nature and science

Volume 7, Numbers 1 - 16

1969 - 1970

REF

nature and science

TEACHER'S EDITION

VOL. 7 NO. 1 / SEPTEMBER 15, 1969 / SECTION 1 OF TWO SECTIONS

Is nature and science . . .

rel·e·vant \'rel-ə-vənt, *substand* 'rev-ə-lənt\ *adj* [ML *relevant-, relevans,* fr. L, prp. of *relevare* to raise up — more at RELIEVE] **1 a :** bearing upon the matter at hand **:** PERTINENT

?

■ Through articles that your pupils will *want* to read, *Nature and Science* will take them on nearly a hundred "expeditions" this year, to explore specific aspects of nature in places as near as the kitchen sink, as far as the distant stars *(see "Previews" on page 4T).*

It will take them into the field, laboratory, and observatory to see how scientists of different disciplines study the ways our world is constantly changing, and how changes in one thing affect many others.

Through SCIENCE WORKSHOPS, projects, and investigations, *Nature and Science* will show your pupils how to observe and test the processes and "laws" of nature in a scientific way, and help them to relate their findings, and those of scientists, to their own lives.

All of this is instructive, exciting, and fun. But how *relevant,* how necessary, is it for your pupils to experience?

Not so long ago, it didn't seem to matter much whether many people understood how things change or how scientists find out about them. It seemed that through "science" and technology we could change the world to suit our desires—without thought, much less fear, of the consequences.

At last—and none too soon—we are awakening to the results of our short-sighted efforts to make life more "comfortable." We see ourselves—the crew of "spaceship earth"—outgrowing our supplies of food and other materials we have come to depend on. We see our wastes, pesticides, and even fertilizers overburdening natural processes and making the air, water, and land unfit for life. We see many fellow animals aboard our ship dying out as we take over their living spaces.

Many people blame our plight on the objective approach of science, instead of on our ignorance in using scientific discoveries. As a result, many students are turning away from science in favor of more subjective courses in the humanities, and many people are exploiting their sensations as an escape from the real world. But we can't escape from our world, and feelings and emotions are no substitute for information, understanding, and reason in dealing with it.

Science tells us how nature works; what we do with that knowledge depends on our understanding of it and on our values and goals. Now, more than ever before, man's survival depends on the decisions we—and, soon, our pupils—make from day to day. To this "matter at hand," nothing could be more relevant than *Nature and Science.*—FRANKLYN K. LAUDEN

FREE **10 ENLARGED NATURE AND SCIENCE WALL CHARTS with your order for 15 or more subscriptions for the 1969-70 school year. Please use the convenient order card bound into this issue.**

PREVIEWS OF UPCOMING ARTICLES ON PAGE 4T

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

How Do Wheels Roll?

This SCIENCE WORKSHOP article suggests ways for your pupils to compare the differences and similarities between wheels and investigate some of the characteristics of rolling wheels. You can help your pupils formulate a definition of a wheel and find out how wheels help us do work.

What Makes It a Wheel?

Can your pupils add some other kinds of wheels to the list at the beginning of the article? How about a steering wheel? Is a screwdriver a wheel? Is the crank on a pencil sharpener? To decide, your pupils will need a definition of a wheel. (What does the dictionary say?) Your pupils can work out a useful definition by finding out how wheels are alike and how they differ from other objects.

Have them try to agree on answers to the following questions about each wheel on the list, then write a description of each kind of wheel.

1. *How big is the wheel?* (Rough estimates of diameter will suffice.)
2. *What shape is it?* (Is the outside edge, or rim, circular? Is the wheel flat, or fatter in the center than at the edge, or some other shape?)
3. *Is it solid, or does it have spokes or holes in it?*
4. *How many parts does it have?*
5. *What material(s) is it made of?*
6. *Does the wheel rotate, or turn around a center point?*
7. *Does the wheel rotate freely around an axle, or do the wheel and axle turn together?*
8. *What makes the wheel rotate?*
9. *What does the wheel do?* (Roll over the ground or other surface as it turns? Turn something else—an axle or another wheel, for example? Or does it do something else?)

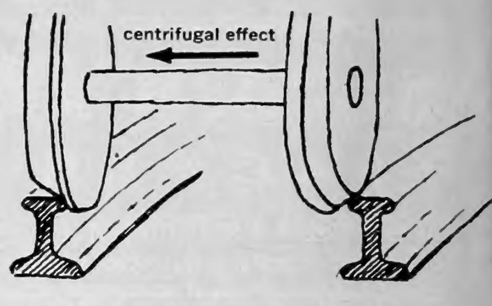
Is the answer to any of these questions the same for all of the wheels? (If your pupils think the rims of all the wheels are circular in shape, then a pencil-sharpener crank is not a wheel. But what about the teeth sticking out from the edge of a gear, or the handles sticking out from the edge of a ship's steering wheel?)

Your pupils will find that the answer to Question 6 is the same for all wheels on the list. Does this mean that any object that turns around a center point is a wheel? Is the earth a wheel? The answers to Question 9 should show that each wheel does *work* as it turns; it helps move something else, either by rolling or by turning an axle or another wheel. This makes the wheel a *machine*—a man-made object that helps us do work. Could you define a wheel as *a machine that turns around a center point?*

The earth is not man-made, so it is neither a machine nor a wheel (though it moves a great many things as it rotates). A screwdriver is a wheel (the handle) that turns an axle (the bit) as the wheel is rotated. The pencil-sharpener crank is a wheel consisting of a single spoke that rotates around a center point and turns the sharpener shaft (axle).

How Does a Wheel Help Do Work?

• Have a pupil try to pull a wagon over rough, unpaved ground, first with the wagon turned upside down and a pupil sitting on it, then with the wagon rightside up and the same pupil sitting in it. Your pupils can see that the rolling wheels eliminate most of the *friction*, or rubbing, between the wagon and the ground, so the wagon and passenger can be moved with less pulling. Does the wagon seem twice as hard to pull upside down as when it rolls on wheels? Three times as hard? Record the guesses.



Compare this diagram with the one on page 3 to see how railroad car wheels "adjust" in diameter to take curves without skidding. The moving car and wheels move toward the outside of the curve, like a weight swung in a circle on a string (the centrifugal effect). The outside wheel's largest diameter now touches the outside rail, and the inside wheel's smallest diameter touches the inside rail. The outside wheel travels farther, though both wheels and the axle turn together.

Attach a spring scale to the wagon handle and—minus the passenger this time—have someone pull the wagon upside down and rightside up and measure the pounds of pull it takes each way. Borrow a spring scale from the high school physics lab, or use a new screen-door spring from the hardware store and measure the distance the spring stretches when the wagon is pulled. Either way, try it first to make sure the wagon can be moved without stretching the spring to its full length. With a weak spring, use a smaller wagon, or similar object on wheels. Your pupils will probably be surprised at how much pulling is saved by rolling wheels.

• Have your pupils try to sharpen a pencil by turning the crank where it is attached to the shaft, instead of by the crank handle. Or have a custodian remove a door knob from its shaft so your pupils can try to turn the shaft with their fingers. Does the crank or knob do anything more than provide a better grip?

To find out, turn a bicycle upside down. Hang a weight on a string from

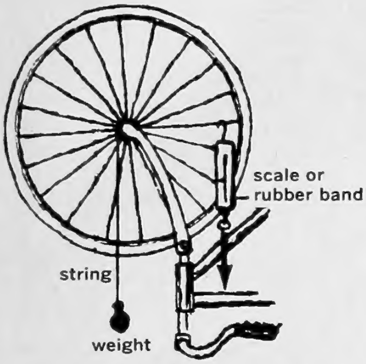
(Continued on page 3T)

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.

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

the axle end of a horizontal spoke in the front wheel *(see diagram).* Then hang a spring scale (or a rubber band attached to a paper clip) from the spoke on the opposite side of the



wheel. By pulling the scale straight downward, from the axle end of the spoke, from the middle, then from the rim end of the spoke, your pupils will find that the farther from the center they apply the turning force to the wheel, the less force it takes to turn the axle and raise the weight.

If your pupils have studied levers, they may recognize the wheel and axle as a lever that can turn continuously around the fulcrum (center point). The force arm is measured from the center to the point where the force is applied; the resistance arm, from the center to the outside edge of the axle (or wherever the weight is attached). The rim of a steering wheel is simply a continuous handle for turning the spokes, which act as levers to turn the steering column.

Lizards of Komodo

Why study the monitor lizards? First of all, to find out whether they are dying out, holding their own, or increasing in numbers. Information about their breeding habits and reproduction may help zoos breed captive monitors so they will not need to take more of the lizards from the wild. More and more, zoos are trying to raise new generations from their captive animals. Someday surplus animals from zoos might even be used to restock wild populations.

Brain-Boosters

Mystery Photo. The roots of most trees grow almost entirely underground. The roots shown in the photograph are above ground because the soil surrounding them has been *eroded,* or carried away by wind and water.

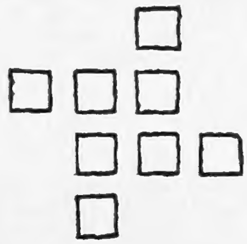
You might take your pupils out into the school yard to look for examples of erosion. Examine the edges of asphalt paths and the soil near playground equipment. Grass is unable to grow in places where people are always walking, and the unprotected soil is gradually carried away by rainwater runoff, or blown away by the wind when the soil is very dry.

What will happen if? Have your pupils bring in some soil from various places for a demonstration in class. Shake up the different kinds of soil in water-filled jars, and set them on a table where they can remain undisturbed for several days.

The soil particles will settle to the bottom of the jar in order of size: small rocks first; then gravel; then a layer of sand above the gravel. After several days, the clay particles should form a thin layer on top of the sand, leaving the water clear.

Can you do it? Air escapes slowly from a balloon through tiny pores in the balloon's rubber "skin." If any of your pupils can think of a way that might stop or slow down this process, let them try it. Hang the balloons from the classroom ceiling, and let the class observe them over a period of several months. For comparison, hang up at least one balloon that hasn't received any special treatment.

Fun with numbers and shapes. Here is one way to arrange eight sugar cubes so that each cube is at the end of a line of three. You might hand out



some sugar cubes and see whether any of your pupils can come up with this arrangement, or its mirror image.

For science experts only. A large oak tree may have more than 200,000 leaves. If possible, take the class outdoors to estimate the number of leaves on a nearby tree. Begin by counting the number of leaves on a small branch. Then count the number of small branches on a larger branch, the number of large branches on a still larger branch, and so on. By multiplying all the figures together, you can figure out the approximate number of leaves on the tree.

World Within the Water

Some of the water animals mentioned in this article can be "enlarged" for classroom viewing with an overhead projector or a slide projector in which slides are inserted by hand, one at a time.

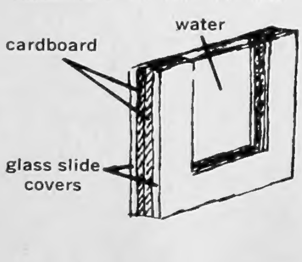
A shallow glass dish containing the creatures can be placed on the stage of the overhead projector. For the slide projector, make a "micro-aquarium" slide to hold the animals, using two glass slide covers (two inches square) from a photographic supply store, some ⅛"-thick cardboard, and Duco cement.

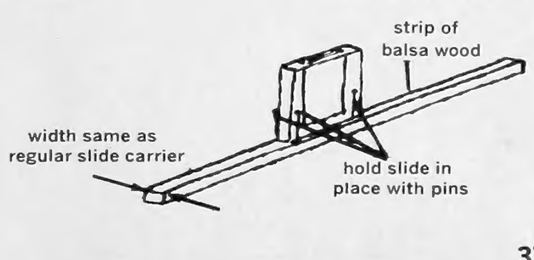
Cut two identical U-shaped pieces of cardboard to fit between the two glass slides *(see diagram).* Cover the edges and both sides of the cardboard pieces with cement, then sandwich them between the glass slides. Allow to dry overnight, pressed down with heavy books.

Remove the regular slide carrier and make a simple slide carrier as shown in the diagram. Use a medicine dropper to fill the slide with pond water.

Heat may kill the animals if you leave the slide in the projector for more than a few minutes. This sort of slide can be used to project views of hydras and planaria as well as of small water insects.

