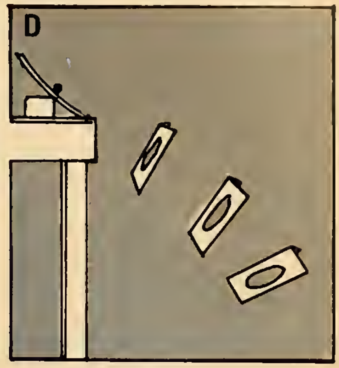
You can make a kind of picture of the path a marble follows from the ramp to the floor by placing paper "rings" where the ball will pass through them. Place the ramp next to a wall or door. Get four or five sheets of heavy paper or cardboard about 5 inches wide and 7 inches long. Near the end of each sheet cut a circle about 3 inches in diameter. Fold the cardboard so the center of the circle is as far out from the wall as the ramp *(see Diagram C).*

Tape one sheet of cardboard to the wall about three or four inches from the end of the ramp. Launch the marble a few times from the same height, moving the circle up or down until the marble goes through its center. Then do the same thing with another circle at five or six inches from the end of the ramp. Then at eight or nine inches, and so on. As the marble moves more and more in a downward direction, you will have to tilt the circles so the marble will pass through their centers *(see Diagram D).*



What will the path look like if you release the marble at a higher point on the ramp? At a lower point? Will a ping-pong ball released at the same height on the ramp as the marble follow the same path? Try it and see if you can explain what happens. How about different-size marbles? ■





Some Things To Try and To Think About

● What would happen if you were walking along a level surface and you let a bouncy ball fall from the end of your hand? Would it bounce back up so you could catch it, or would it bounce up behind you as you continued to walk forward? Try it and see. If you stop walking the instant you release the ball, will you be able to catch the ball on the rebound?

While riding a bicycle, try to drop a ball or stone so that it hits a target on the ground. Where must you release the object to hit the target?

● A man is standing on the rear platform of a train that is going 40 miles per hour. At the instant he passes you, the man throws a ball backward at a speed of 40 mph. From where you stand beside the tracks, what path will the ball follow?

● On the surface of the moon the pull of gravity is only about one-sixth as strong as the pull of gravity at the earth's surface. If you took your ramp to the moon and mapped the path of a marble launched from it, how do you think it would compare with the path the ball followed on earth? Can you guess what it would be like to play baseball on the moon, where the force of gravity is weaker and there is no atmosphere?

● In what direction would you throw a ball to make it land the longest distance away from you? Straight out (⟶)? Up slightly (⟶)? Halfway up (↗)? Almost straight up (↑)?

WHAT'S NEW

by
B. J. Menges

Worldwide poisoning of our environment could result from the continued use of DDT, a substance commonly used to kill insects. At a recent meeting in Madison, Wisconsin, some scientists explained why.

DDT is a combination of several chemicals. Separately, these chemicals aren't particularly harmful; but when combined, they are a poison. After DDT has been used, it doesn't break down into its original parts. It lingers for years as a poison in the air and water, and gradually builds up in the bodies of men and other animals. The scientists pointed out that there are other good insecticides that *do* break down into harmless substances after use, and they are urging DDT manufacturers to switch their production to these safer insecticides.

Most beetles fly with their hind wings and hold their front wings straight out like airplane wings *(Photo A)*. But certain beetles that live in Florida and Arizona are different. Their front wings are locked together permanently over the back of the body *(Photo B)*. (In Photos A and B, you can see the wires that are used to hold the beetles.) Why are these beetles different?

Two scientists—Robert E. Silberglied of Harvard University, in Cambridge, Massachusetts, and Thomas Eisner of Cornell University, in Ithaca, New York—believe they know the answer: The front wings of these beetles are brightly striped, and in their locked position over the beetle's back, the wings look like the abdomen of a bee or wasp *(Photo C)*. And because the beetles use only their hind wings for flying *(Photo B)*, they resemble bees and wasps in flight. (Though bees and wasps use all four wings to fly, the two on each side are hooked together and beat as one.)

The beetles surely benefit from this resemblance, say the scientists. The defenseless beetles are probably often mistaken for bees and wasps, and thus not attacked, by other animals that would normally prey on beetles.

Astronauts are going under water to train for work in space. A sense of weightlessness, such as men feel in space, is hard to achieve here on earth. But engineers at the National Aeronautics and Space Administration have found a way. They built a large, 40-foot-deep tank where men practice "space tasks" under water. The men wear suits filled with air under pressure. Once in the water, the men attach weights to themselves so that the air-filled suits won't make them float. When just the right balance is reached and the men neither rise nor fall, "weightlessness" results.

One astronaut who had been on an actual space trip said conditions in the tank did resemble those in orbit. Knowledge gained in this underwater training will be useful in the early 1970s, when astronauts are expected to build a space station in orbit.

Rats have learned to make their hearts beat faster or slower, and men have learned to raise or lower their blood pressure. In two separate experiments, scientists have shown that an animal can regulate some body processes that were thought to be automatic, and not under an animal's control.

Dr. Neal E. Miller of Rockefeller University, in New York City, trained rats by giving them a reward whenever their hearts beat faster or slower. The rats learned to change their heartbeat rate by 20 per cent. Dr. Miller and his staff also taught the animals to control their blood pressure and other body processes in the same way. A team of scientists at Harvard Medical School, in Boston, Massachusetts, used rewards to train college students to control their blood pressure. The ability of a person to control some "automatic" body processes may be useful in preventing and treating heart disease and other illnesses.

We're running out of places to hide our refuse, says Dr. James E. Etzel, a sanitary engineer at Purdue University, in Lafayette, Indiana. When we pour sewage into rivers and lakes, we pollute the water. To avoid this, we can treat the sewage to remove the solid wastes. But it's hard to get rid of these solids, plus all the trash from modern living. Most solid material can be burned, but this pollutes the air. And dumping is no answer unless we're ready to turn our countryside into one big trash heap.

Is there an answer? Dr. Etzel thinks so: Equip all homes and buildings with "super-grinders" that would grind up all solids, including metals, into tiny particles; then carry the particles through sewers to a disposal plant. There, kill all harmful germs in the ground-up material, and use part of the material as fertilizer to enrich the land. The metals, perhaps, could be removed from the material and used again.

The killer whale is a fearless attacker of walruses, seals, and even the largest whales. But killer whales caught by man have been found to be gentle and friendly, even allowing men to pet and train them. Dr. Paul Spong of the Vancouver Public Aquarium, in British Columbia, Canada, hopes to take advantage of these characteristics by teaching killer whales to work with man in studies of the sea. (Some porpoises have already been trained to do this.)

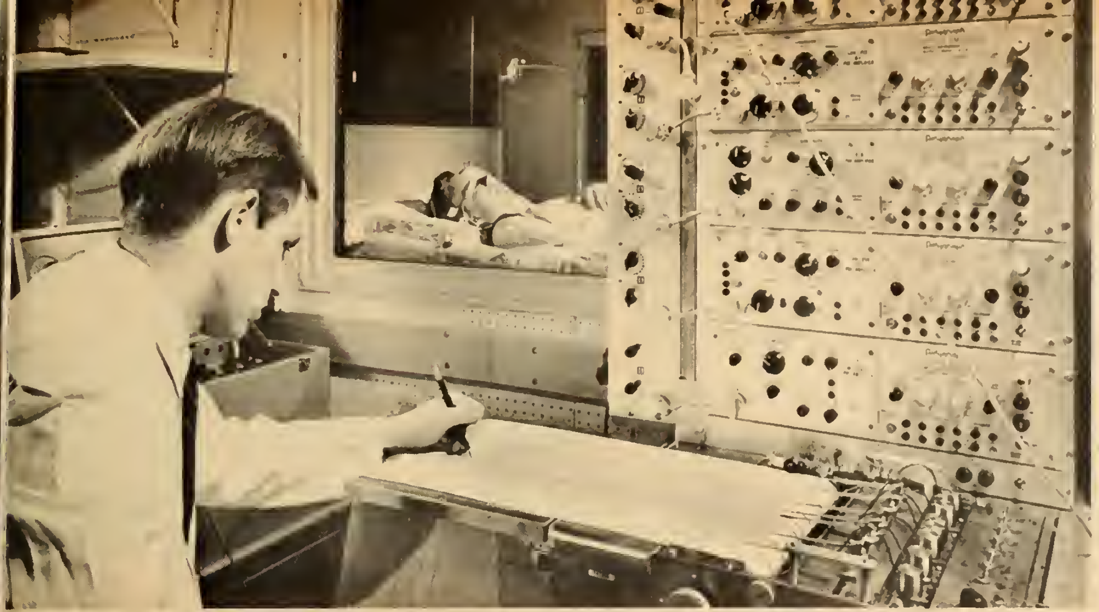
Dr. Spong is observing killer whales that live in net pens off the western coast of Canada, where they were caught. He has found that they are very intelligent and can learn to perform certain tasks on command. Electronic equipment has picked up sounds from the whales that may be part of a "language" they use to communicate with each other.

A

B

C

WASP ABDOMEN BEETLE WINGS



In a sleep laboratory, a scientist works all night as the electroencephalograph records changes in the brain waves, eye movements, and other body processes of a volunteer sleeping and dreaming in the next room.

How Do We Dream?

An accidental discovery and an electronic machine are helping scientists investigate this age-old question.

by Margaret E. Bailey

■ How and why we dream in our sleep is a mystery that has puzzled just about everyone at one time or another. Many different explanations have been suggested down through the ages. Dreams have been described, for example, as magic spells, as messages from "the gods" or from our consciences, as warnings of things to come, and as wishes that we have but don't think about while we are awake.

Such explanations of dreams are still believed by many people, but there is no way to test them and prove whether they are either correct or incorrect. For example, even if you dream about something that later happens, how can you be sure that there is any connection between your dream and what happens? After all, you probably dream about many things that do not happen.

The trouble is that, until recently, the only way to investigate dreaming was by studying what people dream about. And even that depends on what they remember about a dream after they wake up. Few scientists were trying to solve the mystery of dreaming until an accidental discovery suggested a new way of trying to find out how we dream.

From the Eyes of Babes

One afternoon in the early 1950s, Eugene Aserinsky, then a graduate student at the University of Chicago, was studying the sleep habits of babies. He noticed a strange thing. After the babies went to sleep, their eyes kept moving under their closed lids.

The eye movements would stop and then start again from time to time. Aserinsky and Dr. Nathaniel Kleitman, his professor, decided to see whether adults' eyes moved while they were asleep. They found that everyone they tested moved his eyes during certain periods in his sleep. The scientists called these eye wiggles *Rapid Eye Movements,* or *REM*s.

PROJECT

Ask a friend to close his eyes and "look" to the left and right, shifting his eyes rapidly back and forth. Can you see the movements of his eyes through his closed lids?

To help detect these eye movements, Aserinsky and Dr. Kleitman used a machine called an *electroencephalograph (see photo).* The machine was invented to record *brain waves,* the tiny electric currents that constantly change in strength as they flow through our brains.

The machine has several wires, each with a metal disc at one end. Each disc is glued or taped to a different place on a person's head so that it picks up, or *detects,* changes in the electric current in that part of the brain. The wire carries these electrical signals to the machine, where they are *amplified,* or made stronger, then used to move a pen back and forth on a moving strip of paper. The zigzag line drawn by the pen is a "picture" of the brain waves at one place in the person's brain *(see diagrams on next page).* The picture is called an *electroencephalogram,* or EEG.

(Continued on the next page)

1. A volunteer is "wired for sleep" at the State University of New York's Downstate Medical Center, in Brooklyn. 2. Professor Cohen *(left)* and Dr. Shapiro study the lines being drawn by the EEG machine to see which stage of sleep the subject is going through. 3. Waked from the Rapid-Eye-Movement stage of sleep, the subject reports that she had been dreaming when the phone woke her up.

How Do We Dream? (continued)

Dr. Kleitman and Aserinsky also attached wires from the machine to the outer corner of each eye of the person they were testing *(see photo)*. When the eye muscles pulled his eyes rapidly from left to right and back, electric signals were detected and recorded by pens in the same way the person's brain waves were recorded.

The scientists found that when they awakened a person while he was having Rapid Eye Movements, he usually said that he had been dreaming. When sleepers who were not having REMs were awakened, they usually did not report that they had been dreaming. It seemed that Rapid Eye Movements and dreams were connected in some way. But scientists still do not know just how.

The "Stages" of Sleep

In 1953, William Dement began working with Dr. Kleitman, and they decided to take continuous electroencephalograph readings of sleepers through a whole night. (The chart for each sleeper used about 800 feet of paper in a single night!)

By studying the EEG patterns of many sleepers, the scientists discovered that there seem to be four different stages of sleep, and that during each night a person "moves" back and forth through the different stages.

When a person first drops off to sleep, his eyes stop moving, and his breathing and heartbeat begin to slow down. He is now in Stage 1 sleep. This is the "lightest" stage of sleep, during which the slightest sound may wake a sleeper.

After a while the sleeper passes into Stage 2 (still a light sleep). New types of brain waves appear on the EEG. The sleeper's heartbeat and breathing keep slowing down.

Stage 3 is next. The sleeper has a very slow brain-wave pattern. He is going into deep sleep. In Stage 4, his heartbeat and breathing are usually slower than at any other time. His body is quiet, and his eyes are usually still.

After Stage 4 the sleeper starts a return trip. He goes back to Stage 3 and then to Stage 2. Then comes the most unusual stage of all. This next stage is a different kind of Stage 1 sleep.

The sleeper's eyes, which were quiet during the first Stage 1, begin to dart around. The sleeper is having Rapid Eye Movements. If you wake him, he will probably say he has been dreaming. The sleeper's heartbeat and breathing may become faster, too. This new kind of Stage 1 sleep is called REM sleep, because it is in this stage that almost all Rapid Eye Movements occur.

After this first REM period, the sleeper starts off on his second "trip" of the night. He goes back through the deeper stages of sleep—Stage 2, Stage 3, and Stage 4. Then

In Stage 1 sleep, the EEG lines show that the sleeper's brain waves are weak, but changing rapidly; his eyes are moving very little. In Stage 3, the brain waves change more slowly, but reach higher peaks; the sleeper's eyes are rolling slowly. When the sleeper drifts back into Stage 1, his brain waves are rapid but weak. The two top lines show Rapid Eye Movements (REMs), as if he were looking at something. The sleeper is probably dreaming.

3

he comes back for another REM period. All adults take these sleep trips from four to six times every night. Each back-and-forth trip lasts about an hour and a half.

Are REMs Necessary?

Since everyone they tested had Rapid Eye Movements and dreams every night, the scientists thought that both REMs and dreams must be necessary to humans. Dement decided to see what would happen if he awakened a sleeper each time the EEG showed that a Rapid-Eye-Movement period was starting. Then he would let the person go back to sleep. In this way, the person would get all of his usual kinds of sleep except for REM sleep.

Dement tried this with a number of persons. The first few nights a person was being tested, he would start to have Rapid Eye Movements the usual four-to-six times a night, and each time Dement would wake him. After several nights of this, the person would begin to have REMs eight or more times a night. Sometimes he would go right from waking into REM sleep. (This does not usually happen with adults, though it sometimes does with babies.)

In these tests, the longer a person was kept from getting his REM sleep, the oftener he tended to slip into that stage of sleep each night. It seemed that REM sleep is something a human "needs."

REM sleep is often called "dreaming sleep," because sleepers who are awakened in that stage so often say they have been dreaming. But people who are awakened from other stages of sleep sometimes report that they were having "thoughts" or "experiences" that could probably also be called dreams.

A Busy Night's Sleep

Two of the many scientists who are now investigating how we dream are Dr. Arthur Shapiro and Professor Harvey Cohen, both of the Department of Psychiatry of the State University of New York's Downstate Medical Center, in Brooklyn. These two scientists think that in dreams our minds take the day's experiences and compare them with all the experiences we have ever had. Going over the day's experiences in dreams probably helps us pick out important things to remember.

Dreaming about these important ideas or events could be like learning to spell words: You spell the words over and over to yourself, and then you can remember them. Dr. Shapiro and Professor Cohen think we are "practicing" important ideas in our dreams so we can remember and use them in the future. *(Continued on the next page)*

Investigating REM Sleep

Have you ever heard a sleeping dog growl or whine, and perhaps seen its forepaws or head move about, as if the animal were dreaming? Scientists believe that most other animals have some kind of dreams, though probably not the same kind that humans have. We can't be sure, of course, because a dog or cat, for example, can't tell us. But by watching the eyelids of a sleeping cat or dog, you may be able to tell when it is in the REM stage of sleep.