—Catherine M. Pessino





PREVIEWS OF COMING ARTICLES AND SPECIAL-TOPIC ISSUES

HOW DO WE KNOW THE EARTH IS SPINNING? A SCIENCE WORKSHOP investigation of spinning turntables leads into this account of the Foucault pendulum and how air masses, ocean currents, and rockets appear—from our rotating frame of reference—to be moving. Plenty of projects to promote understanding.

THE UNDERWATER WORLD OF THE WEDDELL SEAL A team of biologists donned SCUBA gear and swam in near-freezing water to watch the seals that hunt for food under the ice of the Antarctic Ocean.

MAN THE MEASURER This series of three articles by award-winning science writer Roy A. Gallant tells how our systems of measuring have developed and examines the advantages and problems of adopting the metric system in the United States.

THE HOWS AND WHYS OF EXTINCTION What caused the mysterious "die-offs" of so many animals in the past? What is being done to save the many species now endangered?

QUICKSAND! Wagons, trucks, and even a locomotive have been caught and buried in wet sand. Your pupils can test its capacity to bury objects in the same way a scientist did.

THE SECRETS OF GULL ISLAND A naturalist tells how she and other volunteers first worked to make a small island more livable for shorebirds, then began studying the thousands of birds that now nest there.

ENERGY FROM THE CENTER OF THE ATOM This series of articles describes man's changing views of the atom, tells how scientists unlocked the secret to nuclear energy, and explores the benefits and dangers of putting it to work. By award-winning science writer Roy A. Gallant.

TRASHY READING Articles about trash, litter, and other cast-off materials, the problems of waste management, thermal pollution, the buildup of carbon dioxide in the atmosphere, and other threats to life on Spaceship Earth.

DEAD MEN DO TELL TALES Two anthropologists recount their experiences in "reading" bones for clues to the lives of long-dead humans.

GIANTS OF THE DESERT Years of study have produced a fascinating picture of the life of the towering saguaro cactus and how it affects, and is affected by, other life of the desert.

SWITCHING THE EARTH'S MAGNETIC POLES Evidence from the spreading sea floor shows that the polarity of the earth's magnetism reverses over long periods of time. This SCIENCE MYSTERY article presents theories about the cause, as well as the reversal, of earth magnetism.

WHEN A RATTLER STRIKES . . . A SCIENCE ADVENTURE about the work of scientists who are investigating new ways to save the lives of humans bitten by poisonous snakes.

RETURN OF THE SEA OTTERS Once close to extinction, these fascinating mammals are being re-established in waters off the Alaskan coast.

INVESTIGATIONS INVESTIGATIONS INVESTIGATIO Open-ended SCIENCE WORKSHOP articles show your pupils how to investigate life in an aquarium, spinning things, wave patterns, where growth takes place in a plant, life in a rotting log, changes in body temperature, static electricity, and a wide variety of other phenomena that can be studied at home or in the classroom.

Special-Topic Issues

RIVERS AND MAN A special issue involving anthropology, earth science, and ecology, featuring articles about the effects of rivers on human culture, and man's effects on them.

A NEW LOOK AT LIGHT Scientists have some new ideas about what light is made of, how it travels, and how it appears to be "reflected." Investigating water waves in a simple ripple tank will help your pupils understand these ideas. This issue also explores color and light, how light affects living things, and the wonders of laser light.

FOOD FOR THE FUTURE Will a "green revolution" of food production save the world from widespread famine? This timely special issue reports on efforts to provide enough food for the world's rapidly growing population.

nature and science

VOL 7 NO 1 / SEPTEMBER 15 1969

Investigate the most useful machine ever invented . . .

see page 2

HOW DO WHEELS ROLL?

Join a biologist on a small Pacific island to search out the world's largest lizards

The Giant Lizards of Komodo see page 5

nature and science

VOL. 7 NO. 1 / SEPTEMBER 15, 1969

CONTENTS

PICTURE CREDITS: Cover, p. 5, photos from The American Museum of Natural History; pp. 6-7, F. Wayne King; pp. 2-5, 8-9, 11-15, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 8-9, top photo from Education Development Center, middle left photo from Tishman Realty & Construction Co., Inc., other photos by Franklyn K. Lauden; p. 10, Ivan Polunin; p. 13, photo by David Webster; p. 14, photo by Harry Beede; p. 16, photo by John V. Young.

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 divison 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.

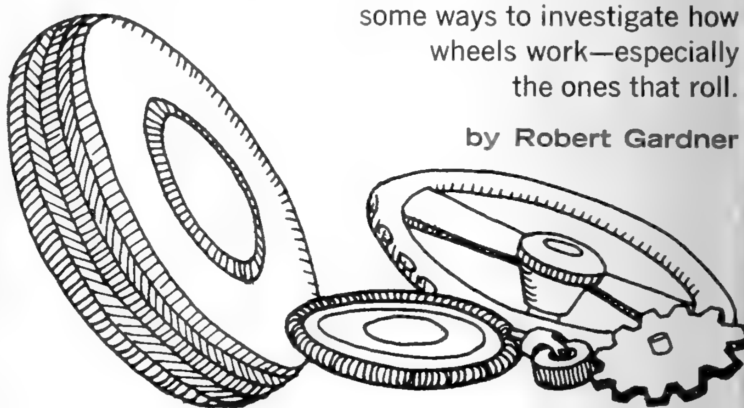
Editorial Office: The American Museum of Natural History, Central Park West at 79th Street, New York, N.Y. 10024.

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.

How Do Wheels Roll?

Some wheels turn around without going anyplace. Others roll forward as they turn. Here are some ways to investigate how wheels work—especially the ones that roll.

by Robert Gardner



■ How many kinds of wheels can you think of? Some common kinds are those on automobiles, airplanes, bicycles, trains, wagons, and roller skates. There are wheels as large as the giant ferris wheels in amusement parks and wheels as small as the tiny gears in a watch. You can probably think of many more kinds—steering wheels, door knobs, pulley wheels, and telephone dialers, for example. (Most machines have one or more wheels, though they may be hidden from view.)

How are these wheels different from each other? How are they alike? In comparing wheels, you might ask yourself questions like these about each wheel: How big is it? How is it shaped? What is it made of? Is it made of one solid piece of material, or of several pieces put together?

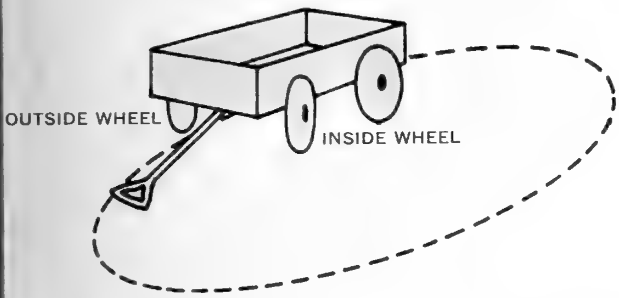
How does the wheel work? For example, does the wheel *rotate,* or turn around its own center point? (Can you think of any wheels that do not rotate?) Does the wheel usually rotate "standing up" or on its side? Can it rotate in other positions? What makes it rotate? What job does the wheel do when it rotates?

Some wheels stay in one place as they rotate. Others roll forward and "go someplace" as they rotate. Here are some ways to investigate rolling wheels with a wagon or a bicycle and some homemade wheels.

Wheels and Axles

Often, wheels are attached to each end of a rod called an *axle.* This is true of trains and wagons. (You can probably think of other examples.) Are the rear wheels of a wagon firmly fixed to the axle so that both wheels and the axle turn together? Or are they attached so that a wheel can rotate without turning the axle and the other wheel? How about the front wheels?

Try pulling a wagon around in a circle *(see diagram).* Does the outside wheel go around the same number of times as the inside wheel attached to the same axle? You

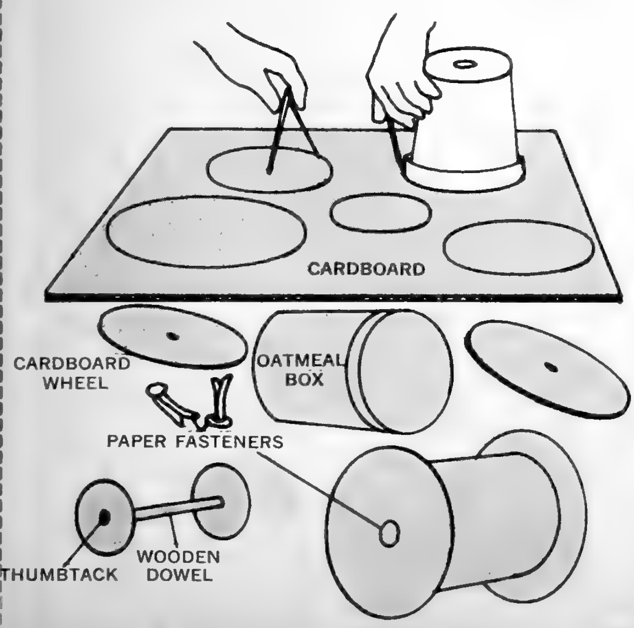


can find out by putting a piece of tape or a mark on each wheel to help you count the number of times the wheel rotates. Does the outside wheel go around more, the same, or fewer times than the inside wheel? Which wheel travels farther?

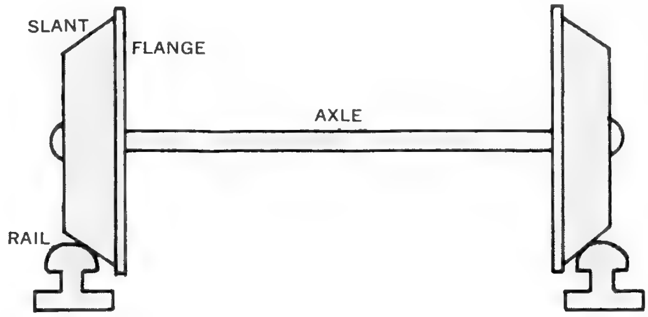
Does it make any difference if you pull the wagon in a larger circle? In a smaller circle? If the wheels were firmly connected to the axle so that both wheels turned together, what would happen when you pulled the wagon in a small circle? Can you pull the wagon in a circle so that one wheel does not turn at all?

PROJECT

With a compass (or some round objects to mark circles) and a pair of shears you can cut out some cardboard wheels of different sizes. Use paper fasteners to attach the wheels firmly to a box such as the kind oatmeal comes in, or tack the wheel to a piece of wooden dowel *(see diagram).* Can you make a set of wheels and axle that will go in a circle when it rolls? Can you make one that will roll in a straight line? What happens if you try to push it in a circle?



When an automobile goes around a curve, the wheels on one side of the car have to rotate faster than the wheels on the other side. (Can you explain why?) Look at the bottom of a car that is raised on a lift at a gas station or garage. (Do *not* go underneath the car.) You can see that the front wheels rotate on separate axles, so they can turn at different speeds. The rear wheels *seem* to be attached to the same axle, but the bulge in the center of the axle contains gears that allow the two rear axles and wheels to rotate at different speeds. This arrangement of gears is

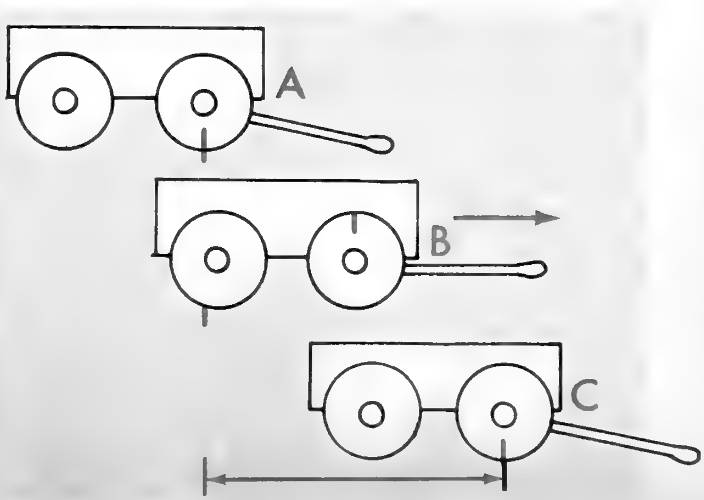


The wheels of a railroad car are connected firmly to the opposite ends of a solid axle. To allow trains to go around curves, the edge of each wheel is slanted and flanged, as shown in the diagram. This makes the inner side of the wheel bigger around than the outer side. Can you figure out how these slanted wheels serve the same purpose as the differential in an automobile?

called the *differential.* Can you guess what would happen when a car with no differential went around a curve?

Around and Forward

When the wheels on your wagon go around once, how far does the wagon move forward? To find out, mark a point on a tire where it touches the ground, and mark the point on the ground where the tire is touching *(see Diagram A).* Then pull the wagon forward *(Diagram B)* until the wheel has gone around once *(Diagram C).* How far has the wheel moved along the ground? How far has the whole wagon moved? *(Continued on the next page)*



PROJECT

Use a yardstick or tape measure to measure the *diameter* of a wheel—the distance from one edge of the wheel across its center point to the opposite edge. Then measure the *circumference* of the wheel. Do this with wheels of several sizes, and also with other round things, such as tin cans, cake pans, and oatmeal boxes. Write down your measurements in a table like the one shown here.

Now try dividing the diameter of a round object into its circumference. Do this for each of the objects you have measured and compare your findings. Can you explain how the circumference of a wheel is related to its diameter?

Measure the diameter of a wheel that you haven't measured before. Can you predict how far the wheel will roll forward in one complete rotation? Try it and see.

Can you measure the diameter of a *sphere*, or ball-shaped object, as easily as the diameter of a wheel? How could you measure the diameter of a basketball?

OBJECT	DIAMETER	CIRCUMFERENCE	CIRCUMFERENCE / DIAMETER
washer	2 in.	6¼ in.	3⅛
wagon wheel			
bike wheel			
fruit juice can			

How Do Wheels Roll? (continued)

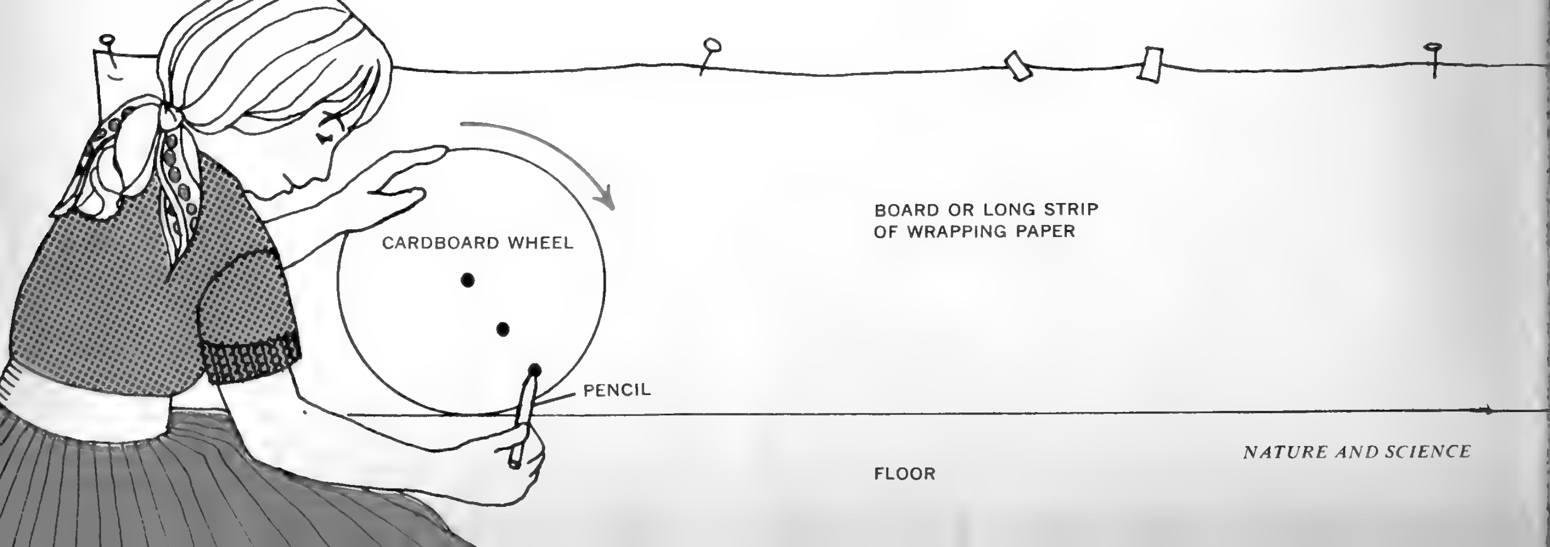
If you have a tape measure, measure the *circumference* of the wheel (the distance around it). Compare this distance with the distance the wheel has rolled forward in one complete rotation. Can you measure the circumference of a bicycle wheel by the distance it rolls forward in one complete rotation? (How could you use a bicycle to measure distance?)

Riding on a Wheel

If a tiny bug were riding on a rolling wheel, what kind of path would it follow? Make a mark on the rim of a wagon wheel and watch it very carefully as you move the wagon. You may be able to see that the mark does not go in a circle. Do you think the path will depend on where the bug sits on the wheel?

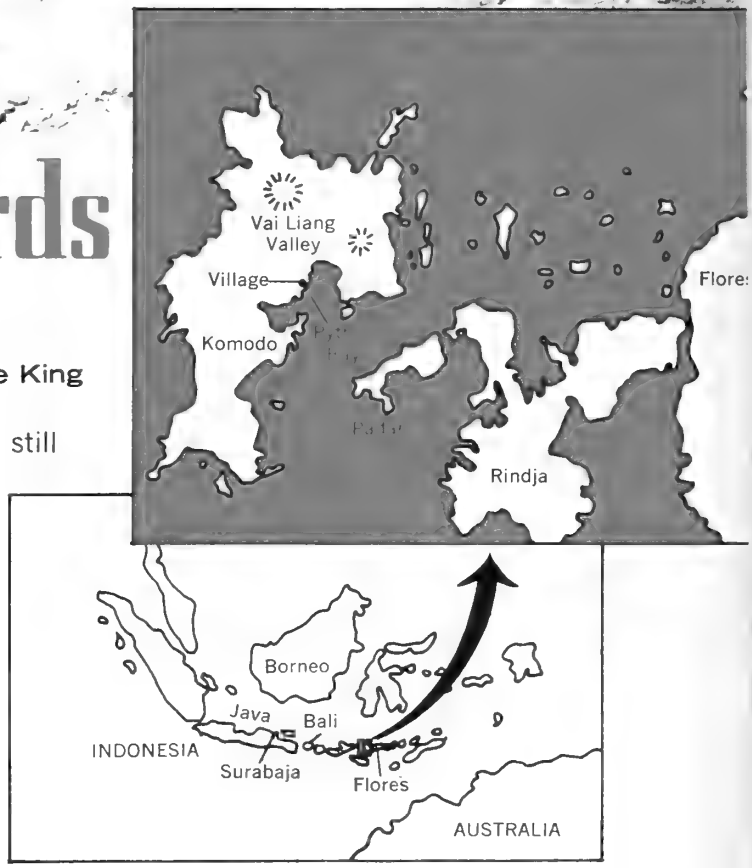
You can map the path of a point on a rolling wheel by punching holes along the diameter of a cardboard wheel. Place a pencil point through a hole and roll the wheel along next to a long box, board, or sheet of wrapping paper *(see diagram)*. The pencil point will draw the path the bug would follow if it were on the wheel. What path would it follow if it were on the rim of the wheel? . . . at the center of the wheel? . . . half-way from center to rim? What do the paths look like if the wheel slips as it turns?

Can you think of some other questions about wheels to investigate? ■



The Giant Lizards of Komodo

by F. Wayne King



Only about a thousand of the world's largest lizards are still alive, on four small Pacific islands. Our expedition was a first step in a new study of these reptiles.

■ Fifty feet away, I heard the crunching of dry brush in the ravine. It was a seven-foot-long Komodo monitor lizard. The big lizard was attracted by the scent of the bait hung from a tree only a dozen feet from my hiding place behind a small tree. The big reptile came out of the bushes and began moving up the ravine toward me.

These monitors are the world's largest living lizards. They are sometimes incorrectly called "dragons" because of their size. Males grow to be over 10 feet long; the record length for females is 7 feet 6 inches. Monitor lizards may weigh as much as 250 pounds. They live only on the islands of Komodo, Padar, Rindja, and Flores in central Indonesia *(see map)*.

I am Curator of Reptiles at the New York Zoological Park (the Bronx Zoo) in New York City. In early April 1968, the New York Zoological Society sent me on an expedition to Komodo. My job was to estimate the size of the monitor lizard population, in order to find out whether there were enough of these reptiles to enable a biologist to study their lives.

A study like this might be important in helping the giant monitors to survive. Fewer than 1,100 monitors now exist, and many biologists believe the lizards are in danger of dying out. They are protected by the Indonesian gov-

(Continued on the next page)

ernment, but until more is known about the lives of the monitors, little can be done to help them increase.

A Camp at Komodo

In April I left New York for Surabaja, Java *(see map),* where I joined the other 10 members of the expedition. One of them was Hilmi Oesman, a member of the board of directors of the Surabaja Zoo in Indonesia. The group also included a nature photographer and a conservationist from the Office of Nature Conservation and Wildlife Management in Bogor, Indonesia.

We chartered a 45-foot, wooden-hulled freighter, and set out on the 500-mile trip to Komodo, expecting to arrive in three days. But the ship's engine broke down and we were towed to Bali by a passing boat, spending a week there before arranging for another ship.

As dawn broke on April 26, we had our first glimpse of the north coast of Komodo. The island is about 22 miles long and 12 miles wide. The central mountains rise more than 2,400 feet from the sea. Komodo is very dry, with no permanent water on the lower parts except for a well in a small village (also called Komodo) on the western shore. Streams flow only during the rainy season, from late November to March.

Most of Komodo is covered with grass and scattered palm trees *(see photo).* The island's only forests grow on the upper parts of the mountains, where the rainfall is heaviest. Widely-spaced trees also grow along ravines and dry stream beds on the lower parts of the island, but the trees on the island are seldom over 40 feet tall.

We set up a camp of tents near a dry stream bed, close to Python Bay *(see map on page 5).* Our first day was spent exploring the grassy northeast part of the island. We found tracks of monitors, but saw none of the lizards.

Then Hilmi Oesman led us to a grassy hillside near the shore of the bay, where the monitors had dug several burrows, each within about 10 feet of the next. We found 14 burrows on the face of another hill nearby. Each burrow, about 20 inches wide and 15 inches high, ran straight back into the soil (which was a mixture of gravel and ash from volcanoes). We couldn't tell how far back into the hillside the burrows extended, or whether they had side branches or rooms.

What purpose do these burrows serve? Perhaps they protect the lizards from the hot, dry climate of Komodo. This is one question that may be answered by a study of the monitors.

Meeting the Monitors

The next day we hiked into the Vai Liang stream valley *(see map on page 5).* Earlier expeditions to Komodo had found monitors there. A stream bed runs along one side of the valley and often narrows to a 15-foot-deep ravine. The tallest trees and tangles of other plants grow in the ravine, making the temperature there lower than in more open areas.

The rocky surface of Komodo is covered with waist-high grass. The island's few trees grow mostly in valleys and ravines.

We hung a dead goat from a tree in the ravine as bait. It had been killed three days earlier, and gave off a strong smell. Then we hid at the top of the ravine, about 100 feet from the bait, and waited.

After an hour and a half, the first monitor came to the bait. I have to admit I was a bit disappointed that it was only a slender, six-foot-long animal. A lizard of that size should impress anyone, but I had hoped that the first monitor would be an impressive nine-foot-long male.

The lizard plodded up the stream bed, swaying from side to side as it moved. Then it sat beneath the bait without trying to reach it. The first lizard was soon joined by two others, one nearly eight feet long. One of them moved up the ravine and lay down on a sunny patch of sand. When we tried to get closer to the lizards—to take photos —they fled into the brush.

The bait had been hung high out of the lizards' reach. At midday we lowered the dead goat to the ground. Earlier, we had planned to build a blind, or hiding place, nearby from which to photograph the lizards when they returned. But Hilmi Oesman said that a blind wasn't needed. He said that we could crawl close enough to take any photos we wanted, or even measure the lizards.