Use a watch with a sweep second hand to time how long the animal's periods of REM sleep last. How much time passes between its periods of REM sleep? How many times during a "nap" does the animal seem to go through this stage of sleep? Are the periods spaced regularly throughout the nap, or does the animal have more REM sleep periods, say, near the beginning or end of its nap?

You might try waking the animal during a period of REM sleep, and at another time when it seems to be in a deeper stage of sleep. Does it take a louder noise to wake it in one stage or the other? Does the animal seem to wake up quicker from REM sleep? Do the animal's periods of REM sleep follow the same pattern whenever it sleeps, or a different pattern during different naps? If you have a baby brother or sister, you might study his or her sleeping habits in the same way (except for waking the baby, of course).

How Do We Dream? (continued)

Dr. Shapiro suggests that during the day we do not have time to practice or sort out our experiences, because we are too busy taking in new ideas and experiences. But at night as we sleep, we "tune ourselves out" from the outside world. We stop taking in information. Then, he thinks, our minds go to work on all that we have learned that day.

Our bodies get a workout during dreaming, too. During Rapid-Eye-Movement periods our eyes dart around, and our heartbeat and breathing may become more rapid. Dr. Shapiro thinks our bodies are "practicing," too.

This idea came partly from Dr. Howard P. Roffwarg, of Columbia University, in New York City. He found that babies born when they have been growing inside their mothers for less than nine months *(premature babies)* spend a great deal of time in Rapid-Eye-Movement sleep. Dr. Roffwarg thinks that all babies probably have REM sleep even before they are born.

"The baby can't see before it is born," explains Professor Cohen, "but we think it may practice moving its eyes with Rapid-Eye-Movement sleep. This prepares the baby's eyes to see when it is born. REM sleep should help the baby's heart and lungs develop before birth, too."

Dreaming is a very complicated process, Dr. Shapiro and Professor Cohen point out, and no one theory tells the whole story at this time. Like many other scientists who are now investigating this age-old mystery, they believe that understanding why we dream will help us understand our feelings and other behavior better than we now can. We may also learn more about how to detect mental illness, why some people have trouble sleeping, and why certain diseases such as asthma or ulcers so often attack people at night ■

What Good Is REM Sleep?

Scientists have found that dogs, cats, sheep, rabbits, mice, monkeys, and opossums go through periods of Rapid-Eye-Movement sleep; they suspect that this may be true of all mammals. But tests show that reptiles and amphibians, such as snakes and frogs, do not have REM sleep. Mammals developed from reptiles between 100 and 200 million years ago, and some scientists think that REM sleep may be a *characteristic* (see *"Big Bills, Little Bills," on page 4)* that has helped mammals to survive.

The opossum, for example, was one of the earliest mammals to appear on the earth. Its ancestors lived in the age of the dinosaurs, and fossils show that they were not very different from today's opossums. Dr. Frederick Snyder, of the National Institute of Mental Health in Bethesda, Maryland, points out that opossums spend nearly one third of their 18-to-20 hours of daily sleep in the Rapid-Eye-Movement stage.

In the REM stage, an animal's heartbeat and breathing are nearly the same as when it is awake, and a human or other animal wakes much more rapidly from REM sleep than from a deeper stage of sleep. In fact, laboratory tests show that humans and other animals often wake up briefly after a short period of REM sleep, then go back to sleep.

Dr. Snyder suggests that by going through frequent periods of REM sleep, an animal can get all the sleep it needs with less chance that it will be caught in deep sleep by another animal. So an animal with this characteristic would be more likely to survive long enough to breed and pass the characteristic along to its offspring than an animal that does not have REM sleep. Through this process of *natural selection* (see *"Big Bills, Little Bills")*, REM sleep may have originated with the earliest mammals and been passed along to other mammals—including humans—in the process of evolution.

FOR DREAMERS ONLY (THAT INCLUDES YOU)

• Do you often wake up thinking that you haven't dreamed at all during the night? Try setting your alarm clock to wake you half an hour earlier than usual some morning. When the alarm goes off early, there is a good chance that you will wake up in the midst of a dream and remember it. Scientists believe that everyone dreams, but that some people remember their dreams better than others do.

• If you seldom remember dreaming, try this for several mornings in a row. When you first wake up, lie still and think about the first thing that pops into your mind. This thought may have something to do with the last dream you had before waking. Then you may be able to remember the whole dream.

• Try keeping a dream diary for a whole month. When you wake each morning, write down all the dreams you remember having during the night. From time to time, read all of the dream descriptions and look for certain subjects or ideas that you dreamed about more than once. Do you think that what you do and think about during the daytime has any effect on your dreams?

• Scientists and other people sometimes report that they have solved a problem in their sleep. You might try this with a homework problem you haven't been able to solve. Before you go to sleep, think over the problem. Because your mind is active even while you are sleeping, it may continue to work on the problem as you sleep. It is possible that you may wake up the next morning with a new idea for solving the problem.

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time, and (2) the rolled marble travels different horizontal distances from the edge of the desktop when it is launched at different speeds. They can see that the marble's trajectory is shaped by the amount of horizontal motion it is given in launching and by the amount of vertical motion it gets from the pull of the earth's gravity.

- This is a good opportunity to explain the difference between *speed* and *velocity*. The speed of an object is the distance it travels in a given period of time, say one second. The *velocity* of an object is its speed *in a particular direction*. When a marble is released and falls straight downward, it starts with zero speed and velocity and gains speed and *vertical velocity* at the same rate as it falls faster and faster (accelerated by the pull of gravity). A rolled marble leaves the table with some *horizontal velocity*, but no vertical velocity. Its vertical velocity increases as it falls, but its horizontal velocity decreases slightly as the marble is slowed by air resistance. To find its *average speed* you would have to divide the length of its curved trajectory by the time it is in flight.

- Releasing the marble from different heights on the ramp provides controlled changes in the marble's horizontal velocity for investigation purposes. (Your pupils' findings will vary more if they use different ramps and marbles than if all use the same ones, because friction between the marble and ramp will vary with the equipment used.)

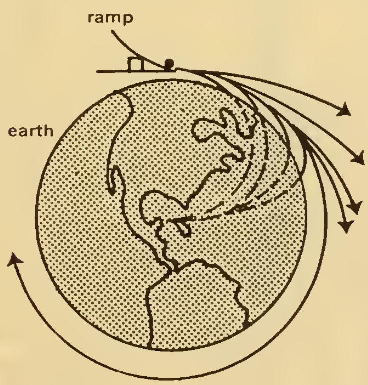
If your pupils have not used graphs before, have them record the horizontal distances the marble travels when released from different heights on the ramp. Then you can show them how to plot this information on a graph like the one on page 11, and how to use the graph to predict the horizontal distances for other release heights, and test their predictions.

Topics for Class Discussion

- *Why does an object with both vertical and horizontal velocities follow a curved trajectory?* Try to draw a straight line across a sheet of paper while someone pulls the paper straight outward from you. The pencil is moving with horizontal velocity, and the paper's motion gives the pencil "vertical" velocity. Will the pencil draw a straighter trajectory if it is moving across and down the paper at more nearly equal velocities?

- *How does raising the height of the ramp from the floor give the marble a longer trajectory?* The marble falls through a longer distance, giving it more time to travel in a horizontal direction before it lands.

- *If you launched a series of marbles with higher and higher horizontal velocities, what would happen to them?* The greater the horizontal velocity, the farther the marble would travel around the earth's curved surface before the ground stops it. With a horizontal velocity of about 18,000



miles per hour, it would travel beyond the "edge" of the earth and keep falling around the earth, or *orbiting* it *(see diagram)*. A horizontal velocity of about 25,000 miles per hour would more than equal the marble's downward vertical velocity, so it would travel out into space.

- *Why are spaceships launched in a vertical direction from the earth instead of horizontally (parallel to the earth's surface)?* A spaceship carries its own power, in the form of rocket engines that accelerate it, or thrust it ahead with increasing velocity. Launched horizontally, the ship would travel farther through the dense air at the bottom of the earth's atmosphere *(see "Discovering an 'Ocean' from the Bottom,"* N&S, *Nov. 11, 1968)* than if it were moving straight upward through the atmosphere. The horizontal path would use up more of the craft's power in overcoming air resistance than the vertical path does.

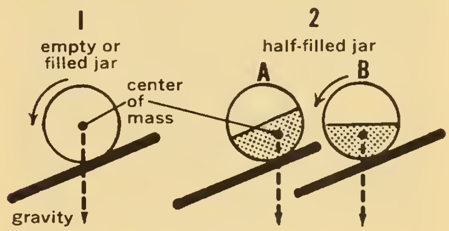
Brain-Boosters

Mystery Photo: The truck is used to collect money from parking meters. The long tube works like a vacuum cleaner to suck up the coins when the meter is opened.

What will happen if? Have your pupils see how a round glass jar rolls down a low ramp, or *inclined plane (see diagram on page 5)*, when the jar is: (1) empty; (2) filled with water; (3) half-filled with water; (4) filled with a *viscous*, or slow-flowing, liquid such as syrup (pancake syrup or Karo) or molasses; (5) half-filled with syrup or molasses. The jar will probably roll differently in each case. Can your pupils explain why?

Liquid in the jar tends to "resist" turning with the jar, and friction between the liquid and the inside surface of the jar slows down the jar's rolling motion. The more of the jar's inside surface that is touching the liquid, the greater the friction. And the "stickier" the liquid, the greater the friction. But that's not all !

When the jar is placed on the ramp, it is "off balance," because the place where it touches the ramp is not directly below the jar's *center of mass*



(angle of ramp exaggerated)

(see Diagram 1; also "Where's Your Balancing Point?", N&S, *Nov. 13, 1967)*. So the jar's center of mass, pulled downward by the earth's gravity, keeps falling—and pulling the jar around—until the jar reaches a place where its center of mass is supported against the pull of gravity. When the jar is empty or completely filled, its center of mass stays at the center of the jar. But when it is only partly filled, its center of mass lies within the liquid, below the center of the jar. As the jar

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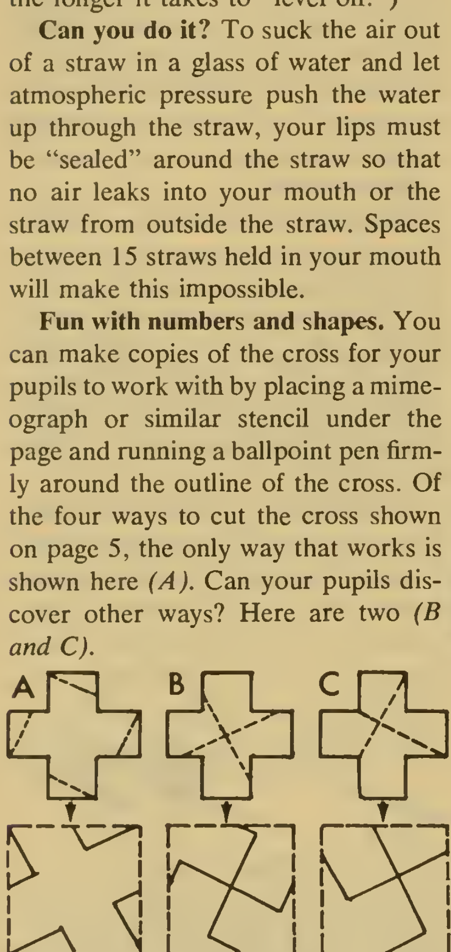
rolls and some of the liquid is pulled around with the jar, the center of mass shifts slightly to a position over, or nearly over, the place where the jar touches the ramp *(see Diagram 2A, page 3T)*. This slows or even stops the jar's "fall," until the liquid levels off and the center of mass shifts back to a position where it is no longer supported against the pull of gravity *(Diagram 2B, page 3T)*. (The "stickier" the liquid, the more it is pulled around by the jar, and the more viscous it is, the longer it takes to "level off.")

Can you do it? To suck the air out of a straw in a glass of water and let atmospheric pressure push the water up through the straw, your lips must be "sealed" around the straw so that no air leaks into your mouth or the straw from outside the straw. Spaces between 15 straws held in your mouth will make this impossible.

Fun with numbers and shapes. You can make copies of the cross for your pupils to work with by placing a mimeograph or similar stencil under the page and running a ballpoint pen firmly around the outline of the cross. Of the four ways to cut the cross shown on page 5, the only way that works is shown here *(A)*. Can your pupils discover other ways? Here are two *(B and C)*.



For science experts only. The flying bird's shadow on the ground is about the same size as the bird, because the rays of the sun that reach the earth are nearly parallel to each other. Your pupils can find the answer by holding a book at different heights in the sunlight and observing its shadow. (Can they discover this approach by themselves? A SCIENCE WORKSHOP on investigating shadows will be published in the next issue.)

nature and science
TEACHER'S EDITION
VOL. 6 NO. 16 / MAY 5, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Exploring Shadowland

Most of us find out at an early age how shadows are made, either by "experimenting" or by asking someone to tell us. From that point on, we tend to assume that we know all there is to know about shadows and simply take them for granted, even when we play shadow tag, make "animal head" shadows on the wall with our hands, or watch the complicated shadow pictures we call "movies." Investigating shadows as suggested in this article should restore to your pupils some of the curiosity and fascination that most of us lose at that early age when we first find out "all" about shadows.

Suggestions for Classroom Use

• You might have your pupils measure the length and direction of their shadows at different hours of a sunny school day or a sunny weekend at home. (A flagpole or fence post in an unshaded area makes a good stationary shadow-caster. The tip of the shadow can be marked each hour—with chalk on a paved surface or with stakes stuck into the earth.)

What makes the shadow point in different directions as the day goes on? The change in direction of the light source — the sun — from the object that casts the shadow. If your pupils express this as "the sun's movement across the sky," ask them whether the sun is really moving as it *appears* to be. The sun seems to be moving across the sky because the earth is rotating eastward, so light from the sun reaches the same spot on the earth from a constantly changing direction throughout the day. At noon the sun seems to be at its "highest" point in the sky, but the post still casts a shadow. By checking the direction of that shadow with a compass, your pupils can see that the sun is still south of the post, not directly overhead. The sun never shines straight down on the latitudes in which the United States is located, because of the tilt of the earth's axis *(see* N&S, *Jan. 20, 1969, page 1T)*.

With this in mind, your pupils can probably guess that the photo on page 4 was taken about noon, near the equator.

• Here's a way to help your pupils find out how to measure the height of a tree *(see first Project on page 2)*. Outdoors on a sunny day, have them hold a yardstick and a 12-inch ruler vertical to a flat horizontal surface, and side-by-side so their shadows do not overlap. Measure and record the length of each shadow. Dividing the length of the ruler's shadow into the length of the yardstick's shadow shows that the yardstick's shadow is three times as long as the ruler's—just as the yardstick itself is three times as "high" (when held vertically) as the ruler. Have your pupils do this at different times of day to see that however much the shadows "grow" or "shrink," the length of the long shadow divided by the length of the short shadow will always be equal to the height of the yardstick divided

(Continued on page 2T)

IN THIS ISSUE

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 complete set of 10 new Wall Charts reproduced and enlarged from the pages of *Nature and Science* (see page 4T).

We hope we will be able to serve you and your pupils again next fall.

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(continued from page 1T)

by the height of the foot ruler.

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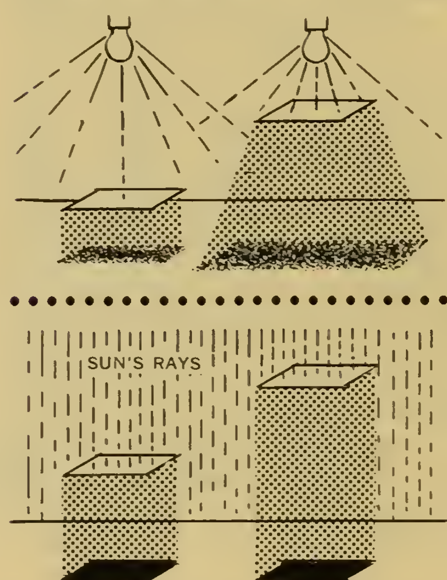

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nature and science
TEACHER'S EDITION

VOL. 6 NO. 16 / MAY 5, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Exploring Shadowland

Most of us find out at an early age how shadows are made, either by "experimenting" or by asking someone to tell us. From that point on, we tend to assume that we know all there is to know about shadows and simply take them for granted, even when we play shadow tag, make "animal head" shadows on the wall with our hands, or watch the complicated shadow pictures we call "movies." Investigating shadows as suggested in this article should restore to your pupils some of the curiosity and fascination that most of us lose at that early age when we first find out "all" about shadows.

Suggestions for Classroom Use

• You might have your pupils measure the length and direction of their shadows at different hours of a sunny school day or a sunny weekend at home. (A flagpole or fence post in an unshaded area makes a good stationary shadow-caster. The tip of the shadow can be marked each hour—with chalk on a paved surface or with stakes stuck into the earth.)

What makes the shadow point in different directions as the day goes on? The change in direction of the light source — the sun — from the object that casts the shadow. If your pupils express this as "the sun's movement across the sky," ask them whether the sun is really moving as it *appears* to be. The sun seems to be moving across the sky because the earth is rotating eastward, so light from the sun reaches the same spot on the earth from a constantly changing direction throughout the day. At noon the sun seems to be at its "highest" point in the sky, but the post still casts a shadow. By checking the direction of that shadow with a compass, your pupils can see that the sun is still south of the post, not directly overhead. The sun never shines straight down on the latitudes in which the United States is located, because of the tilt of the earth's axis *(see* N&S, *Jan. 20, 1969, page 1T).*

With this in mind, your pupils can probably guess that the photo on page 4 was taken about noon, near the equator.

• Here's a way to help your pupils find out how to measure the height of a tree *(see first Project on page 2).* Outdoors on a sunny day, have them hold a yardstick and a 12-inch ruler vertical to a flat horizontal surface, and side-by-side so their shadows do not overlap. Measure and record the length of each shadow. Dividing the length of the ruler's shadow into the length of the yardstick's shadow shows that the yardstick's shadow is three times as long as the ruler's—just as the yardstick itself is three times as "high" (when held vertically) as the ruler. Have your pupils do this at different times of day to see that however much the shadows "grow" or "shrink," the length of the long shadow divided by the length of the short shadow will always be equal to the height of the yardstick divided

(Continued on page 2T)

IN THIS ISSUE

(For classroom use of articles preceded by •, see pages 1T — 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 complete set of 10 new Wall Charts reproduced and enlarged from the pages of *Nature and Science* (see page 4T).

We hope we will be able to serve you and your pupils again next fall.

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

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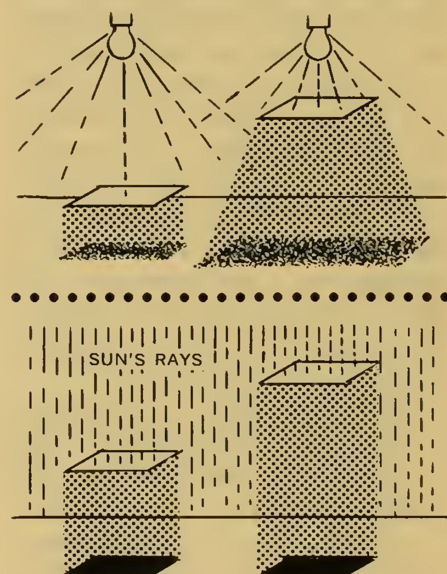

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For some new ideas about the ways dinosaurs lived

see page 11

THE DASHING DINOSAURS?

see page 2

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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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EXPLOR

How well do you know your shadow and the shadows of other things around you? Here's a way to get better acquainted.

by Robert Gardner

■ If you have ever played shadow tag, you know that yo can't run away from your shadow. It stays right beside yo as long as the sun shines. Is there any way you can los your shadow while you are standing in sunlight?

By investigating shadows as suggested here, you ma find an answer to that question—and to other question about shadows that you may never have thought of befor

Outdoor Shadows

The next time the early-morning sun beckons you out of-doors, look at your shadow. In what direction does i "point"? How long is it? Observe what happens to th length and direction of your shadow as noon approache and then as the sun moves toward the western horizon i the afternoon. Can you explain why the length and direc tion of your shadow change as the sun moves across th sky?

How does the direction of your shadow compare with th direction of shadows of other objects? Can you figure ou why shadows of different objects have different lengths?

PROJECT

How can you use your shadow and a yardstick to measure the height of a tree or flagpole?

Move your hand toward the sun and away from it, an see whether the size of your hand's shadow changes. Whe night comes, move your hand toward and away from a street or porch light, and see whether the size of you

IG SHADOWLAND

hand's shadow changes.

What happens to the length and direction of your entire shadow as you walk by a street or porch light? Can you explain the changes you observe? If so, you can probably explain why your shadow changes in size and direction as the sun moves across the sky.

Indoor Shadows

Do you think that shadows made with light from a light bulb are the same as shadows made in sunlight? Place a lamp with a frosted bulb on one side of a room, and use your hand to cast a shadow on the opposite wall. Move your hand closer to the light, then farther away from it, and see what happens to the shadow's size. When is it sharpest? When fuzziest?

Can you figure out why the shadow changes size when you move your hand closer to a light bulb, but not when you move your hand toward the sun? (Hint: The sun is so far away that the rays of sunlight that reach the earth are nearly parallel to each other.)

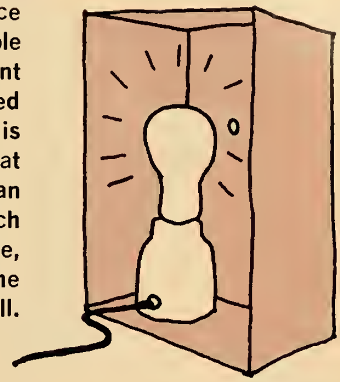
PROJECT

Cut a square of cardboard three inches on each side, and hold it 18 inches from the light. Have someone measure the height of the shadow on the wall. Then move the square so it is 36 inches from the light. What is the height of the shadow now? What is its area? See if you can predict what the height and area of the shadow will be when the square is held six feet from the light. Were you right?

If you can get a clear bulb with a straight filament, you can turn it so that it looks like a point of light *(see Diagram A)*. If you can't find such a bulb, you can make a "point

A

You can make a point source of light by cutting a small hole in a box and placing it in front of a 100- or 150-watt frosted bulb. Be sure that the bulb is not touching the box, and that the box is open so the heat can escape. You won't get much light through the small hole, so you may have to move the light source closer to the wall.



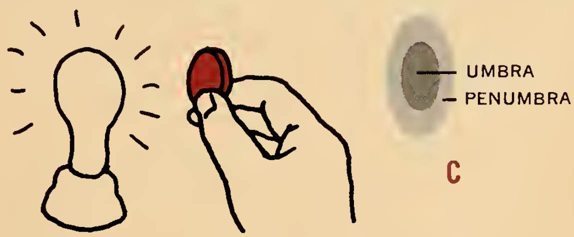
B

source" of light, as shown in Diagram B.

Compare the shadows made by a point source of light with shadows made by a larger light source, such as a frosted bulb or the sun. Can you explain the differences?

Dark and Light Shadows

Place a frosted bulb a foot or two from a wall. Hold a coin or disk so that it casts a shadow on the wall. When you hold the coin near the wall, it casts a sharp, dark shadow. As you move it away from the wall, toward the light, you will notice that the dark shadow shrinks, while a lighter shadow grows around it. The dark inner shadow is called the *umbra.* The lighter, outer shadow is called the *penumbra (see Diagram C).* What happens to the size



C

of the umbra as you move the coin back and forth? Does the umbra ever disappear completely?

Can you explain why there is an umbra and a penumbra? If not, try this: Hold the coin or disk in front of one eye while looking at the frosted bulb. What happens as you move the coin away from your eye, toward the bulb? Where can you place the coin so that it lets no light from the bulb enter your eye? Where should you place it

(Continued on the next page)

This photograph was taken in June. Can you tell by the shadows at what time of day it was taken? And the approximate latitude on the earth where it was taken?

Exploring Shadowland (continued)

so that light from the edges of the bulb can be seen? Now can you explain why some parts of a shadow may be darker than others?

If you use a point source of light, will the shadow of the coin have an umbra and a penumbra?

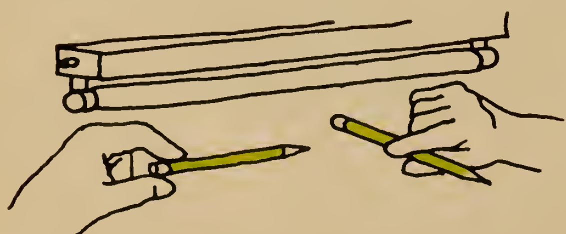
If you place two lights side-by-side and place an object in front of them, how many shadows will you find? Why are some parts of the shadow darker than others? What happens if you move the bulbs farther apart?

If the two light bulbs give equal amounts of light, what can you do to make one shadow lighter than the other? Can you find out which light causes each shadow? If you use two light bulbs of different wattage, which one will cast a darker shadow? Why? What can you do to make the shadows equally dark?

See what will happen to the number of shadows if you light an object with three, four, or five bulbs.

You know that the shadows made by a point source of light are different from those you get when you use a frosted bulb. What about other kinds of light sources? Try making shadows using a spotlight, a candle, a long, thin fluorescent bulb, and a flashlight; then compare them with shadows made by the sun, a point source of light, and a frosted bulb.

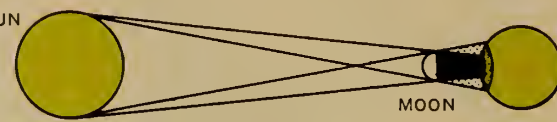
Does the shadow size change much as you move something toward and away from a spotlight? Find out how the shadow of a pencil changes as you turn the pencil



D

beneath a fluorescent light bulb (*see Diagram D*). Which of the various light sources produce similar shadows?

When the moon passes between the earth and the sun, a total eclipse of the sun is visible in those regions of the earth that lie in the path of the moon's umbra (*see Diagram E*). What will people see if they are in the penumbra



E

portion of the moon's shadow?

The shadow the moon casts on the earth during an eclipse of the sun is quite large, but you spend half of your life in an even larger shadow. Can you guess what makes it? ■

MORE INVESTIGATIONS

1. Can shadows be reflected? To find out, arrange a pencil and a light so that the pencil's shadow strikes a mirror standing on a piece of white paper. What do you find?

2. Use a cardboard disk to cast a circular shadow on a wall. Can you use the same disk to cast a shadow that has an oval shape? Can you produce an oval shadow using a ball? Can you use an oval piece of cardboard to make a circular shadow? Can you make a rectangular shadow using a square piece of cardboard? Can you make other kinds of parallelogram-shaped shadows (▱) using a square? Can you use a rectangular piece of cardboard or paper to make a square shadow?

3. Cut a round hole in a piece of cardboard, and hold the cardboard close to the ground in sunlight. Does the shape of the "hole" in the shadow change as you raise the cardboard toward the sun? Now try the same thing with holes of other shapes—square, triangular, or any shape. Can you explain your findings? Will the same thing happen if you use a frosted bulb for a light source?

4. How do shadows made by moonlight compare with those made by sunlight?

5. Using a point source of light, you can cast a shadow of a person's profile on a large piece of paper. Then you can outline his profile with a pencil, and cut it out with scissors. Where should a person place his head to make a large profile? To make a smaller profile? Can someone's shadow profile be smaller than his real profile?

The tansy ragwort weed was ruining Oregon farmland. There was too much to pull out. Spraying it with chemicals might be dangerous. Scientists decided . . .

WE NEED AN INSECT THAT WEEDS!

by Margaret J. Anderson

A cinnabar moth caterpillar eating a tansy ragwort leaf.

■ In the western United States there's a yellow flower that nobody wants—the tansy ragwort. This common weed crowds out grass and other plants that animals eat in pastures. It causes a fatal liver disease in cattle and horses. Beekeepers don't like it because it gives honey a strange taste.

The farmers in Oregon wanted to get rid of the tansy ragwort. Dr. Paul O. Ritcher and Robert Every of Oregon State University, in Corvallis, were asked to find a way to do it. Dr. Richter and Mr. Every are *entomologists* —scientists who study insects. They knew that there was too much of the weed to pull out, and killing it with chemicals would be costly and perhaps dangerous. How could they weed a state?

The Prickly Pear Problem

Looking for an answer, Dr. Ritcher studied the work of scientists who had had an even bigger problem: weeding the whole continent of Australia! These scientists had been trying to get rid of a plant called the prickly pear.

The prickly pear is a cactus that grows naturally in North and South America. There it is kept in check by insects, diseases, and competition from other plants. But when the prickly pear was taken to Australia, it had none of these enemies there. It went wild. In 1900 it covered 10 million acres in Australia. By 1925 it covered 60 million acres, and on half of these it was so dense that neither men nor other large animals could get through it.

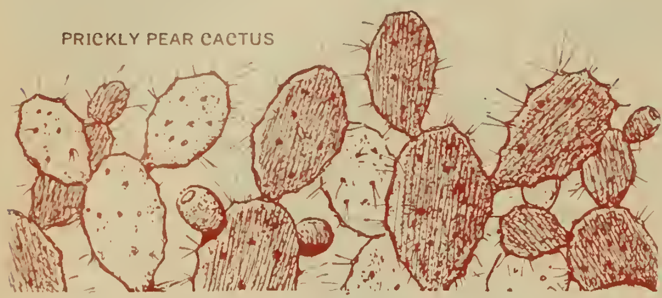
Australian scientists went to South America to study the prickly pear's enemies. They found a small moth in Argentina whose caterpillars burrow into the plant, causing it to wilt and die. The scientists studied the caterpillars to try to be sure that they would eat *only* prickly pear.

In 1925, they took 2,750 eggs of the moths to Australia. When the eggs hatched, the scientists raised the cater-

(Continued on the next page)

pillars to adult moths and collected their eggs. They kept doing this for two years, until they had nine million moth eggs to spread over a vast area.

By 1930 the caterpillars were killing acres and acres of the prickly pear. Finally, there wasn't enough prickly pear food for the millions of caterpillars. They went in search of other food. Fortunately, the scientists had been right when they decided that the caterpillars would eat only the prickly pear plants. The starving caterpillars died without eating any crops. Millions of acres of land had been cleared of prickly pear and could be used for farming again.



Tackling Tansy Ragwort

Dr. Ritcher read scientific papers on the prickly pear and on other weeds that had been controlled by insects. He found out about the work done by other scientists who were studying the tansy ragwort. Like the prickly pear in Australia, the tansy ragwort in the United States had no enemies to keep it in check. Dr. Ritcher decided that insect control would be a good way to get rid of the weed.

The job of finding a suitable insect and studying it had already been begun in France. Europe is the native home of the tansy ragwort, and the climate in France is much like the climate of the western United States. Several insects attack the weed in France, but the most promising for insect control seemed to be the cinnabar moth. Its yellow and black caterpillars eat the ragwort's leaves and flowers (*see photo on page 5*).

Scientists at the Agricultural Research Service Laboratory in France worked with the cinnabar moth for four years. They had to build up populations of the insect that were free from disease and parasites. They also had to find out for sure whether the insects would eat only tansy ragwort.

In 1960 a thousand cinnabar moths were flown to Oregon and released in two areas. But when Dr. Ritcher and Mr. Every went back to check the areas in following years, they could find no cinnabar moths or their caterpillars. What had gone wrong? Why weren't the moths thriving when there was so much food?

Dr. Ritcher thought the moths might have died out because too few of them were released. They might have been too scarce or too scattered to find mates and reproduce.

But the scientists had another worry. Were the caterpillars being eaten by birds?

In France, the birds do not eat the yellow-and-black cinnabar moth caterpillars, because they are colored like other caterpillars there that are poisonous to the birds. But in New Zealand, where farmers had imported cinnabar moth caterpillars to eat tansy ragwort, the caterpillars were eaten by birds. (In New Zealand there are no yellow-and-black caterpillars that are poisonous to birds.)

In the United States, however, it looked as if the caterpillars were safe from birds. Some caterpillars had been released in California, and there the populations were beginning to build up. And the caterpillars seemed to be suited to life in the western states.

So in 1964, and again in 1965, Dr. Ritcher took caterpillars from California and released them in Oregon. Now they are becoming established there. The farmers hope these insect "weed killers," which not only kill tansy ragwort but go looking for it, will succeed this time ■

For more examples of how biologists try to control pests by using knowledge of their lives, see pages 8 and 9.

This weed-control expert is releasing cinnabar moth caterpillars among tansy ragwort plants in Oregon.

brain boosters

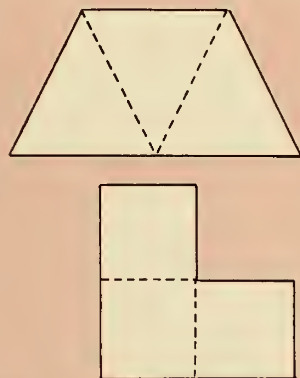
prepared by DAVID WEBSTER

MYSTERY PHOTO

What part of what animal did this bone come from?

CAN YOU DO IT?

Cut a piece of cardboard in an irregular shape, such as the one shown here. Can you find a spot to stick a pin through it so that the cardboard will stay in whatever position you turn it to, even when you take your hand off the cardboard?