He was right. The lizards soon were back at the bait and began feeding. They ignored us as long as we moved slowly. We crept forward while they fed, stopping each time one of them looked our way. When it turned back to the bait, we moved again. In this way five of us crept to within 25 feet of three big lizards.

Each lizard held its body high off the ground, seized part of the goat in its mouth, then reared backward to tear some meat free. Sometimes they almost lifted the goat off the ground.

I crept closer until I was less than 10 feet from one lizard. I decided to get no closer, not because of fear of the lizard, but because of the overwhelming smell from the dead goat. I wasn't worried about being attacked by the monitors. They were busy feeding. But I did remember their sharp claws—a monitor at the Bronx Zoo once tried to climb the leg of a photographer, and it took 56 stitches to close his wounds. I didn't have to worry about this further because soon the lizards had had their fill of goat meat and moved slowly into the brush and out of the ravine.

Killers or Carrion-eaters?

A study of these lizards may finally settle some questions about their food. Some scientists have claimed that the monitors catch and kill the deer and wild pigs that are found on the island. No one, however, has seen them do this. All of the expeditions to Komodo have baited the lizards by using rotten meat. Fresh meat does not attract the lizards, but the odor of rotting meat brings them from afar. This suggests that the adult lizards eat mostly dead animals *(carrion)* that they find.

The young lizards may feed on the eggs of ground-nesting birds, and it seems certain that both young and adults will eat anything they can catch. But if you sit in the woods of Komodo and listen to a big monitor crash and rattle its way through the brush, you will begin to doubt that it can sneak up on a living deer or pig.

Besides gathering information on the food of these lizards, we need to learn about their reproduction. How often do they breed? How many eggs are produced at a time? Where are the eggs laid? No one knows how fast the lizards grow or how long it takes them to become breeding adults. Another piece of missing information is the living area, or *home range,* of an adult lizard. All of these unknowns make it hard to figure out whether the monitors are in danger of dying out. It also makes it hard to keep and breed monitor lizards in zoos.

Fortunately, we may soon know a lot more about these reptiles. I found that there are enough lizards on Komodo to make a longer study possible. And in July 1969, Dr. Walter Auffenberg of the University of Florida, in Gainesville, began a year-long study of the monitor lizards. Dr. Auffenberg is a *herpetologist* (a scientist who studies reptiles). His wife and three of his four sons live with him on Komodo and help with his investigations.

The secret lives of the Komodo lizards may not be secret much longer ■

■ Look in your library or bookstore for this exciting story of a 1926 expedition to collect Komodo lizards: **The Island of the Dragons,** by John Clagett, G. P. Putnam's Sons, New York, 1967, $2.86.

The author photographed this eight-foot-long Komodo lizard when it came to feed on a dead goat. The monitor lizards shown on page 5 and on the cover are part of an exhibit at The American Museum of Natural History, in New York City.

WHAT HOLDS IT UP?

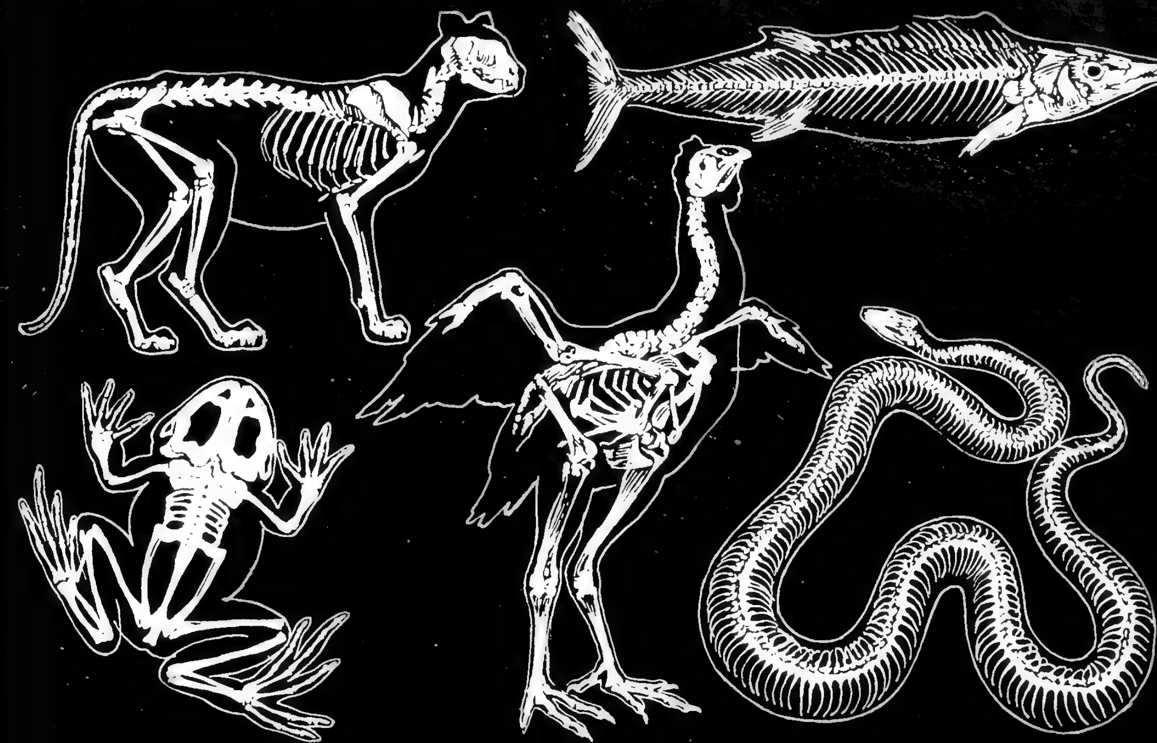
Fill a plastic bag with water, close it with a rubber band, and see whether the bag will stand up in the sink. Chances are the bag will topple over on its side and flatten out a bit. (Can you explain why?) Nearly two-thirds of the mass of your body is water—some of it in the billions of tiny cells that make up most of your body, and some of it in your blood and other body fluids. Yet you probably have no trouble standing up or sitting up, and your body tends to keep its shape whether you are standing, sitting, or lying down.

What makes this possible, of course, is your skeleton—the framework of bones that holds up the rest of your body. Most kinds of animals have skeletons, and so do plants, buildings, and machines. The skeletons may be made of bone, cellulose, steel, brick, or other materials. Some skeletons are inside the things they support, and some are outside. Some things—bridges, for example—are nearly all skeleton. Some skeletons have moving parts, and others are rigid.

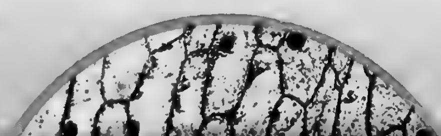
This Wall Chart shows some of the different kinds of skeletons that support things and hold them in shape. Can you think of any other kinds?

—R. J. Lefkowitz

The body of a human or other mammal, bird, reptile, amphibian, or fish is built around an inside skeleton made of bone and *cartilage*, a tough substance that bends easier than bone. Most of the bones are connected so they can turn one way or another without coming apart. This allows the animal to move itself over land, through water, or through the air. Each of these kinds of animals has a "backbone" made of small bones called *vertebrae*, so all these animals are called *vertebrates*.

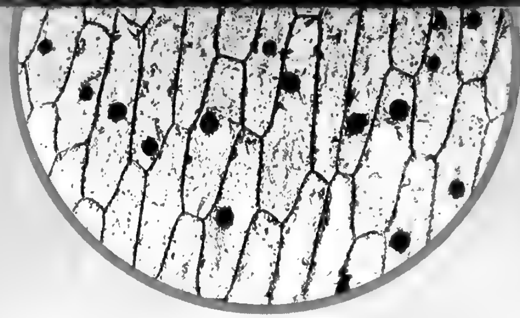


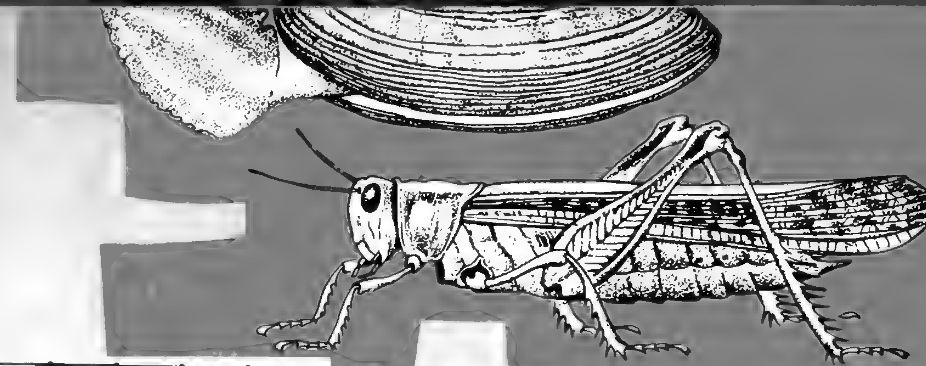
Most animals without backbones have an outside skeleton that surrounds the main parts of their bodies. This skeleton is made of a substance that is *secreted*, or given off by the animal's body, and then hardens when it is exposed to the air. Besides supporting the animal's body, an outside skeleton helps protect the animal from predators. Which of these animals have skeletons that bend in certain places so the animals can move around? What does a crab do when it "outgrows" its skeleton? What does a snail do?

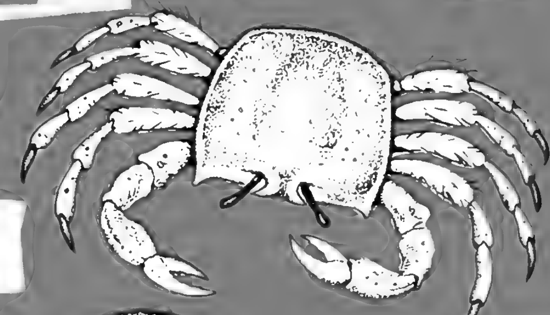


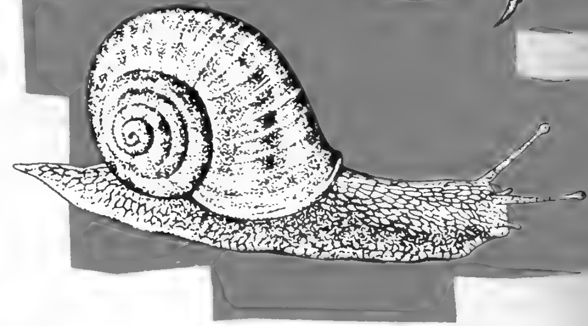
This photo, taken through a microscope, shows some of the millions of tiny cells that form a plant. Each cell is a mass

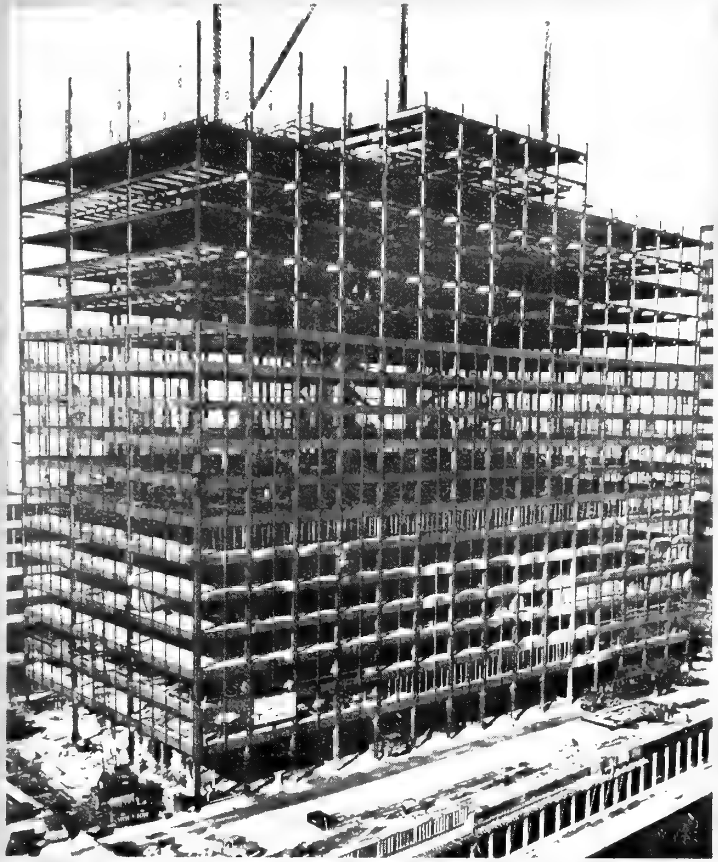
brane, each plant cell has a wall, made mostly of cellulose. In a living plant, the fluid in the cells helps support the cell walls. In a dead stalk or deep inside a tree, the cells contain no fluid, but the cellulose continues to support the plant for some time. Do you think a plant's "skeleton" is inside, or outside, or both?