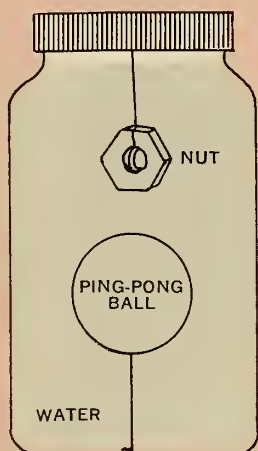


FUN WITH NUMBERS AND SHAPES

Each of these two designs has been divided into three equal parts of the same shape. Can you divide each of these designs into four equal parts of the same shape?

WHAT WILL HAPPEN IF?

Glue one end of a short piece of string to a ping-pong ball, and glue the other end of the string to the bottom of a large, wide-mouth jar. Tie a metal nut to another short piece of string that is glued to the inside of the jar's cover. Fill the jar with water, and screw the top on tightly. What will happen to the nut and ping-pong ball if you: Turn the jar over? Shake it back and forth? Hold the jar still while you swing on a swing? Spin the jar on its side? Swing it around in a circle? Take the jar with you on an auto ride?



JUST FOR FUN

Select a small section of your lawn and ask your parents if you can leave it uncut all summer. How high does the grass grow? Do any weeds appear in the long grass?

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. We regret that ideas cannot be returned or acknowledged.

Answers to these Brain-Boosters are printed on page 15.

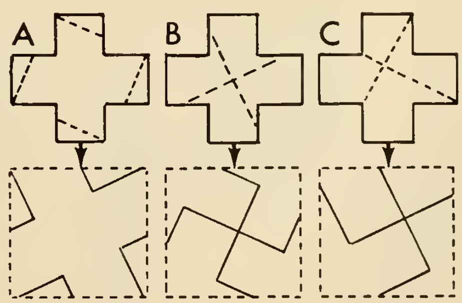
ANSWERS TO BRAIN•BOOSTERS IN THE LAST ISSUE

Mystery Photo: The truck is used to collect money from parking meters. The long tube works like a vacuum cleaner to suck up the coins when the meter is opened.

What will happen if? If the board is not slanted too much, the jar of syrup will roll down quite slowly. What will happen with a half-full jar of water, or a full jar of syrup?

Can you do it? It is difficult to drink water through 15 straws because air leaks into your mouth between some of the straws, so that you can't suck all the air out of the straws.

Fun with numbers and shapes: Of the four ways shown, here is the one way the cross can be cut to make a square (A), along with two other ways to do it (B and C):



For science experts only: The shadow of a flying bird is the same size as the bird.

Putting Down Pests

■ Humans share the earth with about a million-and-a-half other kinds of animals and plants. Of these, only a few thousand are considered *pests*—organisms that cause or carry disease, destroy food, or cause man trouble in other ways.

For many years, one of man's main defenses against pests has been poisons. But these poisons, such as DDT, kill many living things other than pests. Today scientists are trying to find ways of controlling the numbers of a pest organism without harming other plants and animals. The scientists study the life of a particular kind of pest, looking for diseases, natural enemies, and other things that might be used to reduce its numbers. So far, biologists have found ways of controlling several kinds of pests, either by changing the organisms themselves or by using another kind of plant or animal to control them. This WALL CHART shows some examples of such *biological controls* ■

Young insects produce a substance called *juvenile hormone*, which can be collected from the insects themselves or made in a laboratory. When insects are given more of this substance than they usually have, the insects die, or else fail to grow into adults that could produce more young. The drawings show two mealworm beetles, one a normal adult *(left)*, the other an adult that failed to develop normally because it was given juvenile hormone. In one test, a tiny fraction of an ounce of juvenile hormone was enough to rid five tons of wheat of mealworm beetles.

Porcupines damage and sometimes kill trees. One of the few animals that eat porcupines is the fisher *(above)*, a fox-sized mammal related to the mink and weasel. Conservation departments in Oregon, Wisconsin, and other states have released dozens of fishers in areas having high numbers of porcupines. Biologists hope that the fishers will reduce the numbers of porcupines—and the porcupine damage.

Rabbits that were brought to Australia

Rabbits that were brought to Australia multiplied rapidly because they had no natural enemies (except man). They ate grasses and other plants that could be eaten by sheep. In 1950, rabbits with a disease called *myxomatosis* were set loose in parts of Australia. In some areas, almost all of the rabbits caught the disease and died. Grass sprang up again, sheep thrived, and Australia's wool production rose. But the disease didn't kill all of the rabbits. Some rabbits seem able to resist myxomatosis, and the disease itself may have become less deadly.

In seven weeks, one water hyacinth plant can produce 1,000 new plants. The hyacinths clog canals, keep fish from reproducing by spoiling their nesting places, and provide places for mosquitoes to breed. The photo shows a huge machine used to clear water hyacinths from a stream in Louisiana. In the southern United States, biologists are testing the effects of two kinds of organisms that eat water hyacinths—an insect caterpillar, and the 1,000 pound mammal known as the "sea cow"—in hopes of bringing this plant under control.

LIFE CYCLE OF BLOOD FLUKE

The diagram shows the life cycle of a blood fluke, a tiny worm that works its way into the human body and causes a disease called *schistosomiasis*. At one stage in its life, the young fluke lives and develops inside a snail. In fact, a young fluke dies if it does not find its way inside a snail within 24 hours after hatching from its egg. So one way to control blood flukes is to get rid of the snails they need for life. The photo *(left)* shows a rice farmer in the Philippines trying to get rid of snails by clearing the snails' food plants from a ditch.

X rays, or other kinds of radiation, can make insects *sterile*—unable to reproduce. In laboratories, scientists used radiation to sterilize millions of screw-worm flies, which injure livestock. Airplanes dropped these sterile flies on parts of the West Indies and the southeastern United States. When the sterile flies mated with normal flies, no young were produced. In less than 18 months, screw-worm flies were no longer a problem. The photo above shows an olive-eating dacus fly, which is getting the same treatment in Greece.

WHAT'S NEW?

by
B. J. Menges

The sea otter, once believed to be extinct, is making a comeback, says writer George Laycock in *Audubon* magazine. Larger than their fresh-water cousins, sea otters range from three-and-a-half to five feet in length. Sea otters were once abundant along the Pacific Coast, from California to Alaska. Then explorers from Europe discovered them, and for two centuries the animals were slaughtered for their beautiful fur. Sea otter skins have sold for as much as $1,700 each.

In 1911, when sea otters seemed doomed, Russia, Japan, Canada, and the United States finally agreed to protect them. The U.S. set aside more than 200 islands in Alaska as a sea otter refuge. Today, some otter colonies in Alaska are doing so well that "surplus" otters are being airlifted to other areas in the state to start new colonies.

It's hot and dry in the part of Australia where a small, plant-sucking insect lives. This insect belongs to a family of insects called jumping plant lice. It feeds on juices from the leaves of eucalyptus trees, and lays its eggs on the leaves. What keeps the eggs from drying out in the hot, dry climate? Dr. T. C. R. White of the University of Adelaide suspected that the eggs absorb water from the leaves. He set up an experiment to see whether this was true.

Removing the bottom of a small plastic container, he put in its place a piece of eucalyptus leaf that had some of the insect's eggs on its underside. He filled the container with water that had a radioactive substance in it. If the eggs absorbed water through the leaf, they would take up the radioactive substance, too. Sure enough, the eggs were later found to contain the substance, which could only have come from the water in the container. Dr. White believes that water from the eucalyptus leaves not only keeps the eggs moist, but also, through evaporation, keeps them from overheating.

The close fit between the bulging coast of South America and the indented coast of Africa has led to the theory that these two continents were once connected. *(See "The World's Biggest Jigsaw Puzzle,"* N&S, *October 28, 1968.)* Further evidence was presented recently by Dr. Gilles O. Allard and Dr. Vernon J. Hurst, geologists at the University of Georgia, in Athens.

At matching points on the two continents, they found the same rock layers arranged in the same order. The two sets of rock layers, laid down from 180 million to 100 million years ago, contain fossils of the same 30 species of fresh-water animals. Both continents have a thick layer of salt above the rock layers; but they show little similarity to each other above the salt. The geologists thus conclude that the continents were once connected, but split apart and went their own ways when salt water invaded the area.

Total extermination of much ocean life might result if a sea-level canal replaces the Panama Canal, say some scientists. The Panama Canal is too small for many modern ships, and a new waterway seems necessary. In the present canal, a system of locks raises ships up to a lake at the middle and then lowers them again on the other side. The proposed sea-level canal would simply connect one ocean to the other.

The land barrier of the Isthmus of Panama has separated the Atlantic and Pacific Oceans for about three million years. Plants and animals in each ocean have developed independently. The Panama Canal continues to keep Atlantic and Pacific ocean life separate, because the fresh water of the canal is a natural barrier to salt-water life. But if a sea-level, salt-water canal were constructed, each ocean would be invaded by plant and animal species native to the other. This would be a catastrophe, says Dr. John C. Briggs of the University of South Florida, in Tampa. He and other scientists believe that many Atlantic species are hardier than their Pacific cousins, and would be better able to survive under the new conditions. In time, many Pacific species might die out altogether.

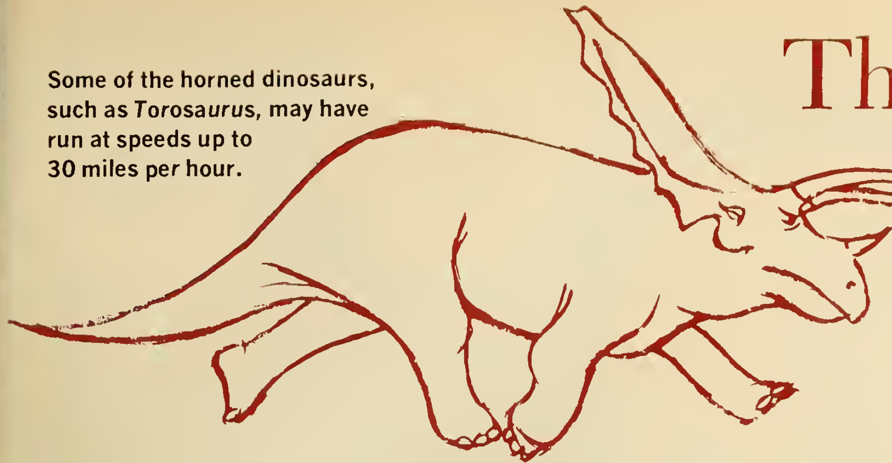
Wind tunnels may help skiers break records at the 1972 Winter Olympics. As a skier crouches motionless in the wind tunnel, air is blown past him at a speed about the same as his normal downhill speed. The effect is the same as if he were moving through the air.

Air slows down any object passing through it; but the more "streamlined" an object is, the less it will be slowed. The wind-tunnel tests have already helped skiers develop a new crouch that makes them more streamlined. Improved ski clothes and equipment may also help.

Pulsars have been seen at last. Since these small, very dense stars were discovered about a year ago *(see "What's New?",* N&S, *December 16, 1968),* they had only been "heard" as radio signals by radio telescopes. But now three astronomers at the University of Arizona, in Tucson, have seen one.

Using a 36-inch telescope, John Cocke, Michael Disney, and Donald Taylor found a flashing star in the Crab nebula. Its flashes matched exactly the pulses recorded by radio telescopes aimed at the star. So the astronomers concluded that they had seen a pulsar. Meanwhile, astronomers at the University of California's Lick Observatory succeeded in photographing the star *(see photos).* Astronomers still don't know what makes pulsars blink.

These photos, taken a fraction of a second apart, show the blinking star in the Crab nebula as it flashes on *(above)* and off *(below)*. This *pulsar*, which blinks on and off 33 times each second, is the first that scientists have been able to photograph (see *"Pulsars have been seen"*).



Some of the horned dinosaurs, such as *Torosaurus*, may have run at speeds up to 30 miles per hour.

The Dashing Dinosaurs?

What were the dinosaurs really like? One scientist's study suggests that our ideas about some of these early reptiles should be changed.

by Susan Wernert

■ Huge lumps of flesh plodding slowly through muddy marshland. Is that your picture of the largest of the dinosaurs? That's the way people usually think of them. But now, 70 million years after the last of the dinosaurs died out, that picture may need some changing.

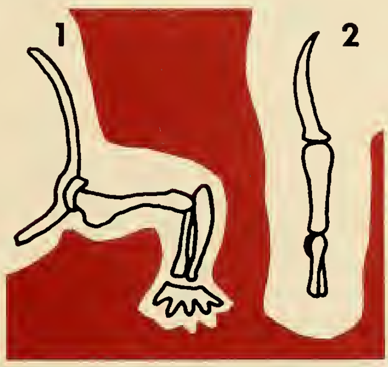
For the past two years, Robert Bakker, a staff member of the Peabody Museum of Natural History in New Haven, Connecticut, has studied dinosaur fossils. The fossils are usually bones and teeth, and they can often be put together to form at least part of a skeleton. Mr. Bakker has compared dinosaur skeletons with those of modern reptiles, such as crocodiles, that are related to the dinosaurs. His work suggests that some of the big dinosaurs might have been lively reptiles that moved quickly—not through marshes, but over dry land. Some scientists disagree with Mr. Bakker's theory, and only time—and more study—will reveal if it is correct.

Bones Tell the Tale

Dinosaurs shown in books and museums often look like clumsy animals. Certain kinds, such as *Stegosaurus* (*see drawing*), usually have only the hind part of their body raised above the ground. Their front limbs sprawl out to the sides, so that the front of the dinosaur is close to the ground. "More than anything else," says Mr. Bakker, "their posture looks like a man cheating at push-ups."

Modern animals with a posture like this, such as lizards and salamanders, are usually slow and sluggish. So scientists have thought that many kinds of dinosaurs, too, were slow-moving animals.

But the way the dinosaur fossil bones actually fit together tells a different story, Mr. Bakker believes. The shoulder socket faces down, not out (*see diagram*). The front limb fits into the shoulder so that it extends down from the shoulder, not sideways. Because the bones fit together in this way, dinosaurs could have walked upright. They could have walked with the graceful steps of animals such as dogs, instead of the close-to-the-ground movements of lizards.



The front leg of a lizard (1) fits into its shoulder so that the leg extends sideways. The front leg of a sauropod dinosaur (2) extends downward from the dinosaur's shoulder.

The bones bear another clue to the dinosaur walk—

(Continued on the next page)

Stegosaurus, like other large dinosaurs, is often pictured with the front part of its body close to the ground. But some of the large dinosaurs may have walked upright.

muscle markings. The bones still have grooves where muscles were once attached. The larger the groove, the thicker and more powerful the muscle. The grooves of the front leg bones of some kinds of dinosaurs show that one of the muscles for swinging the front legs was especially powerful. So the dinosaurs might have been fast, agile animals, rather than slow-moving creatures.

Dashing Through the Marsh

This is not the only change that should be made in our picture of dinosaur life, says Mr. Bakker. He suggests that the largest dinosaurs, known as *sauropods,* might have lived on dry land, not in marshes.