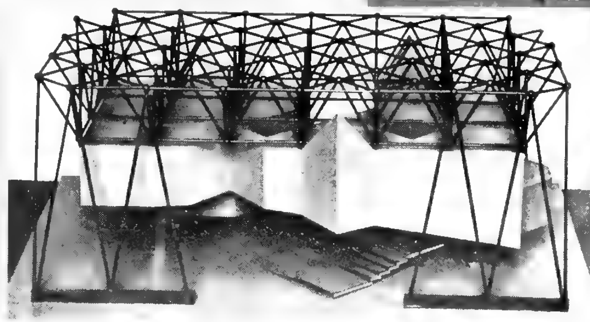








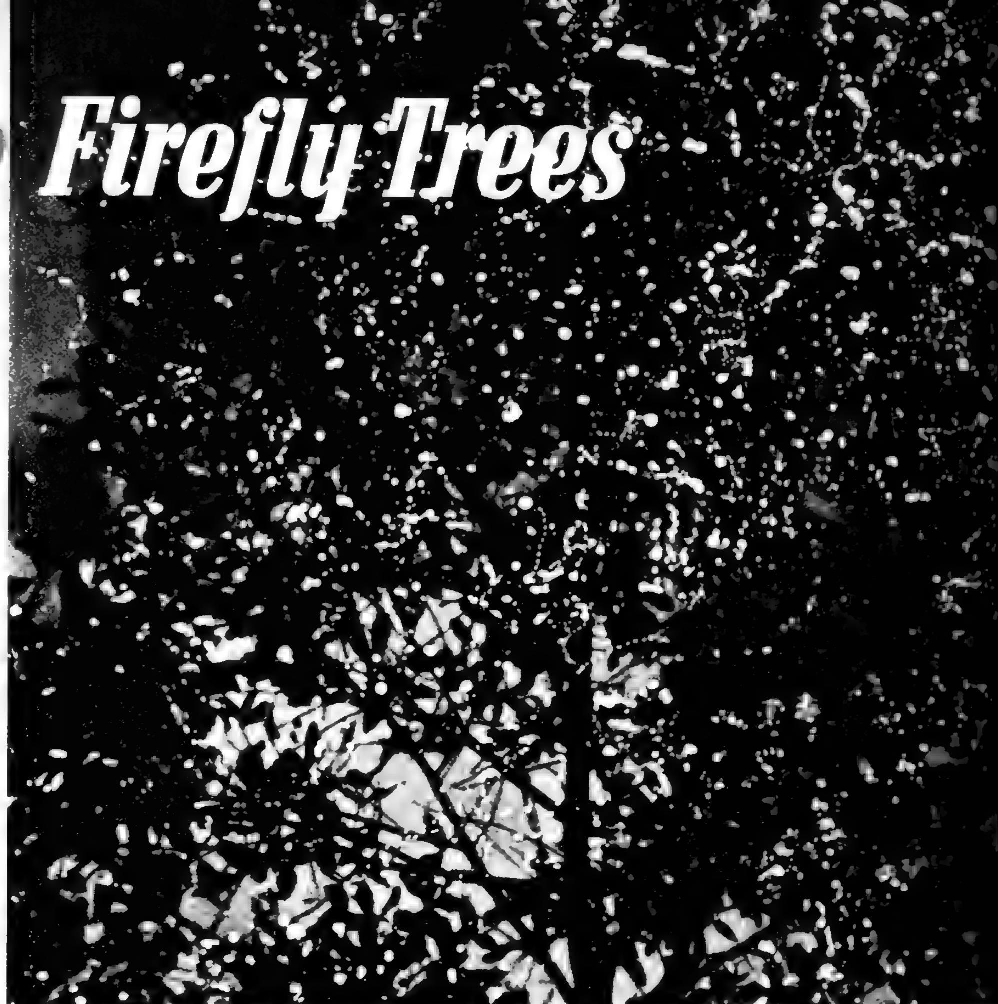
Most buildings have an inside skeleton that supports the floors and walls and the people and things inside the building. The skeleton of a house is usually made of wood, but larger buildings usually have a skeleton made of steel, or of concrete with steel rods running through it. Can the skeleton of a building have movable parts like those of an animal skeleton?



A small building, such as a garage, may have an outside skeleton. Walls made of brick, cinderblock, or concrete slabs, for example, can support themselves and a roof. (Can you guess why larger buildings are not made this way?) Another kind of outside skeleton is shown in this photo of a model of a giant exhibit entitled "Can Man Survive?", at The American Museum of Natural History in New York City. The exhibit "building" is hung from its steel skeleton.

This model of a Rambler automobile's skeleton shows that the roof and floor parts are outside (like the skeleton of a crab), while the part of the skeleton that supports the engine will be inside the body of the finished car. Look at other machines and see what kinds of skeletons they have. Does the skeleton do anything more than just support the machine and hold it in shape? Does the skeleton have any moving parts? Why? Do such things as furniture and lamps have skeletons?

The Firefly Trees



■ Sometimes in tropical countries thousands of fireflies gather in a line of trees along a riverbank and flash their lights on and off at exactly the same time *(see photo)*. The flashes of light from these "firefly trees" can be seen from a distance of more than 100 feet. At times the insects in the trees flash on and off together like this hour after hour, night after night, for weeks or even months. Scientists have long wondered how all of the fireflies flash together—in *unison*—and why this happens only in tropical places.

One scientist who is trying to solve these mysteries is Dr. John Buck, of the National Institutes of Health in Bethesda, Maryland. An expert on fireflies, he knew that a male American firefly lights up in a certain pattern of flashes to "advertise" that he is seeking a mate. When a female that is ready to mate sees the flash signals of a male of the same species, she waits a certain brief time, then flashes a signal that guides the male to her.

Dr. Buck tested some male fireflies of a North American species by using a flashlight to imitate the mating signal of the female of that species. Sometimes as many as 15 or 20 males would fly toward the flashlight, flashing in unison as they came. They seemed to adjust their flashes to the timing of the "female" signals from the flashlight. Dr. Buck thought that a small group of male fireflies might begin flashing together like this in a tropical "firefly tree." Then, perhaps, other males would be attracted by the flashing and would join in.

This and other experiments sharpened Dr. Buck's curiosity so much that he and his wife went to Thailand and Borneo to investigate the firefly trees. They found that male and female fireflies mate in these trees, but the females do not flash in unison with the males. The Bucks thought that many males flashing together might attract females from the surrounding forest.

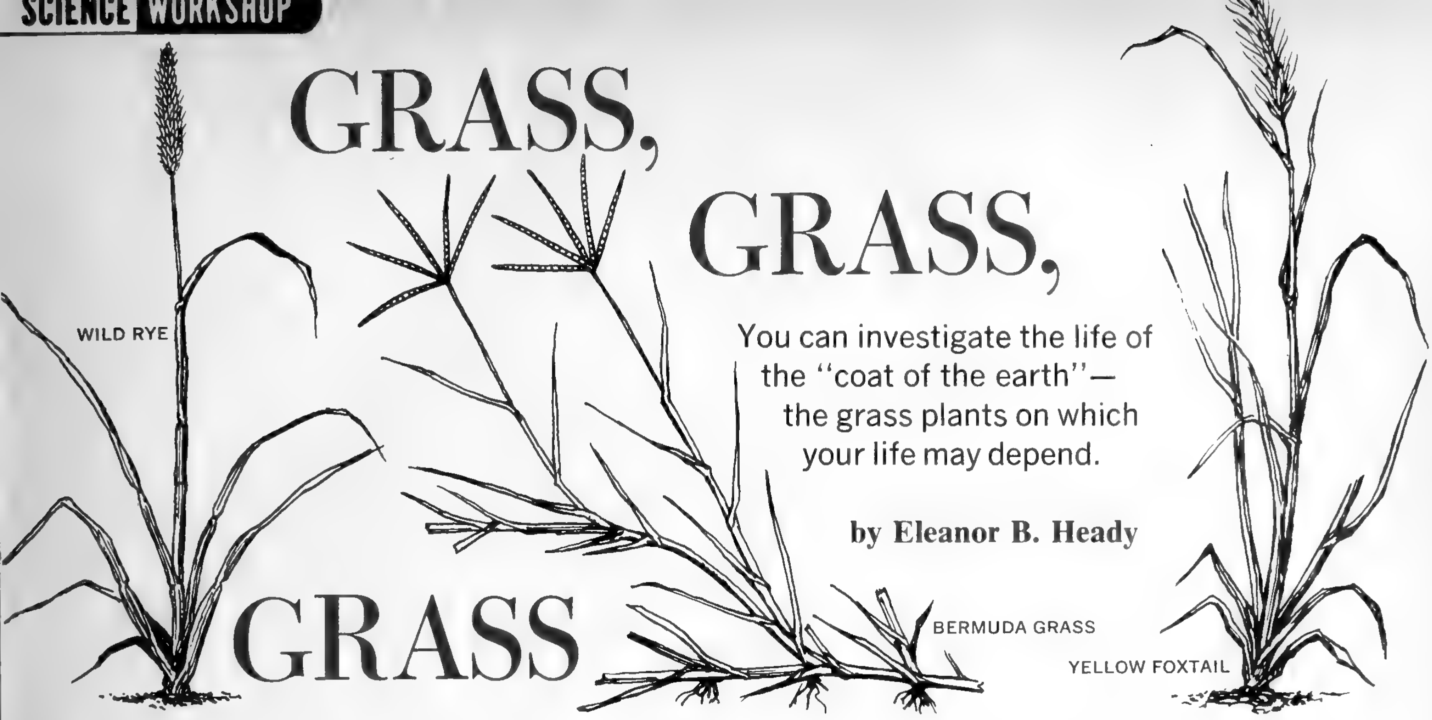
The Race for Mates

Since the adult fireflies in those tropical areas live only a few days, they must find mates quickly if they are to reproduce before they die. The Bucks pointed out that a firefly would have a hard time seeing the flashes of a single prospective mate through the thick, tangled plants of these swampy areas. But many males flashing together in a tree on a riverbank would easily be seen by other fireflies, both male and female. Perhaps gathering in trees and flashing together is a kind of behavior that has *evolved*, or come about slowly through the years, to make it easier for fireflies to find mates in these areas.

This idea has not been proved, though. No one is sure, for example, that more adults keep coming to the firefly trees and that mated females keep leaving the trees. Still, it seems likely that wandering fireflies are attracted to the trees, because while the insects live only a few days, the trees often glow in unison for many nights in a row.

How fireflies that are spread through a long row of trees all flash at the same instant is still a mystery, too. Laboratory tests suggest that the closer a number of fireflies are to each other, the more accurately they can flash together. But how this comes about is still to be discovered ■

GRASS, GRASS, GRASS



You can investigate the life of the "coat of the earth"— the grass plants on which your life may depend.

by Eleanor B. Heady

■ Grasses are all around us, so common that we scarcely notice them. Yet, they are an extremely varied group of plants. There are over six thousand different kinds *(species)* of grasses. Since so many plants belong to this one family, you may be wondering just how to tell grasses from other plants. There are certain characteristic things about them that tell us they are grasses.

Pick a grass plant from the lawn, being sure to dig way down to get all the roots. Perhaps a plant at the very edge of the lawn will be easier to dig up and taller, too, for the lawn mower may have missed it. Carefully remove the leaves. Notice that they are like ribbons, with dark streaks (called veins) running lengthwise. These long, slender leaves are attached to the stem alternately, not opposite each other. Notice, too, how they fit around the stem like split tubes.

Now take a sharp knife and cut through the stem. You will see that it is hollow between the joints, or places where the leaves attach to the stem. It is easy to tell a grass from some other kind of plant because of its ribbonlike leaves and its stems with joints, or *nodes,* to which the leaves are attached alternately. Almost all grasses have hollow stems, but a few, including maize (corn) and sugar cane, have solid stems.