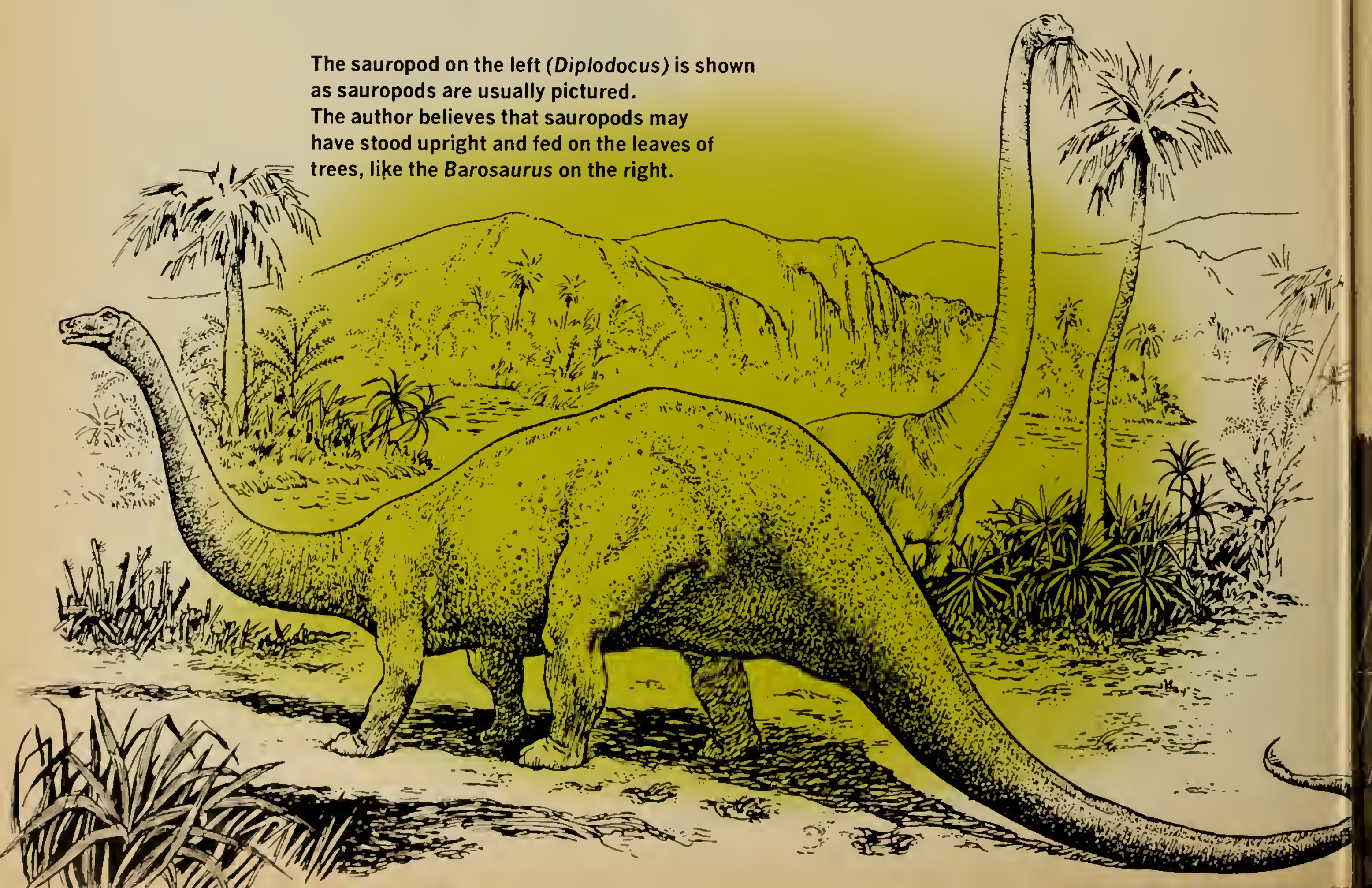
Sauropods have long been pictured as marsh animals. *Paleontologists* (scientists who study the prehistoric life of the earth) thought that sauropods could eat only water plants. They thought this because the sauropods had no grinding teeth. Teeth for grinding aren't necessary for eating water plants, which are usually soft. But land plants are harder to chew than water plants. If sauropods had no grinding teeth, it would seem that they couldn't eat land plants.

Nevertheless, Mr. Bakker suggests that sauropods might have been able to eat land plants. The tough food might have been ground up in the dinosaurs' stomachs with the help of pebbles that the reptiles had swallowed. Crocodiles, the reptiles of today that are most like dinosaurs, seem to grind food in this way. "Stomach stones" have been found near sauropod skeletons, and one small skeleton has been found with over a hundred pebbles in its rib cage. If sauropods could eat land plants, they wouldn't have been limited to life in marshes. They could have survived on dry land.

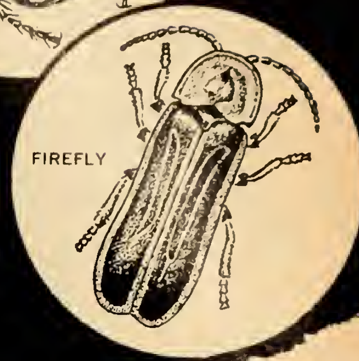
Why Did Sauropods Have Long Necks?

Evidence from the fossil bones of sauropods also suggests that these dinosaurs lived on dry land. The number and size of the sauropod neck bones show that the animals were extremely long-necked. The long necks would have helped sauropods to survive in woodlands, where they could reach food high in the treetops. Such necks would not be needed in marshes, where food grows close to the ground. So the long necks of sauropods seem to have made them better suited for woodland than for marshes.

Paleontologists can never be sure that their picture of dinosaur life is exactly correct. Perhaps the big dinosaurs weighed so much that they couldn't move quickly. As paleontologists continue to study fossils and discover new evidence, they will have a clearer picture of how dinosaurs lived. And that picture might be quite different from any one we have today ■



The sauropod on the left *(Diplodocus)* is shown as sauropods are usually pictured. The author believes that sauropods may have stood upright and fed on the leaves of trees, like the *Barosaurus* on the right.



Night falls, and many kinds of animals awaken and become active. Here's how you can use some simple equipment to study the...

INSECTS of the NIGHT

by Margaret J. Anderson

■ During the day, bees, flies, beetles, and many other insects are busy in the world around us. Then, when the sun goes down, the "night shift" takes over. Moths flutter to the window, and crickets chirp in the grass.

Some evening you might investigate the lives of some of these night insects. It can be exciting—and besides, it gives you an excuse to stay up late!

How will you find the insects in the dark? The answer to that is easy, for you have probably seen moths come to a lighted window, or circle around a porch light. Scientists call these insects *positively phototropic*—another way of saying that they are attracted to light.

Moths find their way by the light of stars. They fly so that the light rays always strike their eyes at the same angle. The stars are so far away that the light rays that reach the earth from them are almost parallel to each other. When a moth tries to steer by a light that is close—such as a street light—the rays from it are not parallel to each other, and the moth spirals into the light *(see Diagram 1)*.

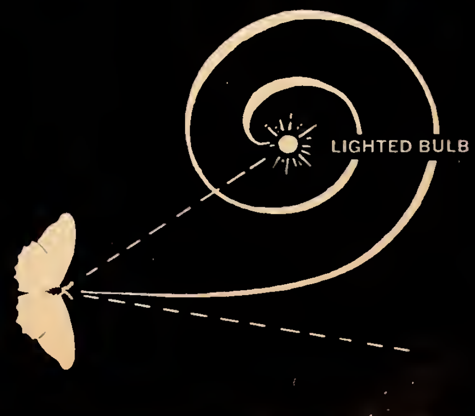
Make a Light Trap

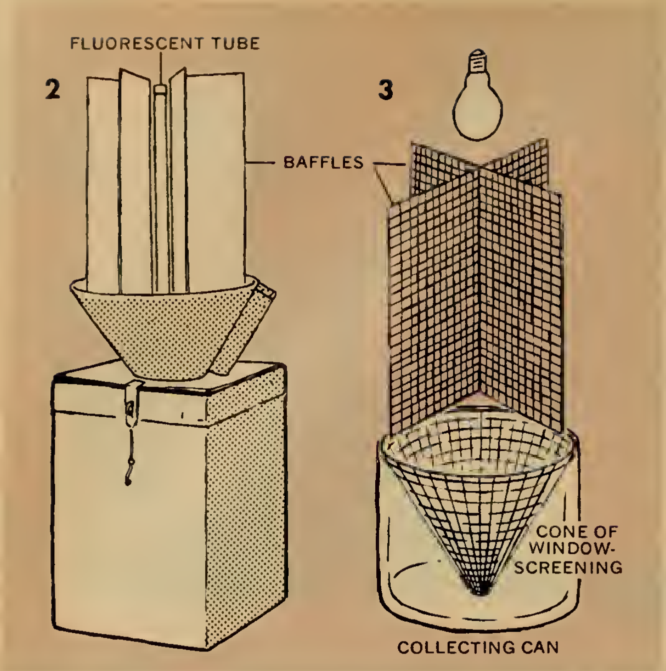
You can attract moths (and other insects) by using this "spiraling" effect of light on their flight. A simple light trap can be made with an electrical extension cord, a lamp, and a piece of white sheet. Hang the sheet behind the lamp. Some of the insects circling around will settle on the sheet, and you will get a chance to look at them. Are you getting mostly moths, or beetles, or little midges?

Make a count of the insects that settle on the sheet in, say, 15 minutes. Try it again the next night. Some nights are buzzing with activity, while others are quiet. Can you find a reason for this? The thermometer might give you a clue. Or is there a breeze? Do a little detective work and see if you can find out how weather affects the activity of night insects. *(Continued on the next page)*

1

A moth flies in a straight path by keeping itself turned so that the parallel light rays from a bright star always meet the moth's eyes at the same angle. When a lighted bulb appears brighter than the star, the moth has to keep turning toward the bulb so that its rays meet the moth's eyes at the same angle. This makes the moth fly in a spiral path that ends when it hits the bulb.





When night insects circle near these light traps, they hit the baffles and fall into the containers below them.

Insects of the Night (continued)

You can also use a light trap to find out if the same kinds of insect fly at night from spring through fall. Does the June "bug" fly only in June, or can you catch it in August?

To answer such questions, you can make a more elaborate light trap, with which you actually catch the insects (so that you can identify them). And you don't have to stay and watch for them. The trap shown in Diagram 2 uses a fluorescent tube with four "baffles" set at right angles to each other. The insects circling the light hit the baffles and then drop into the collecting can, which contains poison.

You can make a simpler light trap with baffles set below an ordinary light bulb *(see Diagram 3)*. A can with a little water and detergent makes a trap under the baffles. If you want to trap the insects live, put a cone of wire or window-screening in the can *(see Diagram 3)*. The stunned insects will fall down and will not be able to find their way out of the can.

Does Color Make a Difference?

Entomologists, the scientists who study insects, have found that insects are more attracted to some colors of light than to others. In fact, insects almost ignore some colors. This interests entomologists, who want to know what color of light will *attract* most insects. It interests almost everyone else because they want to know what color of light will keep insects *away*.

You can try to find out on your own what color of light attracts insects best. You might simply try replacing your porch light with different-colored bulbs, and counting the insects that come circling around. There's a problem with this method, though. If you have tried the light trap you will have found that some nights are good for collecting insects, and some are poor. If you try a yellow light on a night that is humming with action, and a green light the following evening when few insects are active, can you then say that yellow is better than green for attracting insects?

One way to get around this problem is to check the weather and temperature, and test the different colors of light on nights when the weather is about the same. The best way of solving this problem, though, is to compare the effects of the colored lights on the *same* night. You can try to do this by hanging up a string of outdoor Christmas-tree lights. Use four bulbs—red, yellow, green, blue—separated as far as possible along the cord. Attach a paper plate behind each bulb, using tape to hold it in place. Lay strips of sticky "fly-paper" across each plate *(see photo)* so that insects landing on it will be caught. Then switch on the lights and wait. After an hour or so, count the catch on each plate.

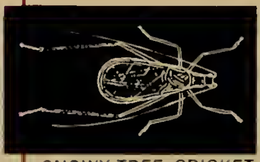
Test the effects of the bulbs on several nights. And remember, the insects may be attracted by a bulb's brightness as well as by its color. Once you have discovered

LISTEN TO THE INSECT CHORUS


FIELD CRICKET

When you're out hunting insects at night, you'll hear the sounds of insects, too. See if you can find the insects that are making the sounds you hear. The male field cricket makes music with his wings, and the female listens with ears on her knees.

If you can get to know the song of the snowy tree cricket (see *drawing*), then you can tell the temperature by using a watch with a second hand. Count the number of chirps the cricket makes in 15 seconds, add 40, and you have the temperature in degrees Fahrenheit. Check the temperature with a thermometer and see how accurate the cricket is.


SNOWY TREE CRICKET

You may hear the hum of a mosquito. That is a female mosquito calling a mate. She makes the sound by the rapid beat of her wings. She needs a meal of blood before she lays her eggs. So you don't need a light trap or overripe peaches to attract the mosquito. You are the bait!


KATYDID

Insects that are attracted by the light from a Christmas tree bulb will be caught on strips of sticky "fly-paper" spread across the paper plate behind the bulb.

which bulb attracts the greatest number of insects, you can use that color bulb in your light trap.

Trapping Without a Light

Some flowers stay open at night. Moths visit them and sip nectar. The moths accidentally carry pollen from one flower to another, and this enables the plants to produce seeds. These flowers have characteristics that attract insects such as moths to them. You'll notice that most of these flowers are white or pale yellow—colors that show up well in moonlight. And many of them are scented. Night insects are attracted by smells as well as by light.

This gives a clue to another way to collect insects at night. For this you will need some overripe fruit—peaches or bananas are best. Mash them with a tablespoon of molasses and a tablespoon of brown sugar. After a few hours this mixture will be just right for attracting insects. Toward evening, "paint" the mixture on a post or tree trunk, and then wait for darkness. (Entomologists call this way of catching insects *sugaring.*) Then, after dark, go back to the bait with a flashlight and see what you can find. Moths, ants, beetles, perhaps a cockroach? The cockroach will scuttle away from your lighted flashlight, for it is *negatively phototropic.* It is repelled by light *(see "The City Slicker,"* N&S, *March 31, 1969)* ■

■ These books will help you identify the insects you catch: **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.

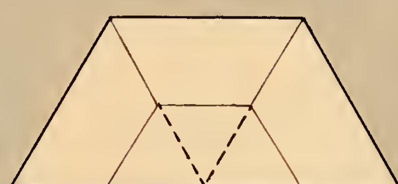
ANSWERS TO BRAIN-BOOSTERS IN THIS ISSUE

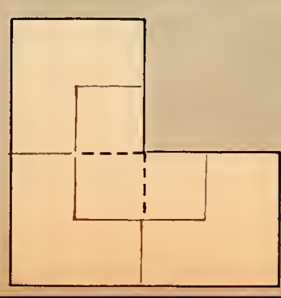
Mystery Photo. The bone that many people think is an animal skull with horns is really a hip bone (pelvis) of a cow. What do you think the holes are for?

What will happen if? The ping-pong ball and nut in the jar of water always move in opposite directions. When the jar is swung around in a circle, the *centrifugal effect* pushes the nut toward the outside of the circle. But the floating ping-pong ball moves toward the inside of the circle. (The water that is forced to the outside of the circle by the centrifugal effect forces the lighter ball in toward the center.)

Can you do it? Here is how to find the spot to stick a pin in the cardboard so that the cardboard will remain balanced in any position. Tie a small weight to one end of a piece of string, and tie the other end of the string to the pin. Stick the pin through the cardboard, near the edge, and hold the pin so that the cardboard and string hang down. When the string has stopped swinging, draw a line alongside it. Then move the pin to another spot near the edge of the cardboard, and draw another line in the same way. The "balancing point" for the cardboard will be where the two lines cross. Stick the pin through that point and see what happens when you turn the cardboard.

Fun with numbers and shapes: Here is how to divide the designs into four equal parts of the same shape:





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Using This Issue . . .
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VOL. 6 NO. 17 / JULY 7, 1969

SPECIAL ISSUE

Summer Adventures in Science

EXPLORE A DEAD TREE

MAP YOUR BACK YARD

MEASURE MINICLIMATES

AISE A RAGONFLY

WATCH BIRDS BATHE

GROW CRYSTALS

TRAIN YOUR DOG

nature and science

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PICTURE CREDITS: Cover, pp. 2-4, 7-9, 11, 16, drawings by Graphic Arts Department, The American Museum of Natural History; cover photos, (top left) Leonard L. Rue III, (top right) Franklyn K. Lauden, (bottom left) Annan Photo Features, (bottom right) Martin Slessers; p. 5, Martin Slessers; p. 6, Franklyn K. Lauden; p. 7, photo by Laurence Pringle; p. 10, Annan Photo Features; pp. 12-13, Frank Wesley; pp. 14, 16, photos by Roy Gallant.

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

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly September, October, December through March, monthly November, April, May, 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. $1.15 per semester per pupil, $1.95 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 $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, two years $6. Single copy 30 cents. In CANADA $1.25 per semester per pupil, $2.15 per school year in quantities of 10 or more subscriptions to the same address. Teacher's Edition $6.30 per school year. Single subscriptions per calendar year $4.25, two years $7. ADDRESS SUBSCRIPTION correspondence to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530. Send notice of undelivered copies on Form 3579 to: NATURE AND SCIENCE, The Natural History Press, Garden City, N.Y. 11530.

The decay and death of a tree may start when a branch is broken, and the tree's cells are invaded by bacteria and fungi.

At first glance, a dead tree may seem lifeless and useless. But if you look closely, you'll find that . . .

There's Life in the Old Tree Yet

by Laurence Pringle

■ This summer, watch a single tree to see what kinds of living things you find on or near it. Robins, squirrels, ants, moths—how many different kinds of animals visit the tree?

A living tree is a lively place. But its importance to other living things doesn't end when the tree dies. Even after a dead tree falls to the ground, it is food and shelter for many kinds of plants and animals. This article tells something about what happens to a tree as it dies and decays, and how this affects other plants and animals. You can discover more about this process by observing some trees this summer.

When a Tree Begins To Die

The death of a tree usually begins with a wound. Fire may burn the bark; insects, squirrels, or birds may cut or bore into the wood; wind, snow, or ice may break a branch. Humans wound trees in many ways, especially when building houses and highways.