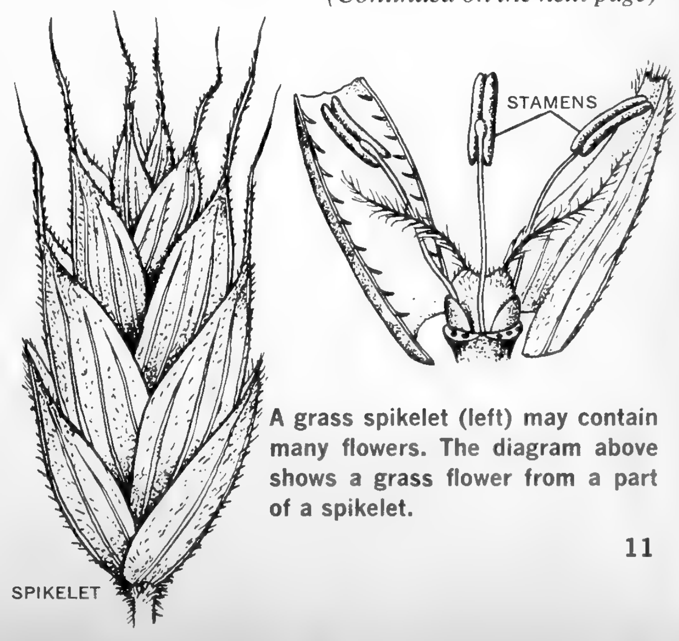
Get Close to Grass Flowers

Grasses are flowering plants, although most people seldom notice the blossoms. The flowers are tiny, often colored much like the rest of the plant, green or greenish yellow. They grow in bunches, usually on long stems at the top of the plant. The tassel of corn stands up like a big whisk broom, but this is only half the flower—the male part. The female part, called the *silk,* is found tucked away under the husk at the top of the ear of corn.

Some grass flowers are very beautiful. The great fluffy plumes of pampas grass are popular in gardens throughout the warmer regions of the world. Sugar-cane flowers are large and sometimes brightly colored. However, most grass flowers are small. Because their pollen is carried by the wind, they need no gay colors, no fragrance, no honey to attract insects. Grass flowers get along very nicely with only the breeze to blow the pollen from one flower to another.

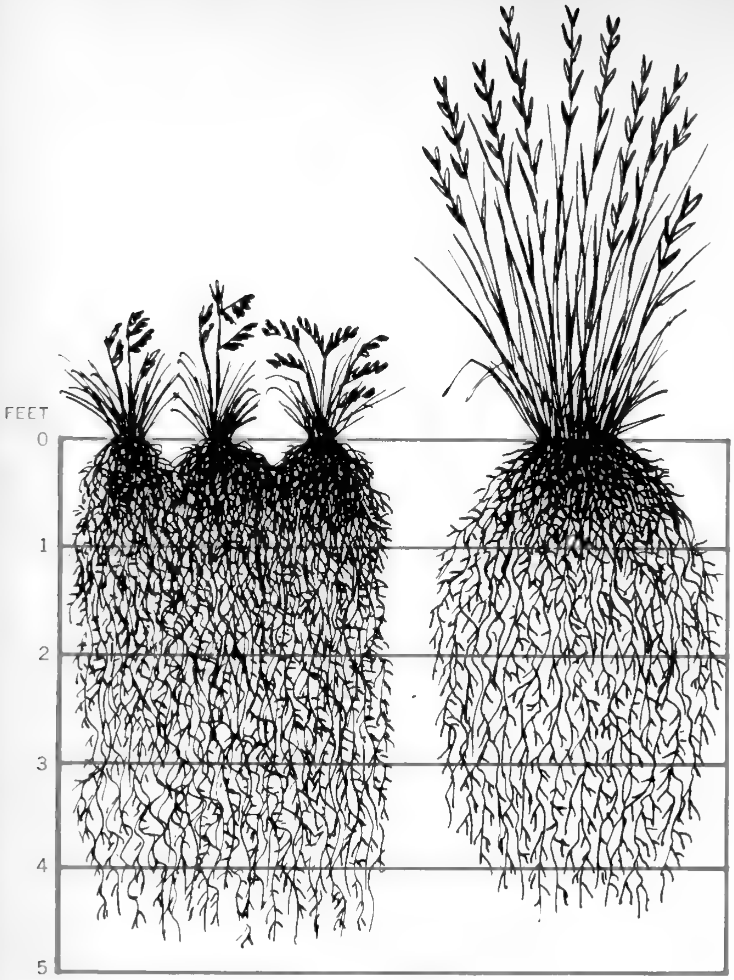
Take a look at a grass flower under a low-power microscope or a magnifying glass. Most grass flowers contain both male and female parts. The male parts, at the top, are called *stamens (see diagram).* There may be two, three, or

(Continued on the next page)



A grass spikelet (left) may contain many flowers. The diagram above shows a grass flower from a part of a spikelet.

This article is adapted from Coat of the Earth: The Story of Grass, *by Eleanor B. Heady, published by W. W. Norton & Company, Inc., New York, New York. Copyright © 1968 by Eleanor B. Heady. Printed by permission of the publisher.*



Grass roots have many small branches, and reach deep into the soil. The plants shown here are buffalo grass (left) and bluebunch wheat grass (right).

Grass, Grass, Grass (continued)

six stamens, depending on the species of grass. The stamens produce pollen, a yellow or yellow-white dust. The pollen drops onto the female part, called the *pistil,* causing it to swell and form a seed.

A cluster of grass flowers is called a *spikelet.* There may be *from one to over 30* flowers on one spikelet, and there are often many spikelets on one grass plant. Look at several different species of grass and see how many spikelets and flowers you find.

Meanwhile, Underground...

Grasses have tremendous root systems with hundreds or sometimes thousands of finely divided rootlets *(see diagram).* If you pull up a grass plant, you will find that the part of the plant that is underground is often many times larger than the part you see growing above. The root systems in some varieties of grass are so large that if all the roots of one plant were laid end-to-end they would measure up to three miles long. These roots may go down into the earth as far as 100 feet. Some grass plants have larger root systems than others. Those growing in dry regions produce more roots, sending them deep into the earth in search of water.

Many grasses have stems that grow just underneath the surface of the soil and send up new little plants at nodes in the stem. These grasses with underground nodes are able to form dense networks of grass and roots from only a few plants. As each plant branches from a node, it spreads in all directions, sending down more roots and sending up shoots to grow above ground. Soon a thick, springy mat of grass and roots called a *sod* covers the soil and the earth beneath the soil.

Some kinds of grasses grow from seeds each year—coming up in the spring, living for one season, making a crop of seeds, then dying at the end of the season. Grasses that grow from seeds each year are known as *annual,* or yearly, grasses. Other kinds live from year to year, sending up new shoots from the same roots each season. These are called *perennial,* or many-year, grasses. The grasses planted in lawns are perennial, while a common weed in lawns—crabgrass—is an annual.

How Grasses Get Around

Grass seeds are spread in various ways. Some are so lightweight that they can be blown from place to place by the wind. Others have barbs or burrs that stick to the fur or wool of animals or the clothing of people, carrying the seeds from place to place. Some seeds drop into streams and float down to other countries, or even to the sea and across it to other continents. Birds drop grass seeds as they carry them away for food. Ships carry "stowaway" grass seeds all over the world. Even airplanes have accidentally carried grass-seed passengers across the wide oceans. Of course, many grass seeds have been shipped on purpose so that a particularly valuable variety could be grown in a country far from its native home.

Today, grass plants cover nearly one-fourth of the surface of the globe. Grass is a giver of life, feeding humans and other animals, holding and building the soil, making cool, clean places for us to rest and play, and serving as material to build houses and countless other useful articles.

The milk we drink, the cheese, butter, and ice cream we eat, all come to us because cows eat grass and can turn this grass into milk. The meat we eat is the flesh of animals that first ate grass and the seeds of grass to make the meat. Nearly all our bread and cereals are made from the fruits or seeds of grasses. Sugar from the stems of the giant grass sugar cane sweetens our desserts. Grass lawns surround our houses and carpet our parks and playing fields ■

CAN YOU DO IT?
A balloon full of air very slowly collapses and becomes smaller. Can you find a way to keep a blown-up balloon from gradually shrinking? Suppose you put several balloons inside of one another? Would a balloon tied under water keep its air? Will a coating of grease help?

brain-boosters

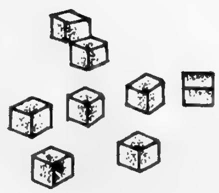
prepared by
DAVID WEBSTER

MYSTERY PHOTO
Why are the roots of this large oak tree sticking out of the ground?

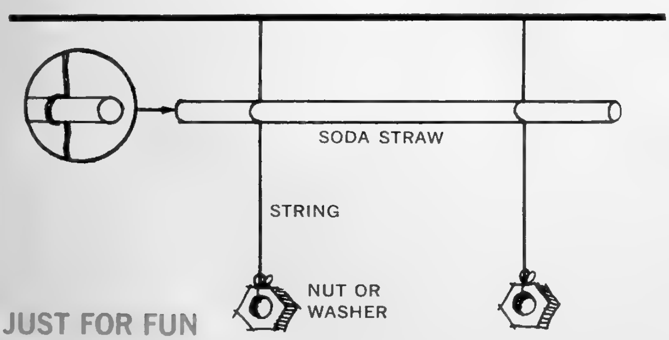
FOR SCIENCE EXPERTS ONLY
About how many leaves are there on a large oak tree:

16,000?
200,000?
3,000,000?
40,000,000?

FUN WITH NUMBERS AND SHAPES
Arrange eight sugar cubes so that each one is the end in a line of three.

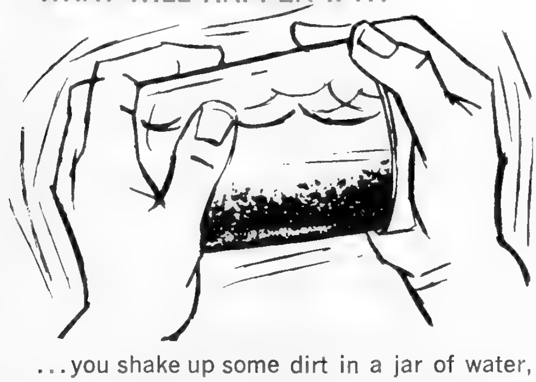


Submitted by Mike Horstman, Richland, Washington



JUST FOR FUN
Make a pair of coupled pendulums with string and two small weights. Loop the string of each over a straw, as shown in the diagram. Then start one pendulum moving by pulling the weight out to the side. Watch for a while to see what happens. Move the straw up higher on the two strings and start one of the pendulums swinging again. What difference do you notice? Try the straw down lower also. What would happen if the straw were tipped so it was higher on one string? Suppose one pendulum were shorter than the other one? Connect the two pendulums with a piece of string instead of a straw. Now what happens?

WHAT WILL HAPPEN IF...



...you shake up some dirt in a jar of water, and then set the jar where it will not be disturbed? Will the water stay muddy forever? Are all particles in soil the same size?

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 will appear in the next issue of *Nature and Science*.)

A hand lens and some water from a pond, puddle, or stream are all you need to explore the . . .

World Within the Water

■ A jar of water from the outdoors is a jar full of tiny water animals. Look through a hand lens (magnifying glass) into their world. You may see a one-eyed animal that jerks so fast it's impossible to catch—a creature that uses poison to capture its prey—and many other kinds of animal life.

There's quite a difference in the numbers and kinds of animals in water from different places, so sample several spots. Take water from near the surface of a stagnant pond in one jar, and water from a clear pond in another jar. Use water from a birdbath, or from a hole in a tree stump where rainwater has collected. Put some dry grass in tap water. (Before adding the grass, let the tap water stand uncovered for a couple of days so that harmful chemicals escape.) What other sources can you think of? Be sure to wash your collecting jars before using them, and to label each one according to where the water came from.

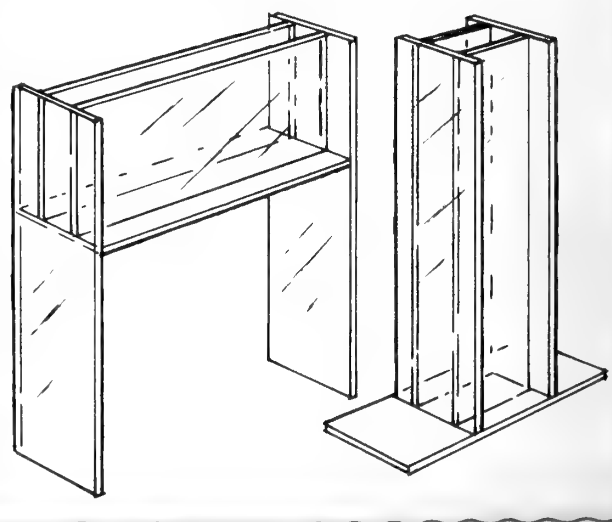
The animals in your water samples need just a little care to keep them alive and active. Put them in a place where the temperature stays constant. Every few days, add tap water that has stood for a few days, to replace water that evaporates from the container.

Most water animals will eat tiny pieces of meat or decaying plants. You might put in other things, such as cooked egg yolk, and watch to see if they are eaten. Remove any uneaten food after several hours.

A small, well-washed, open glass jar (such as a baby-food jar) makes a good home for the water life. An easy-to-make "micro-aquarium" *(see box)* is even bet-

Micro-Aquarium

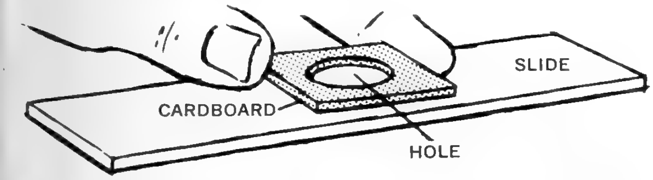
Five microscope slides and some waterproof household cement are all you need for a micro-aquarium. After washing and drying the slides, cement them together *(see diagram)*. You can make a shallow and wide aquarium, or a deep and narrow one. After the cement has dried, use a little water to make sure the micro-aquarium is leakproof.—Jon H. Emerson



ter, since the water animals are kept in a small space.

The Better To See Them With

For some observations, you might need an extra-small container. Try a microscope slide with a shallow "well" in it. First get an ordinary microscope slide (usually available from drugstores). Then cut a round hole in a thin, narrow piece of cardboard. The hole should be almost as wide as the slide *(see diagram)*. Dip the piece of cardboard in shellac, place it in the center of the



slide, and let the shellac dry. The well in the cardboard will keep the animals in a small space while you observe them.

Some of the animals may move around too quickly to be watched, even in the well of a slide. If you put fibers from a piece of absorbent cotton in the well, the fibers will trap the animals so that they remain almost still. Some of the animals will show up better if you look at them against a background of dark paper. To move the animals to another container, use a medicine dropper.

What's Within?

The drawings on this page and the books listed at the end of this article will help you to identify the water animals that you might see through a hand lens. Through a microscope, you can see even more kinds.

After a week or so in captivity, there may be more animals of some kinds and fewer of others than when you first looked at your water sample. If so, why might one kind have increased in numbers while another decreased? How are the animals' new surroundings different from the place where the water came from?

Can you figure out which animals prey on others? Watch closely for unusual ways of capturing food. For example, *hydras (see drawing)* shoot out threads from their tentacles. Some threads act like lassoes and trap the prey, and others poison the prey. (With a hand lens, you can see the tentacles, but not the threads.)

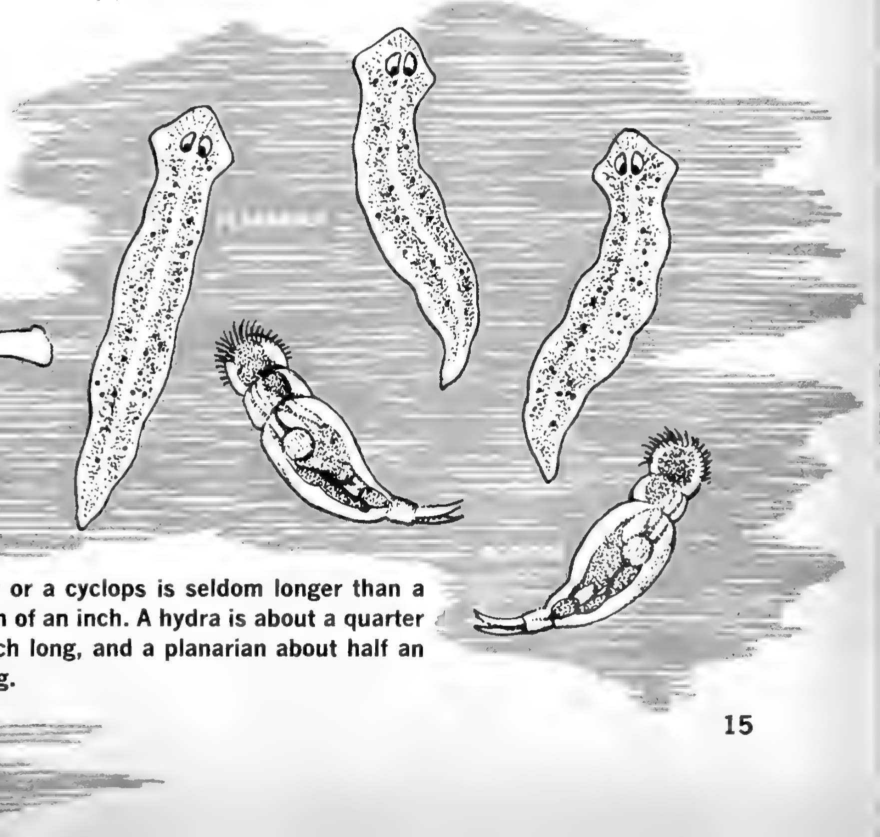
How do the different animals move? Look for *rotifers,* which seem to move by turning a waterwheel. The wheel is actually a fringe of "hairs," which beat in a wave-like motion. The hairs, called *cilia,* do more than move the rotifer; they also send food into its mouth.

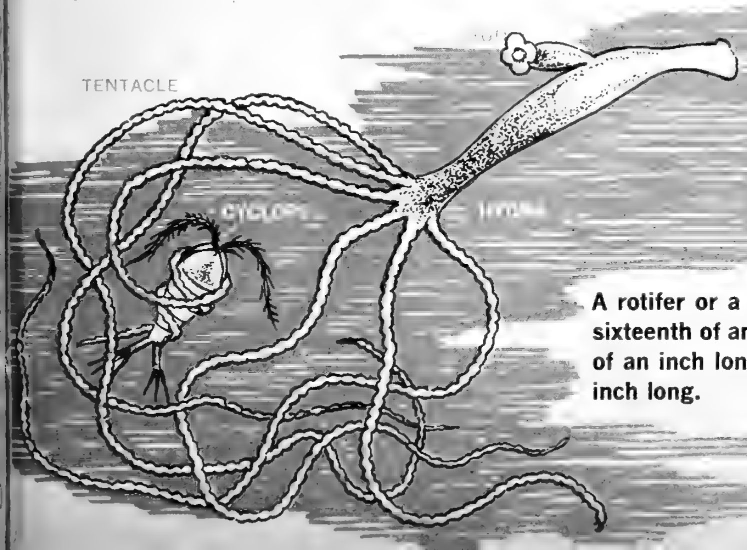
Can you find an animal that is reproducing? With some kinds, just one parent is needed to produce offspring. This is the case with well-fed, healthy hydras. You might see a bump, called a *bud,* on a hydra. This is a young animal, which breaks off from its parent after a few days. With some other kinds of animals, both a male parent and a female parent are necessary to produce offspring. *Planaria,* which are flatworms that glide through the water, usually reproduce in this way.

What happens when you move a small flashlight beam toward some of the animals, and then away from them? When you touch them with a pin, or touch a pin to the water around them? How do they act when you put them in water that is warmer than room temperature, or after you leave them in the refrigerator for a few hours? ■

Look for more investigations with tiny water animals in future issues of Nature and Science.

■ Look for these books in your library or bookstore to help you identify small water animals: **The New Book of Freshwater Life,** by Elsie Klots, G.P. Putnam's Sons, New York, 1966, $4.95; **Adventures With Freshwater Animals,** by Richard Headstrom, J. B. Lippincott Co., Philadelphia, 1964, $4.25; **Underwater Zoos,** by Millicent E. Selsam, William Morrow and Co., New York, 1961, $3.36.





A rotifer or a cyclops is seldom longer than a sixteenth of an inch. A hydra is about a quarter of an inch long, and a planarian about half an inch long.

WHAT'S NEW

by
B. J. Menges

Taking the temperature of trees while flying above them in a helicopter is the unusual job of John F. Wear of the United States Forest Service. Like humans, trees have a higher-than-normal temperature when they are "sick." The higher the temperature, the more infrared (heat) rays a tree gives off. An infrared-sensing device in Wear's helicopter detects these rays and translates them into temperature readings.

Research forester Wear hopes that finding areas of diseased trees in forests will enable some of the trees to be cured. If there is no cure for a disease, perhaps the infected trees can be cut down before their lumber becomes worthless, and before the disease spreads to healthy trees nearby. If Wear's work is successful, he may eventually lose his job to earth-circling satellites carrying infrared sensors.

Could monkeys talk if they were smarter? No, say Drs. Philip H. Lieberman and William H. Wilson of the University of Connecticut, in Storrs, and Dr. Dennis H. Klatt of the Massachusetts Institute of Technology, in Cambridge.

The scientists studied the full range of sounds made by certain monkeys. These sounds fell far short of the wide range of vowel sounds used in human speech. In man, basic vowel sounds are produced by the voice box *(larynx),* and pass through the vocal tract *(pharynx)* in the throat. The root of the tongue forms the front wall of the vocal tract. As the tongue moves, the vocal tract changes shape and produces the wide variety of vowel sounds used in speech.

Though a monkey also has a voice box and vocal tract, its tongue isn't able to change the shape of the vocal tract, the scientists report. So monkeys just can't make the sounds of human speech.

An avalanche of trash threatens to bury the countryside around our cities. The dumping of solid refuse is becoming as big a problem as air and water pollution. Trash is increasing not only because the population is increasing, but also because individuals are throwing away more rubbish. Every man, woman, and child in the United States discards an average of five pounds of trash a day.

Trash used to be dumped in the wide open spaces between cities and towns. But as cities and towns grow, open spaces are disappearing. Many solutions have been suggested for the trash problem, including dumping the trash in the ocean, making fertilizer of it, and filling in marshes and other lowlands. Some scientists think that the only long-term solution will be to find ways to break the trash down into its basic materials and use them again.

Mosquitoes aren't choosy. In their desire for a meal, they attack not only people, but also many other animals, including snakes. They even bite other insects, according to recent studies by three scientists in Canada's Department of Agriculture.

The scientists put mosquitoes in cages with the larvae, or young, of other insects. The mosquitoes promptly bit the larvae and drank their body liquids, which are quite different from the red blood that the mosquitoes take from other animals. It is not known whether mosquitoes feed on insect larvae in the wild. If they do, they may spread diseases from insect to insect just as some kinds of mosquitoes spread diseases among humans.

Manned landings on Mars are the next major goal of the United States' space program. The first steps toward that goal were taken this summer when two Mariner spacecraft flew by the red planet and sent back information about it. Next, two Mariner spacecraft will be launched into orbit around Mars to gather more facts.

Then, capsules containing instruments will be dropped onto the planet to determine what hazards may await human explorers. Finally, around 1982, an atomic-powered spaceship will be assembled from parts launched into an earth orbit. The spaceship—or perhaps several of them—will carry men to Mars and back again, a round trip that will last over a year.