When a tree is wounded, some of its cells are killed and others are injured. The cells that have been exposed to the air are soon invaded by tiny organisms such as bacteria and fungi. These organisms begin to "eat" the food inside the damaged cells of the tree. If the wound is not great and the tree is healthy, the bacteria and fungi do not spread beyond the wound. Healthy tree cells release chemicals that form a barrier around the wound.

A tree that is old or badly wounded may not be able to protect itself so well against bacteria and fungi. The invaders begin to spread into the healthy cells of the tree. They are joined by other kinds of fungi, called *decay fungi*. Unlike the first invaders, these tiny plants can digest the *walls* of the tree's cells. This weakens the wood.

The tree is now fighting for its life, and the battle may go on for many years. Even when more than half of a tree is dead, the live part keeps growing, producing seeds, and forming new chemical barriers around the invaders. When the whole tree has died, however, all of its cells become food for the decay fungi.

Whether dying or dead, a tree attracts many kinds of animals. Insects come by the thousands, feeding on the wood or laying eggs in it. Birds peck out the insects for food. This tears the bark, exposing more wood to bacteria

(Continued on the next page)

As more and more of a tree dies, it becomes a home or source of food for many kinds of insects and other animals.

Moisture from the soil helps speed the decay of the fallen tree. The rotting log provides food or shelter for ground-dwelling animals such as salamanders and millipedes. The drawing at the bottom of the page shows a log in its final stage of decay: merging with the soil, but still a source of food for ferns, other plants, and soil animals.

There's Life in the Old Tree Yet (continued)

and fungi. Some birds hollow out nest sites in the partly decayed wood. Later these may become homes for squirrels, insects, or other animals.

KNOCK ON WOOD

Look for trees that have small holes (one inch or more across). Hit the tree with your knuckles or palm and see if anything comes out. Often nothing will. But a bird may flee from its nest; a flying squirrel may glide away. See what animals you can find living in holes of dead trees. (Be careful not to damage the tree or disturb a nest any more than necessary.)

Bacteria and fungi weaken the roots of a tree, too. And insects and other small animals find food and shelter there. Gradually, the roots lose their tight grip on the soil, and eventually the tree falls. Now the decay speeds up. With part of the tree pressed against the soil, small soil creatures find food in the tree, and moisture from the soil gets into the wood. This makes it easier for fungi to grow.

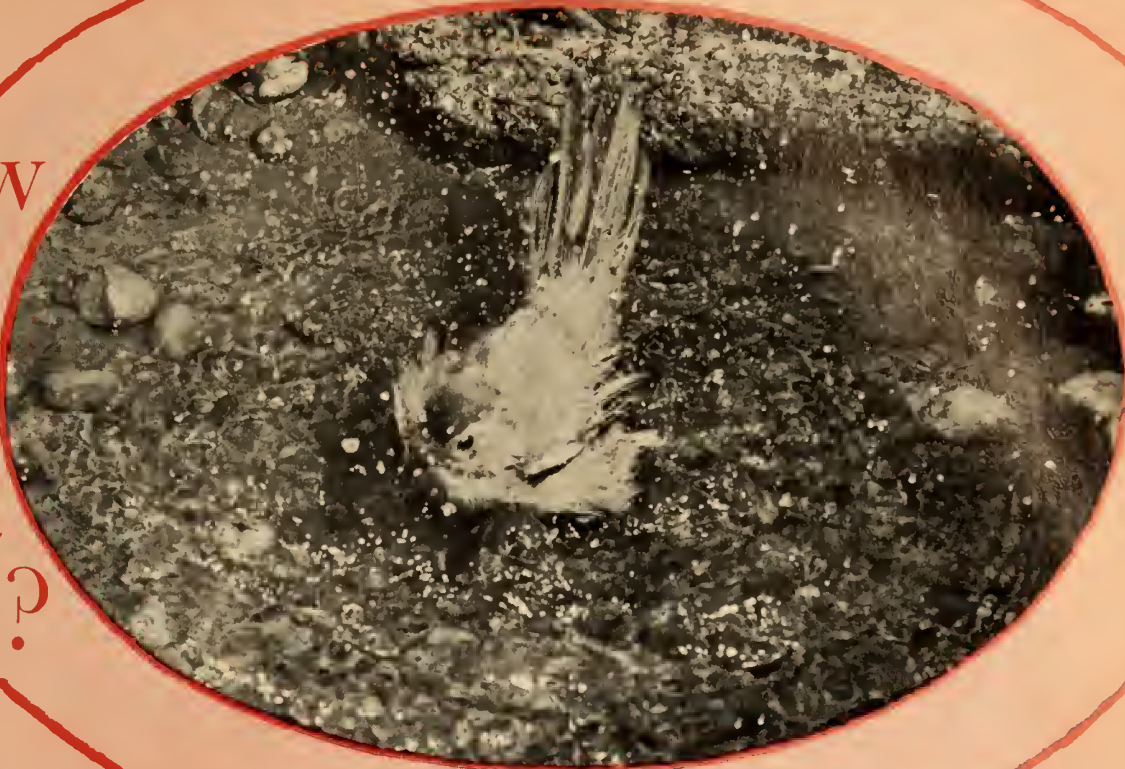
Once a sturdy tree, now a rotting log, the tree still attracts many kinds of living things. In fact, it probably attracts more life than it did as a living tree. It is like a "boom town," providing food and shelter for insects, spiders, amphibians, reptiles, mammals, mosses, fungi, ferns, wildflowers, and many other living things. And like a boom town, eventually the log is almost completely "used up," and can no longer support a great variety of life.

EXPLORE SOME LOGS

In a forest, look for logs that are in different stages of decay, including freshly-fallen ones and some that are merging with the soil. Explore parts of them with a trowel or hatchet to see what is living inside. Turn some over to see what animals you find underneath. (Be sure to put the logs back the way you found them.) Keep notes on the numbers and kinds of living things you find in different logs. What stage of decay seems to attract the greatest variety of living things?

Eventually the remains of the log become part of the soil. There, the dead tree still provides food for earthworms and other soil animals. And when a seed from another tree falls on that spot and sprouts, it gets a head start in life as its roots take up the last remaining food energy from the decayed tree ■

How Does a Bird Take a Bath?



■ You may have seen birds splashing in a puddle or birdbath. But some kinds of birds seem never to take baths. And some "bathe" in dusty soil. So little is known about the bathing of birds that you may make some important discoveries by observing how they go about it.

First, find a good location for your observations. Roam the fields, parks, and woodlands near your home. Pay special attention to small water basins, such as springs, streams, ponds, and muddy water pools. Also watch for patches of dry, dusty soil where birds flutter so that soil gets on their bodies. (This may help rid them of lice and other *parasites* that live on their bodies.) Remember that birds usually bathe in a protected area.

If the surroundings offer good protection for birds but the water is more than three or four inches deep, make it shallower by putting gravel or sand on the bottom. You can also use a ring of rocks or a log to separate the spot you choose from deeper water. If you find a good bathing place for birds that is not well protected, put some branches near it for shelter.

When you have picked a spot, find a hiding place in nearby bushes or trees. Improve it if necessary by adding a few branches or some inexpensive cloth. The closer you are to the bathing place, the better you should be hidden. In partly open places, you should not be closer than 30 feet to the bathing place. You might spread seeds on the ground near the bathing spot to attract birds.

If you want to observe bird bathing in your own yard, make a birdbath yourself. Any large-size tray made of clay, metal, or even plastic can be used. A top from a garbage can makes a fine birdbath. The depth should vary from one to two or three inches. Use sand or gravel to regulate the depth in the bath. Find out which kinds of birds use the shallow water and which use the deeper spots.

Place one or several sticks in a horizontal or slanting position near and slightly above the water. The distance between the sticks and the water may vary from one to 10 or more inches. Watch to see how different kinds of birds use the sticks. Do they use them as springboards for diving and dips, or as resting places?

Keep records of your observations in a notebook. Jot down the kinds of birds you see in the area, the time of day they bathe, and how long they bathe. Do some kinds of birds bathe more often than others? Count and jot down how many times a bird rolls in the water and pauses. Also keep notes on the temperature and weather to see how this affects bird bathing.

Do birds that take dust baths also take water baths? Be sure to watch to see what birds do *after* taking a bath. How do they dry and rearrange their feathers?

These are just a few of the questions you can investigate while watching birds this summer.—MARTIN SLESSERS

Exploring *Mini*climates

by Roy A. Gallant

If you're looking for a summer project, why not explore an area near where you live, map some of its different *mini*climates, and catalog the plant and animal life you find.

■ Ever heard of a *mini*climate? Your back yard, a nearby field, or a vacant lot in the city all have different small areas, each with its own private climate. And each has plant and animal life suited to that particular climate.

A *mini*desert only a few feet across may be right next to a *mini*forest about the same size. Or the two may be separated by a *mini*mountain or valley. Some of these areas may be no larger than squares on a checkerboard. Others may be several yards wide. As with large mountains, valleys, forests, and deserts, the daily rise and fall in temperature, amount of rainfall, wind force, and humidity of back-yard *mini*climates differ.

Daily reports from the weatherman do not tell you very much about weather conditions behind or under your garage, or near the front lawn hedge, or in your vegetable garden. The weatherman's thermometer is protected from the sun and wind and measures the air temperature several feet above the ground. The same is true of the rainfall and wind-speed measurements he makes. They are not measurements of conditions under a shade tree, or in a patch of woods, or in a field, for example.

This article is based on a Cornell Science Leaflet entitled Little Climates, *by Verne N. Rockcastle, published by New York State College of Agriculture at Cornell University.*

What Makes a *Mini*climate?

During a rainstorm, the windy side of a hill in a field gets more rain than the sheltered side of the hill. The weatherman tells you that the temperature reached a high of 84°F yesterday and a low of 62°F. But he did not measure the temperature at ground level in your field. If he had, he might have found that it reached a nighttime low of 31°F and a daytime high of 105°F.

The shape of the ground surface, how well it absorbs and stores heat from the sun, how much wind and rainfall it receives, how moist or dry the soil is, and what kinds of plant and animal life it has—these are the main things that make one *mini*climate different from another.

*MINI*DESERTS: Ground that has become hard-packed and that does not have grass is one example of a *mini*desert. So are a well-used foot path, a sidewalk, a road shoulder, and a sandy area. The temperature, amount of moisture, kinds of plant and animal life, hardness of the soil, and motion of the air above a *mini*desert are all different from those of other *mini*climates.

*MINI*FORESTS: The ground on one side of a building may not be much exposed to the weather, and so may be a *mini*desert. But the ground on the opposite side of the building may get lots of sun, rain, and other kinds of weather, and be a *mini*forest. Here, the temperature right

Can you figure out what caused the narrow valley in the center of this dry, barren *mini*desert?

With your eyes at ground level, a grassy plot becomes a thick *mini*forest with its own climate and animal life.

next to the ground may reach 100°F and the relative humidity may be 90 per cent. Because of the dense plant life, the moisture, and the softness of the soil, there are apt to be more and different kinds of animal life in the *mini*forest than in the *mini*desert on the opposite side of the building.

Down among the grass stems, the air may be calm, even though there is a 15-mile-an-hour wind 10 feet above the ground. The rain that reaches this area soaks into the ground and helps keep the soil soft, which in turn attracts earthworms and other soil animals. But in the *mini*desert on the opposite side of the building, the small amount of rain that falls runs off and leaves the ground hard and dry.

*MINI*MOUNTAINS AND VALLEYS: A *mini*mountain may be as small as an anthill, or it may be a boulder or a mound of earth a foot-or-so high in a field. A *mini*-valley may be a shallow rut left by the wheel of a tractor or a power mower. The valley may collect and keep water longer than the surrounding flat area does. The north side of the *mini*mountain will have a lower temperature than the south side, which faces the sun for most of the day. The moisture and amount of plant life differ from one of these small areas to another.

Measuring *Mini*climates

Here are four kinds of measurements that will help you compare *mini*climates of your own and get to know them.

1. Temperature—When you measure the temperature of a *mini*climate, always put the thermometer right at the soil surface. Keep a record in a notebook or on a chart of the daytime (noon) and the nighttime (just before bedtime) temperatures. It might be interesting to compare these with the weatherman's high and low reading.

2. Soil hardness—You can compare the hardness, or *compaction*, of the soil in different *mini*climates with the simple gauge shown on this page.

3. Soil porosity—Does water soak into the soil easily, or does it tend to stay on top? Cut out the ends of a small fruit-juice can, then push one end of the can firmly against the ground so water cannot leak out around the bottom. Now pour a measured amount of water into the can. Time how long it takes for all of the water to soak into the earth, and record the time. Do this for each *mini*climate you decide to explore.

4. Animal life—Look for signs of animal life in each *mini*climate. Signs might be burrows, tracks, wastes. You will be able to see ants, grasshoppers, and other such animals. Again, keep a list of the animal (and plant) life in each *mini*climate you explore.

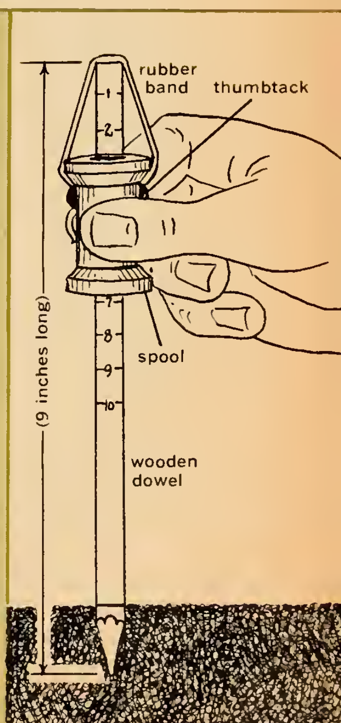
Most animals get on well in their *mini*climates. If they don't, they do not survive, or they move to a different place. The light-colored skins of some desert animals reflect heat from the sun, and so help keep the animals from becoming overheated. Certain insects fly close to the ground during the day, but in the evening fly higher. They are responding to a flood of cold air flowing down a nearby hillside or mountain and filling the land depression where the insects happen to be. Earthworms move deeper into the soil or nearer the surface as the moisture and temperature of the soil change. Some animals stay under or in a rotting log during the hot day, but come out in the cool of the evening. These are only a few of the things you can observe in *mini*climates. See how many other things you can find ■

(If you want to map a back-yard area of mini*climates, read the article on the next page.)*

Is the temperature the same at all sides of an anthill *mini*-mountain? All around a *mini*lake? (See cover.)

SOIL COMPACTION GAUGE

To make this soil hardness (compaction) gauge, get a wooden spool and a nine-inch length of dowel that will slide easily through the spool. (You can buy a dowel at a hardware store.) Sharpen one end of the dowel in a pencil sharpener, then mark a dark line around the dowel, one inch from the point. Mark lines each half-inch from the other end of the dowel and number them as shown. Fasten a wide rubber band over one end of the spool with thumbtacks, and place the spool over the end of the dowel. Rest the point of the dowel on the soil to be tested, and pull down on the spool, forcing the point into the soil. When the dark line is at the surface of the soil, read the number at the top edge of the spool. This number is a measure of the soil compaction.



MAPPING YO

As you explore the little world o
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■ Did you ever draw a map to show someone how to get to your house? Chances are that it wasn't nearly as accurate as a printed map—but then, it didn't have to be. If you showed streets and roads meeting and crossing at just about the angles at which they actually do meet and cross, then your friend probably was able to follow your map, even if it didn't show distances very accurately.

Suppose, though, that you want to record the locations of different "little climates" *(see page 6)* in your back yard, or in a vacant lot. Or you might want to show where different kinds of plants and animals live in that area. On a printed map, the area would probably be shown too small for you to mark the locations of such things. You can make your own map of the area, but to be of any use, it will have to show distances and directions more accurately than the map you drew to guide a friend to your home.

Mapping a Room

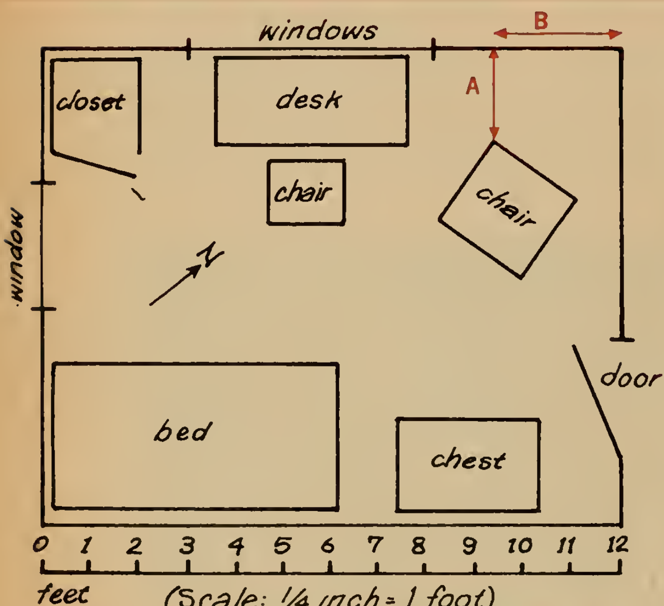
As a starter, you might draw a "practice" map of a room in your house and show where the furniture is located in the room. Suppose the room is 12 feet long by 10 feet wide. You could make the map that size, but it would take an awful lot of paper and it would never fold up to fit in your pocket. A map-maker solves this problem by drawing a map to *scale*.

By "scale," we mean that a certain distance on the map represents a certain distance in the room. For example, you could let 1 inch on the map equal 1 foot of distance in the room. Since the room is 12 feet by 10 feet, on the map it would be 12 inches by 10 inches.

If you wanted to fit the map on a piece of typing paper, which measures 11 by 8½ inches, you would have to make the scale still smaller. You could let ½ inch on the map equal 1 foot in the room. This would make the room on the map 6 inches long by 5 inches wide.

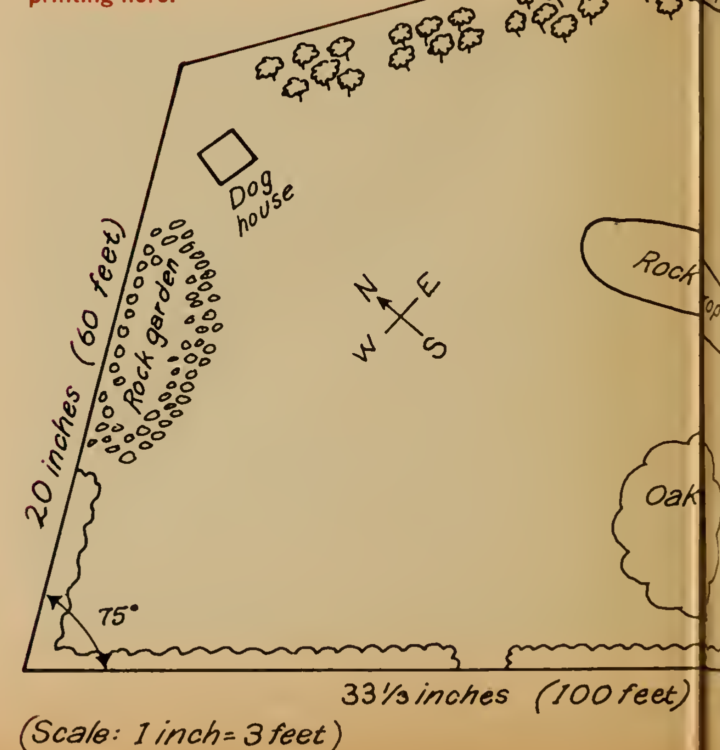
After you have selected your scale and drawn the outline of the room to that scale, you can add the *details*—the pieces of furniture you wish to show on the map. Measure the length and width of a chair, for example, and reduce these measurements according to the scale you used to draw the map of the room. The room map on this page shows you how to position a chair on the map as it is positioned in the room.

A room is usually easier to map than an outdoor area, because the room's corners are likely to be right angles, and there probably isn't a large boulder or a hill in the middle of the



Each ¼ inch of distance on this map represents 1 foot of distance in the room that was mapped. The compass arrow shows the direction in which the room is turned. In the room, the corner of the large chair is 2 feet from the nearest point on the wall (distance A) and that point on the wall is 2½ feet from the nearest corner of the room (distance B). On the scale of the map, distance A becomes 2 times ¼ inch, or ½ inch, and distance B becomes 2½ times ¼ inch, or ⅝ inch. By measuring distance B on the map, then distance A, you can find the point where the corner of the chair should be placed on the map.

This map of the author's back yard in Rangely, Maine, was drawn to scale, then reduced in size for printing here.



R BACK YARD

back yard, or a vacant lot, you
ep track of the little changes
life that take place there.

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loor to get in the way when you are measuring the distance across the room. Even so, you can go about mapping an outdoor area in just the same way as you mapped a room.

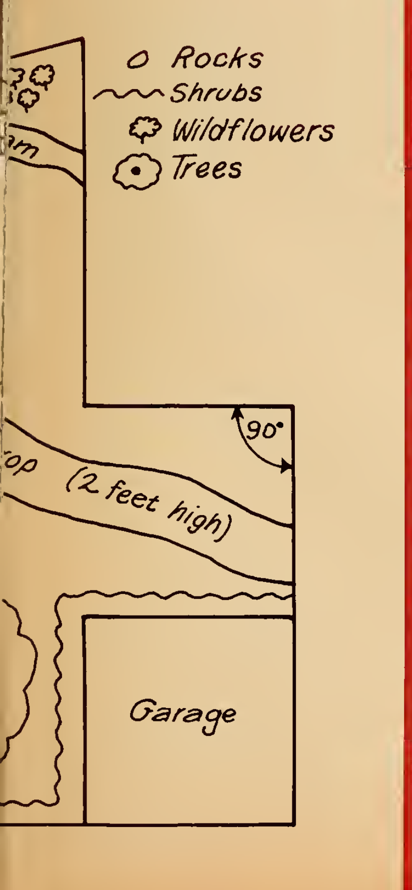
Mapping an Outdoor Area

Suppose that you are mapping your back yard, as shown below. First make a rough measurement of the area you are going to map, so that you can decide on a scale. Say that your yard is 75 feet by 100 feet. You might decide to let one inch on the map equal three feet of distance in the yard. Your map would be 25 inches (75 divided by 3) the narrow way, and 33⅓ inches the wide way. You could draw a map that size on a sheet of wrapping paper 36 inches square.

You might start by drawing the 100-foot side of the yard as a line 33⅓ inches long on your map. Using an angle measurer *(see box)*, you find that the 60-foot boundary line along the northwest side of the yard meets the 100-foot side at an angle of 75°. You can use the protractor from your angle measurer to draw a line at an angle of 75 to the end of the 33⅓-inch line. The new line will be 20 (60 divided by 3) inches long. By sighting on the boundary markers around your property, you work your way around the yard, measuring the angle of each corner and the distance of each side.

When you have drawn an accurate scale outline of your yard, you can start filling in the details. But which details do you want to include? For instance, if you were making a map in order to show the location of the different kinds of plants in your yard, then you would certainly want to show some detail about the wildflowers growing by the small stream along the northeast boundary line. Probably you would want to make up different kinds of picture symbols for the different kinds of wildflowers. You would also want to position each tree and shrub carefully.

Again, when you start to fill in the details, don't try to include *everything*. Select carefully. And if the things you decide to include are large enough to show to scale, measure them and draw them to scale on your map. A tree or shrub can be drawn to scale on your map, but it would be hard to show all of the rocks in the rock garden to scale. However, if you were making a map of the rock garden alone, you could use a scale that would let you show the size of each individual rock and flower if you wanted to. You can see how important it is to select a scale that lets you show exactly what you want to show, and in enough detail ■

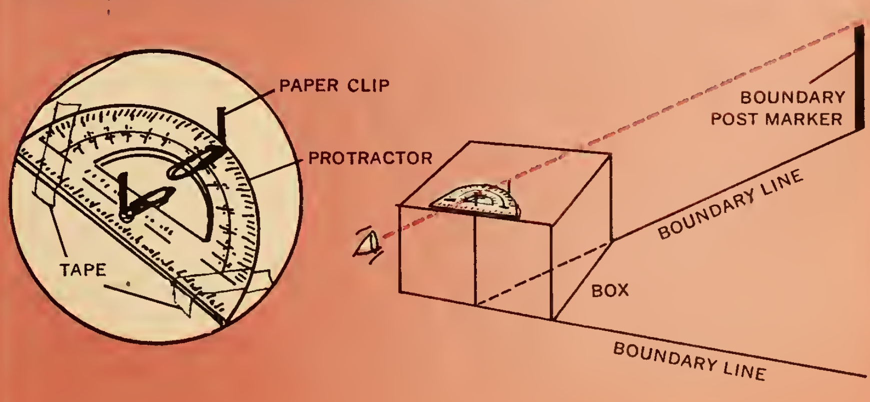


AN ANGLE MEASURER

You can make an angle measurer by taping a protractor to the top of a cardboard box. Make sure that the straight edge of the protractor is even with one edge of the box. Two paper clips bent as shown make good sighting markers.

Line up the straight edge of the protractor along a boundary line of your yard. Now sight along the paper clip marker that is fixed in the center hole of the protractor toward the boundary post marker at the end of the boundary line. Now place the second paper clip marker on the edge of the protractor so that it is exactly in your line of sight. Read the angle off the correct scale on the protractor. That is the angle of the corner you are measuring.

Can you figure out a way to use your angle measurer to position an object on your map, instead of measuring the distances from the object to the nearest boundary and from there to the nearest corner?



Dinner for My Dragonfly

By John Eastman

A young dragonfly is a deadly hunter in its underwater world. I kept one in my home to watch it capture and eat small water animals.

A dragonfly nymph waits for a small fish to come near. Its jaw flicks out, stabbing the fish. Then the jaw folds back, bringing the fish into the nymph's mouth.

■ Last summer, I captured a neck-twisting, jaw-thrusting, mosquito-eater—and kept it in a dish of water on my kitchen table until spring. It was a young dragonfly, called a *nymph,* and it's a lively kind of insect that you, too, might enjoy watching.

I investigated mainly the eating habits of my nymph, for the eating equipment of a dragonfly is special. The nymph's jaw bends in the middle and is folded back under the head most of the time. When capturing prey, however, a nymph flicks its jaw forward *(see photos),* as far as one-third the length of its body. A pair of sharp hooks at the tip stab the prey. Then the nymph draws its jaw back, carrying the food to its mouth as if the jaw were a spoon.

Dragon's Feast

Young dragonflies, I learned, will eat just about any kind of water insect—including other young dragonflies. I put several nymphs in one dish. In two hours, the dish was strewn with parts of nymph bodies. Only one large nymph remained, and that was the one I kept.

My captive nymph ate a great variety of insects and other small animals—crickets, house spiders, snails, small bloodworms, mosquito *larvae* (called "wrigglers"). The pond where I had caught the nymph did not have all of these kinds of food. There, young mosquitoes seemed to be the main nymph food. *Adult* dragonflies eat *adult* mosquitoes. So the dragonfly is a *predator* of mosquitoes during both the swimming and flying parts of the life cycle of these two insects.

In a pond, nymphs eat only live insects. In captivity, my nymph would eat dead insects if they had been dead only a short time—and if I wiggled them on the end of a broom straw to make them seem alive. The nymph didn't try to capture insects, dead or alive, that did not move, even if they were nearby. Because of this, I concluded that a dragonfly nymph finds food by *seeing* something move, and not by touching or smelling the prey. Besides, the antennae ("feelers") that dragonflies have for both feeling and smelling are tiny, but the eyes are immense.

The Capture

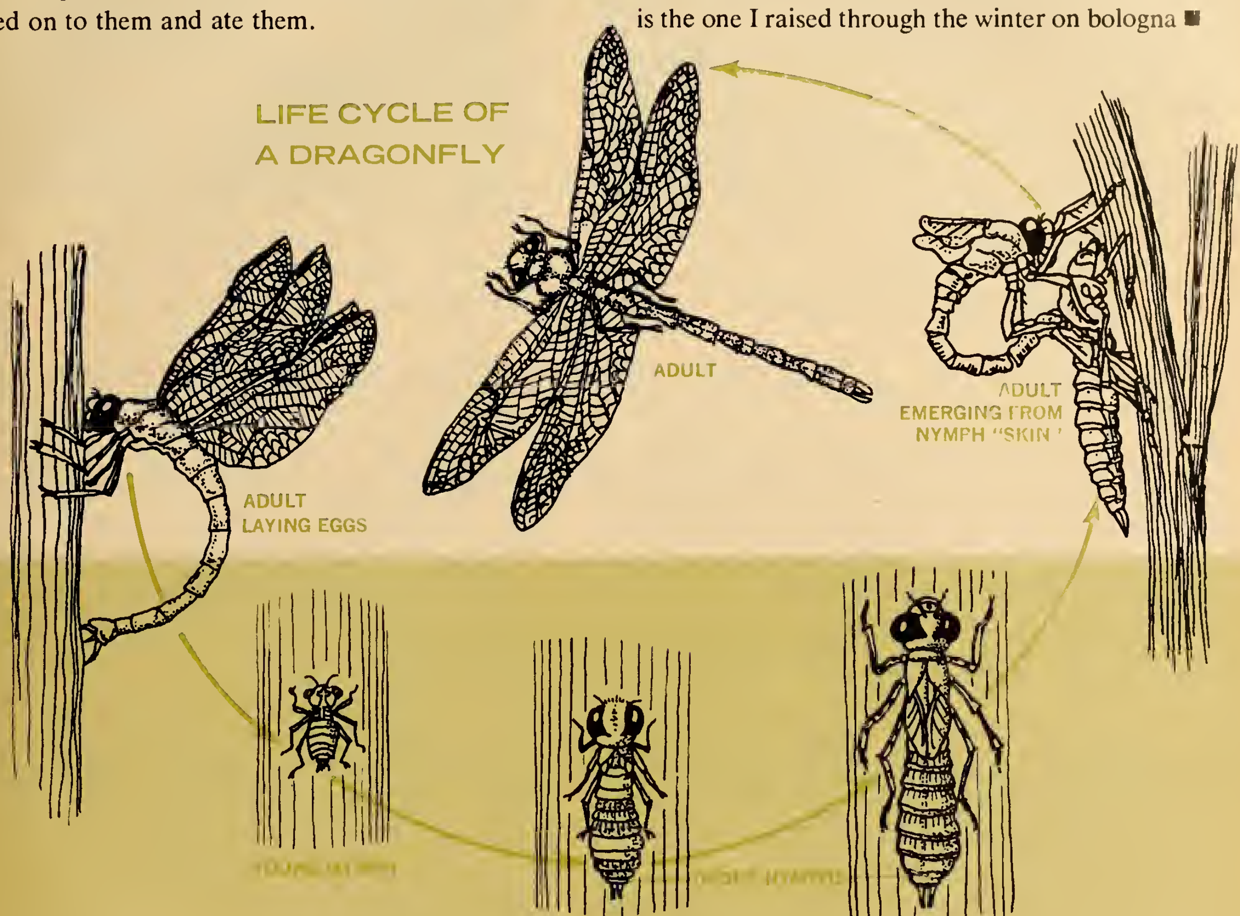
My nymph didn't always capture animals moving near it. A mosquito "wriggler" moves very fast, and quick motions seemed to confuse the nymph. It would watch a rapidly-moving insect for a while, but sometimes would then lose track of it altogether.

A successful capture of food was quite exciting to watch. The nymph would walk very slowly, with a sliding sort of motion. When it sighted movement, it stopped, and followed the prey only with its eyes. To keep the prey in sight, it turned its head—something that few insects can do. As the prey came nearer, the nymph stretched its body forward. Then out snapped its jaw, and the sharp hooks fastened. If the victim was the same size as the nymph, or larger, the nymph would twist from side to side, trying to keep hold. Finally, the nymph folded back its jaw, and slowly ate the prey.

In the winter I found few insects, and I worried about what I would feed my captive nymph. I began to try other kinds of food. I discovered that the nymph would not eat bits of cheese, the yolk of a hardboiled egg, or cooked chicken. Then I tried bologna—and found that if I wiggled little pieces of it in the water, the nymph quickly hooked on to them and ate them.

Bologna seemed like rather "tame" food for an insect that had once preyed on creatures beneath the surface of a pond. But my nymph survived, and grew so much that it had to shed its skin, or *molt*, three times while under my care.

In the spring, I returned the nymph to the pond where I had found it. It was then about two inches long, and I could already see "buds" where the wings would develop. Now, many winged dragonflies are darting around the cattails in that pond—and I can't help wondering which is the one I raised through the winter on bologna ■



WATCHING YOUR OWN NYMPH

You too might want to raise a dragonfly nymph of your own, and observe it as it grows. Here are a few suggestions to help you begin.

- Dragonfly nymphs can be found near the shores of a lake or pond. They cling to the underwater parts of plant stems, sunken logs, and dock pilings. They are spotty green-brown in color, and about one-and-a-half inches long *(see drawings)*. Collect nymphs of several different sizes so you'll probably have nymphs of different ages. Keep each one in a water-filled container along with a few twigs. (Use water that has been standing uncovered for several days, and change it when it is cloudy.)
- Investigate the eating behavior of the nymphs. Will your nymphs "attack" a moving pencil point, or a bit of dark paper? How near does a small object have to be before the nymphs seem to notice it?
- Watch the nymphs move in a shallow dish. How does water help them move? Do you think the water is useful to them for anything else?
- Do the nymphs seem to prefer a background of a certain color? Tape white paper to half the outside of each of several clear dishes, and brown or green paper to the other half. Then put a nymph and water into each dish. Check daily to see which side most of the nymphs are on.
- Your nymphs will probably *molt* about once every two months. What changes occur with each molt? Look at body length and color pattern, and watch for the appearance of tiny holes on the side (to be used by the adults for breathing out of water), and the growth of "buds" on the back. Can you arrange your nymphs in order of age?
- The hour-or-so in which a bright-colored, adult dragonfly emerges from a dull-colored, crawling nymph is a fascinating one. This happens in the summer. Look for a large nymph crawling *above water* on a twig, and wait for it to change into an adult. Let the adult dragonfly go outdoors once its wings are dry.

"Conditioning" Your Pets

by Frank Wesley

A famous scientist discovered this way of training animals to obey different signals. You can find out more about how it works by trying it on your dog and other pets.

A. In Step 3 of discrimination training, Dr. Frank Wesley sends their dog Coin to his daughter Claire by pointing to her and saying her name.

■ Training a pet dog to come to you when you say "Come here" is fairly easy. You can do it best at a time when the dog has not eaten anything for three or four hours and is hungry. Just hold up a piece of food, and the hungry animal will come toward it. As the dog starts toward you, say the words "Come here." When it reaches you, give the animal the food, as a "reward."

Do this over and over, using small pieces of food so the dog doesn't lose its appetite. After you have done this about 10 to 20 times, the dog will probably come to you when you say "Come here," even when you do not hold up any food. This means that the dog has learned to accept the words "Come here" as a *cue*, or signal, for coming. This new cue can be used in place of the "natural" cue (food) to make the dog come to you.

Timing Your Cues

In the early 1900s, the Russian scientist Ivan Pavlov investigated this kind of simple learning, which he called *conditioning*. He experimented with dogs for more than 50 years, trying to find some general "rules" for conditioning animals, including humans. One thing he found was that giving an animal a new cue just *before* it is given a familiar cue speeds up the conditioning process.

This means that if you want to train your dog to come when you ring a bell, for example, you should ring the bell (new cue for coming) about half a second before you hold up the food (old cue for coming). (One of Pavlov's students tried giving a dog the food first, and then ringing the bell. He did this about 500 times, but the dog never learned to come when the bell was rung but no food was offered. Can you guess why?)

Pavlov also found that a dog or other animal must be given a reward at least once in a while when it responds to a cue. Otherwise it loses its conditioning. When you call your dog, you must reward him every once in a while with food or petting. If he does not come very often when you call, you probably have called him too often without rewarding him.

Learning More than One Cue

Once your dog has learned to come when you say "Come here," try to train it to perform one act when you give it one command and a different act when you give it a second command. (Pavlov called this type of learning *discrimination*, because the animal has to *discriminate*, or tell the difference, between the two commands.) You could get two friends to help you, and train the dog to go to the helper whose name you call out.

You can do this best in a place and with helpers that are familiar to your dog. It should be a quiet place with no one else around. Your dog should not have had food for three to four hours before the training session. (If it is *too* hungry, it will be too interested in the food to pay attention to its task.)

Before you begin the training, prepare the reward. You could use ½-inch-thick frankfurter slices, or any other food your dog likes. Wrap each piece in plastic food wrap, and give each helper about 15 pieces in a plastic bag he can keep in his pocket. (Your dog should not be able to smell or see the food that is left after your helper gives him a piece as a reward.)

Dr. Frank Wesley is a Professor of Psychology at Portland State College, in Oregon.

. Coin receives a reward from Claire's brother Walter for oing to him at Dr. Wesley's command. (This is still part of tep 3.)

C. In Step 4 of the training program, Claire and Walter have changed positions to make sure that Coin is discriminating between their names, and not their positions.

Arrange yourselves in a triangle formation, about five ards apart for indoor training, or about 10 yards apart or outdoor training (*see photos*).

It will be easiest for your dog to learn to discriminate etween your helpers' names if you give the dog as much elp as possible in the beginning, and less help as the training goes on. You might follow these steps:

STEP 1. Kneel down and hold your dog with one hand. Point the other hand to one of your helpers (let's call him "David"), and say "Go to David." Release the dog and ay "Go to David" once or twice again.

As soon as you have said this, David should call the dog by saying "Come here" once or twice. With all this help. your dog should go to David. If it doesn't, then lead the log to David for the first few trials.

As soon as the dog reaches David, it should be given one piece of food, which your helper can unwrap as the log moves toward him. When the dog has eaten its reward, call it back to you. Rest with the dog beside you for a few seconds. Then send the dog to your second helper (we'll call her "Mary") in the same way you sent the dog to David.

Keep sending the dog to one helper or the other, but not n any regular pattern. For instance, you might send it to David, then Mary, Mary, David, Mary, David, David, and so on. If the dog goes to the wrong helper, it should not be given any reward; just call it back and start the next trial. Do not punish the dog at any time during the training session, though. Punishment might make it dislike the training, and this would make learning more difficult.

After your dog has had about 10 trials with no errors—or only one or two—you are ready for Step 2.

STEP 2. Repeat Step 1, but without your helpers' telling the dog to "Come here." If the dog makes more than two or three mistakes in a row, repeat all of Step 1 a few times. But if it performs Step 2 correctly about five times, go on to Step 3.

STEP 3. Keep on as in Step 2, but instead of saying "Go to Mary," say only the helper's name, "Mary," pointing to her as you say it. When your dog has performed correctly several times with each helper, try Step 4.

(Continued on the next page)

Use This in Training Your Dog To Discriminate

Here is a handy list of the cues to give your dog during each step of the discrimination training program described in this article. Notice that the cues get fewer and fewer until only one is left—the one you are training the dog to discriminate and obey.

STEP 1. a) Your command: "Go to (name)"
b) Point
c) Helpers in same positions
d) Helper's call: "Come here"
e) Lead dog to helper, if needed

STEP 2. a) Your command: "Go to (name)"
b) Point
c) Helpers in same positions

STEP 3. a) Your command: "(name)" only
b) Point
c) Helpers in same positions

STEP 4. a) Your command: "(name)"
b) Point

STEP 5. a) Your command: "(name)"

STEP 4. Same as Step 3, but have your helpers trade positions now and then. That way you can be sure that your dog is able to tell your helpers apart by *name,* and not just by the places where they are standing.

STEP 5. Stop pointing. Simply say the name of the helper you want the dog to go to. When the dog has done this correctly a few times, and has been rewarded each time, it will probably go to the helper you name from then on, without pointing-help from you, calling-help from him, or even a show of food.

In this way you can condition your dog to discriminate between two different cues and to act differently when you give it one cue or the other. Notice that you begin by giving the dog new cues (pointing and saying "Go to David" or "Go to Mary") along with familiar cues (your helpers' saying "Come here" and showing food). In each step of the training you stop using one of the cues, until the only ones left are the new cues you want your dog to act on.

How long it takes you to condition your dog in this way depends on the intelligence of your dog, how calm it is, and how well you have taught it each step before going on to the next. You can give your dog perhaps 30 trials a day, if you divide them into two sessions with a long rest period in between. You might finish the training in two days, but it is just as well to give fewer trials per day and take longer.

Some dogs have learned to discriminate between 20 words or so and perform a different act when each word is used as a cue. How many words can your dog accept as cues for different kinds of action? ■

INVESTIGATIONS

- Can you condition your dog to act on a *visual* cue, instead of a spoken one? How would you train it to go to the helper you *point* to, for example, instead of the one whose name you say?
- How long will your dog remain conditioned to a particular cue if it is not given some reward (food or petting) now and then when it acts correctly? Does this depend on how many times the dog is given the cue without being rewarded? On how much time passes between the trials for which it is rewarded? Both?
- Can you condition another kind of pet animal —say a cat, goldfish, turtle, or canary—to come toward you "on command"? You might try using such things as a bell, a whistle, a flashlight, or a bright-colored object as the new cue, and the animal's regular food as the old cue. Can you train the animal to discriminate between two cues?
- Can you think of any particular cues that *you* are conditioned to act on? (Remember, there are other kinds of rewards besides food.)

How does your crystal garden grow?

With some simple equipment, some commo chemicals, and a little patience, you can gro crystals like the ones shown in this enlarge photograph, and other kinds as well.

■ A diamond, a snowflake, a grain of salt, the graphite in a pencil—all are alike in one way. All are *crystalline* substances—substances whose atoms or molecules are arranged in a particular pattern that is always the same for each substance. Crystals are not living things, but they do have a way of "growing." And although you can't grow a glacier or a snowflake, you *can* grow some other kinds of crystals with materials from a drugstore *(see list)*.

MATERIALS YOU WILL NEED FOR GROWING CRYSTALS

- A one-quart, wide-mouth glass jar with screw-on cap, and another large container.
- A half-pound of potassium alum, in lump form if possible, or in powder form. Ammonium alum can also be used.
- A postage scale or other small scale.
- A measuring cup.
- An old drinking glass.
- An old spoon (*not* made of aluminum).
- Needle and thread.
- Scissors.
- Sticky tape.

Crystals grow as the atoms or molecules that make up a substance arrange themselves into regular patterns throughout the substance. There are many different ways that the atoms or molecules can arrange themselves, but for a particular substance the pattern is always the same.

The pattern of the molecules in some solids can be broken up if the substance is put into a liquid, such as water. When the molecules of the solid are mixed freely with the molecules of water, they are said to be dissolved, or *in solution (see "Making Solids Disappear,"* N&S, *March 17, 1969)*. Warm water can hold more molecules of a substance in solution than cooler water can hold. You can grow a crystal by first packing an amount of warm water with all the molecules of a substance that it can hold, then letting the water cool. Crystals will form as some of the molecules of the substance come out of solution in the cooler water.

Growing a Crystal

When you have collected the materials shown in the list, your crystal-growing can begin. How carefully you perform the following steps will determine how good your results are.

1. Place the glass jar upside down on a piece of cardboard and trace the outline of the jar's mouth with a pencil. Cut out the disc with a pair of scissors and put it aside to use later.

2. Use a measuring cup to pour 19 fluid ounces of water into the jar, then screw the cap on *loosely*. Place the jar in a pot about half full of water, and heat the pot until the water in the pot simmers. Weigh out four ounces of alum, and add it to the water in the jar, stirring as you add. (Do *not* use an aluminum spoon.) When all of the alum has dissolved, turn off the heat.

3. Use a potholder or towel to remove the jar from the pot; then tighten the cap and seal the jar to keep the water from evaporating. Masking tape or adhesive tape wrapped around the edge of the cap and overlapping the glass will make a good seal. Next, place the jar on the floor of a closet, or in some other place in your home where the jar will not be disturbed and where the temperature always stays about the same.

4. After at least two hours, examine the jar. By this time the liquid in the jar should have cooled to about the temperature of the closet, and crystals should have begun to form. If they have not, open the jar and drop in half a dozen pinhead-size crystals (or a pinch of powder) from the supply of alum you got at the drugstore. Then reseal the jar, shake it a few times, and put it back in the closet. Small crystals should now begin to form in the solution.

5. Leave the jar in the closet for at least two days, swishing the liquid around twice each day by gently shaking the jar. Each time you shake the jar, take a good look at the crystals that are forming and growing larger on the bottom of the jar. When the crystals have stopped growing, you will be ready for the next step. If you are not sure whether the crystals have stopped growing after two days, leave the jar in the closet another day or two. Don't try to rush the process along.

6. When you are sure that the crystals have stopped growing, pour off just enough of the liquid into a drinking glass so that the liquid is just one quarter of an inch deep in the glass. Reseal the jar containing the leftover liquid, or *stock solution*, and put it aside. Let the drinking glass stand uncovered in the closet for a few days while crystals form, as before.

7. Look at the glass twice each day, rocking the liquid gently each time. If some of the crystals in the glass begin to grow together, separate them and weed out the smaller ones with tweezers. It is important that the larger ones have room to grow without being crowded. When some of the crystals have grown about ⅛ to ¼ inch in size, take them out of the glass and dry them on a paper towel. These are your "seed" crystals *(see photo)*, which you will use to grow larger crystals.

8. Now unseal the stock-solution jar and pour all of the liquid into a clean container. Be careful not to let any loose crystals spill into the container. The crystals that

(Continued on the next page)

Crystals grown to about ⅛ to ¼ inch in a glass, then removed and dried, are "seeds" for growing larger crystals.

Your Crystal Garden (continued)

have formed on the bottom of the stock-solution jar can be taken out and added to the original supply of crystals you bought. Then the jar can be rinsed out and dried.

9. Next, pour your stock solution back into the jar, and add ¾ of an ounce of alum to it from your original supply. Heat the solution as in step 2, stirring until all of the alum is dissolved. Then reseal the jar, now containing your growing solution, and put it in the closet to cool.

10. While you are waiting, tie a piece of strong thread about a foot long around one of your seed crystals. Attach the other end of the thread to a needle, and use the needle to punch a hole in the cardboard disc you cut out in step 1. Pull the thread part-way up through the hole with the needle, then remove the needle.

11. After the growing solution has been in the closet for at least two hours, unseal the jar and lower the seed crystal into the solution. When the cardboard disc comes to rest on top of the jar, pull the thread up or down through the hole so that the seed crystal hangs about half-way down into the solution *(see diagram)*. Use a piece of sticky tape to hold the thread in place; then cap and seal the jar, and put it back in the closet for several days.

12. Examine the jar every day, but do not touch it. The crystal hanging on the thread should grow larger and larger. When you are sure that the crystal has stopped growing, you can remove it from the solution, dry it on a paper towel, and use it to begin your crystal collection.

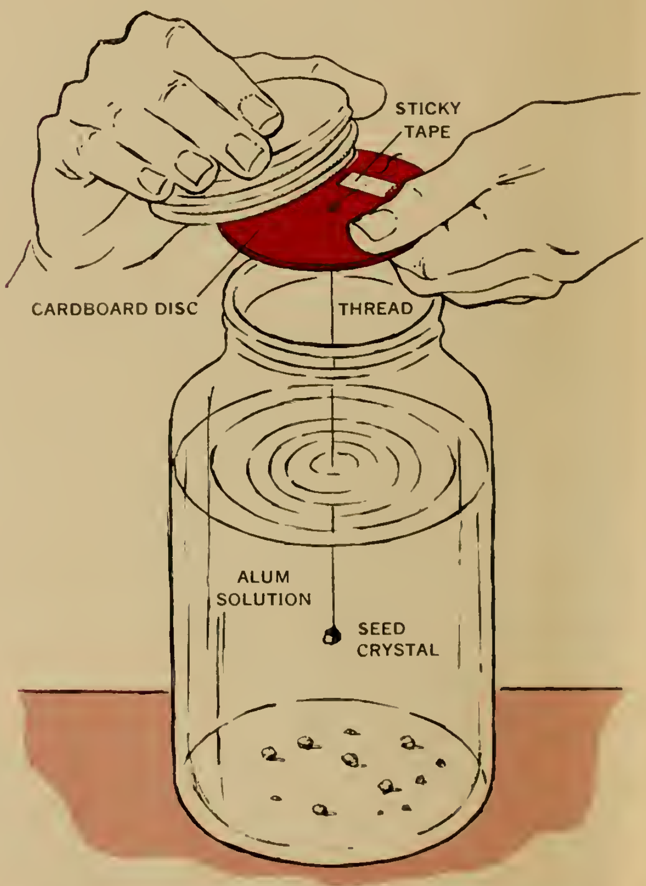
How Does Your Garden Grow?

If the crystal you have grown is cloudy in appearance, you may not have used quite enough alum. You can try it again, using the same stock solution you used to grow the first crystal. Each time you grow a new crystal or remove seed crystals from the stock solution, weigh them on your scale so that you can replace them with about the same weight of alum from your original supply. Heat and stir the solution each time to dissolve all the alum. The tiny crystals that form on the bottom of the jar can be put back into your alum supply each time and used over again.

Can you grow a crystal that is "crystal clear"? How large a crystal can you grow? Does the temperature of your growing solution have an effect on the size of the crystal? What happens if you keep the growing crystal in a warmer or cooler place?

Crystals of other shapes and colors can be grown with other substances that you can get at the drugstore or at a scientific supply house. The books listed below will tell you how to go about it. How colorful a garden can you grow?—MARTIN L. KEEN

■ Look in your library or bookstore for these books about crystals: **Crystals and Crystal Growing**, by Alan Holden and Phylis Singer, Anchor Science Study Series, Doubleday & Company, Inc., Garden City, N.Y., $1.45; **The Curious World of Crystals**, by Lenore Sander, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1964, $3.75.



This diagram shows how the "seed" crystal is hung by a thread from a cardboard disc that rests on top of the jar (see steps 10 and 11).