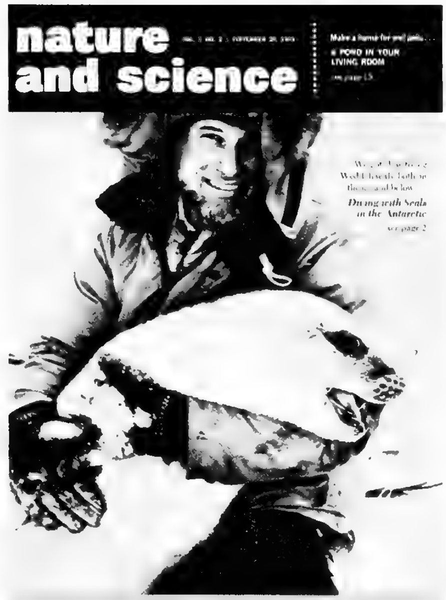
The wandering rocks of California's Death Valley have been a mystery since their discovery around 1900. The rocks move about on the flat surface of a dry lake bed called the Racetrack. Though no one has actually seen the rocks in motion, their movements can be traced by the straight, curved, or zigzag trails they leave in the lake bed from time to time *(see photo).*

Geologists have tried for years to explain what makes the rocks move. They hope soon to set up an on-the-spot study of the problem. One theory is that rain or snow might make the lake bed so slippery that the rocks could be blown along by the 100-mile-an-hour winds that have sometimes been reported there. The geologists dismiss an older and simpler explanation—that the rocks are pushed by ghosts.

nature and science

TEACHER'S EDITION

VOL. 7 NO. 2 / SEPTEMBER 29, 1969 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Diving with Seals

This SCIENCE ADVENTURE describes some of the adaptations of the Weddell seal to life in the Antarctic, and how biologists went about investigating the life of this marine mammal. You might emphasize some important points of the article by using these discussion questions:

• *Why are seals called mammals?* Review with your pupils the characteristics of *mammals* (animals with hair that feed their young with milk) that distinguish them from other groups of animals such as birds, fish, and reptiles. Other marine mammals include whales and porpoises *(see "The Ways of Whales,"* N&S, *March 17, 1969).*

• *In what ways are Weddell seals adapted for life in the Antarctic?* Adaptations fall into three categories: 1) *morphological* (shape, size, color of animal and its parts), 2) *physiological* (processes within the animal's body), and 3) *behavioral.* Some characteristics of the Weddell seal, such as its ability to dive deeply and to stay underwater for long periods, are due to all three types of adaptations. Your pupils might also think of these morphological adaptations — streamlined shape, flippers, fur, and blubber. Behavioral adaptations include the mother seal's seeking a sheltered place for giving birth.

• *Why are the Weddell seals fearless of man?* These seals have no enemies in their shore-ice habitat, so they have no reason to fear large animals such as humans. Fortunately, the few humans that reach the Antarctic have not taken advantage of the seals' tameness except to study them. Some kinds of animals, such as the famous dodo, have become extinct due partly to their fearlessness.

For Your Reading

For more information about how animals are adapted to life in cold climates, see the special issue "Life in the Arctic," (N&S, *Jan. 20, 1969*) and its Teacher's Edition.

"Pop Gas" in the Atmosphere

This article shows how many of the things we do to make life more comfortable are increasing the amount of carbon dioxide in the earth's atmosphere—a change in our environment that we do not know enough about to predict how it may affect us and other living things.

Through reading this article and discussing the topics suggested below, you can help your pupils understand and appreciate the importance of this basic concept: *Changes in one part of nature cause changes in other parts of nature.* Man is a part of nature, and our activities change our environment in ways we often do not recognize until they become a threat to our comfort, or even to our survival.

Topics for Class Discussion

• To help your pupils realize the amazing complexity of the earth's carbon dioxide cycle, have them think

(Continued on page 2T)

IN THIS ISSUE

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

• Diving with Seals in the Antarctic
Your pupils can share a SCIENCE ADVENTURE with scientists who studied the lives of Weddell seals.

What Lifts an Airplane?
This SCIENCE WORKSHOP shows your pupils how to investigate the Bernoulli principle of air speed and pressure.

Niagara is Falling!
Engineers have "turned off" Niagara Falls to see whether they can find a way to stop the falls cliff from caving in.

Our Ocean of Air
This WALL CHART gives your pupils a cross-sectional view of the atmosphere and characteristics, objects, and phenomena found at different levels within it.

• Is "Pop Gas" Warming the Atmosphere?
This article shows your pupils how we are pouring carbon dioxide into the atmosphere without considering what effects it may have.

• A Pond in Your Living Room
A SCIENCE WORKSHOP shows your pupils how to set up a pond aquarium and study the living things in it.

• Brain-Boosters

IN THE NEXT ISSUE

A SCIENCE WORKSHOP investigation with spinning turntables brings out the concept of a "frame of reference," and leads to a project that shows how we know the earth is rotating . . . How a group of children explored the ecology of a pond . . . Discovering life in a rotting log.

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

about what goes on inside a spaceship headed for the moon. Daily, each astronaut takes about two pounds of oxygen from the spaceship's "closed" atmosphere and pours into it about two-and-a-quarter pounds of carbon dioxide.

If just 1/200th of the spaceship's atmosphere became CO_2, the astronauts would be less able to do their work and probably would get sick. Still more CO_2 in the spaceship atmosphere would asphyxiate them. But a device in the ship's "atmospheric control subsystem" takes the CO_2 out of the spaceship "air," separates the carbon from the oxygen, and returns the oxygen to the ship's atmosphere. This process keeps the amount of CO_2 in the ship's atmosphere at a low level. (What might happen if the astronauts tried to run a gasoline engine in the spaceship?)

If your pupils have not already thought of it, suggest to them that the earth is like an immense spaceship, occupied by billions of people and other living things, and stocked with a large but limited supply of the materials needed to keep them alive *(see "Spaceship Earth,"* N&S, *April 1, 1968).* The amount of CO_2 in Spaceship Earth's atmosphere depends on the complicated "system" shown on pages 10 and 11.

Your pupils can see that while natural processes tend to keep the amount of CO_2 in the earth's atmosphere at a fairly low level, man's activities over the past 300 years or so have poured so much CO_2 into the atmosphere that our "control system" can't handle the load.

• *Is the growing amount of CO_2 in the earth's atmosphere a direct threat to our health or lives?* Probably not. Only about 3/10,000 of the atmosphere is now carbon dioxide and it would take about 17 times that much to make 1/200th part of the atmosphere (the danger point for astronauts). The amount of CO_2 in the atmosphere is growing very slowly, but it is growing slightly faster each year as we burn more and more carbon fuels to power our machines, factories, automobiles, airplanes, and—yes—to boost spaceships out of the atmosphere.

• *If the growing amount of CO_2 in the atmosphere does not threaten our health, why should we be concerned about it?* The main reason is that we know very little about how this change is affecting the surface of the earth, the oceans, the atmosphere, and the living things that make up our environment. (Figures in the diagram with the article are only *estimates*—guesses based on the little information scientists have been able to gather about our environment up to now.)

While the "greenhouse effect" of CO_2 tends to warm the atmosphere, its average temperature may also be affected by such things as changing amounts of energy radiated by the sun *(see page 11)* and the amount of particles in the atmosphere—dust, smoke, and volcanic ash—that block some of the sun's radiation from the surface of the earth.

We can only be sure that the amount of CO_2 in the atmosphere will continue to grow a little faster each year as we burn larger and larger amounts of carbon fuels to make ourselves "more comfortable." Whatever effect this has on the environment will be part of our "gift" to future generations of humans and other living things.

• *Can we find out more about the increase of CO_2 in the atmosphere and how it may change the environment?* Probably we can, but it will take many more scientists than we now have—geologists, biologists, oceanographers, meteorologists, astronomers, and especially ecologists (scientists who study how changes in one part of nature cause changes in other parts of nature). Besides the cost of training these scientists, they will have to be paid—like the scientists of the National Aeronautics and Space Administration (NASA)—to do research that will not "pay for itself" by producing new materials or machines that can be sold for a profit. What they could find out might make a big difference, though, in the comfort—and perhaps even survival—of future generations of life on earth.

• *Can you think of some ways we could reduce the amount of CO_2 we pour into the atmosphere each year?* Your pupils can probably think of at least three ways: 1) Stop burning carbon fuels, or at least cut down on our use of them. 2) Use devices like the ones in the Apollo spaceships to take CO_2 from the air and separate it into carbon and oxygen. 3) Use nuclear ("atomic") energy instead of energy from carbon fuels to power our factories and machines.

• *What are some of the problems each of these "anti-CO_2" measures would bring?* 1) Your pupils will have quite a time imagining what would happen if we stopped all burning of coal, oil, and wood. If we decided to burn less than at present, who should be permitted to burn these fuels? And for what purposes?

2) How much would it cost to equip every carbon-fuel-burning device with a CO_2 trap and "breaker-upper"? Or to build and operate plants to "de-carbon-dioxidize" the atmosphere? (Where would we get the energy to power such plants?)

3) Nuclear power plants produce electricity without pouring much CO_2 into the atmosphere, but they produce waste heat that must be released into the air or waterways, as well as radioactive waste materials that are already a problem to those who must find ways to dispose of them safely. (Which causes more serious changes in the environment—CO_2 or the wastes from nuclear power plants?)

Scientists in several countries are
(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.

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

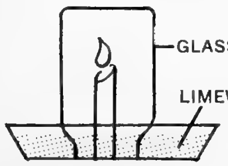
trying to find a way to get useful energy by *fusing,* or combining, the nuclei of atoms instead of by "splitting" them apart, as our present nuclear power plants do. If this fusion process can be controlled, it can probably fill most of the world's energy needs without producing CO_2, radioactive wastes, or much of anything else (except heat) that will pollute and change our environment.

Activities

Your pupils can easily detect carbon dioxide in the atmosphere and from many different sources, even though the gas is both colorless and odorless. They will need only some "limewater," made by dissolving *calcium hydroxide* [$Ca(OH)_2$, also called "slaked lime"] in water. Obtain about a cup or so of this substance from the high school chemistry lab. Pour one teaspoonful into a jar about half full of water, cover the jar tightly, and shake it thoroughly. Let the covered jar stand overnight, then pour the limewater solution into another clean jar, taking care not to stir up material that has settled to the bottom of the first jar.

Pour some limewater into a shallow dish and leave it uncovered. Within an hour or so, CO_2 from the air will combine with the limewater to form a milky white substance in it. What happens is this: Calcium (Ca) and oxygen (O) from the $Ca(OH)_2$ combine with carbon (C) and oxygen from the CO_2 to form *calcium carbonate* – $CaCO_3$, or *chalk*; the hydrogen (H) and the remaining oxygen form water (H_2O). Whenever chalk forms in limewater, you can be sure that some carbon dioxide gas is present; the more CO_2, the faster the chalk will form.

- While you are waiting for the water in the dish to become "milky," have one or more pupils exhale through straws into a fresh jar of limewater to detect CO_2 in their breath.
- You can use a balloon to catch some CO_2 from a bottle of soda pop. Use a warm bottle and try to remove the cap without shaking it. As soon as the cap is off, stretch the mouth of the balloon over the bottle opening. Then shake the bottle to make gas bubble out of the pop and into the balloon. Hold the neck of the balloon tightly closed as you remove the balloon from the bottle. Then hold the mouth of the balloon in fresh limewater and squeeze the gas from the balloon. What happens to the limewater?
- Your pupils can use this same method to test the gas that forms when they pour a mixture of vinegar and water (about half and half) into a clean bottle containing some baking soda (*sodium bicarbonate,* or $NaHCO_3$). Is the same gas formed when you mix Bromo Seltzer or Alka Seltzer with water? How can you find out?
- Stand a small candle in the center of a shallow dish, then pour fresh limewater into the dish. Light the candle, then cover it with a clean glass jar *(see diagram).* In a short time the



flame will die out, and the limewater will turn "milky." Can your pupils explain what has happened? (The flame results from the rapid combination of carbon from the wick and wax with oxygen from the air inside the jar, producing carbon dioxide, as shown by the formation of calcium carbonate in the limewater. The flame dies out because there is not enough free oxygen left in the jar "air" to support the burning process.)

Pond Aquarium

A classroom aquarium can be a valuable teaching aid, helping to illustrate interrelationships among different kinds of organisms. Beware, however, of the myth of the "balanced aquarium." Fish and other aquarium animals do not depend on plants to provide oxygen and remove carbon dioxide from the water. Nearly all of the oxygen required by aquarium animals enters the water through its surface. The chief reason for keeping plants in an aquarium is to provide shelter and perhaps food for some of the animals, and to give the aquarium a more natural appearance.

Your pupils should help plan, set up, and maintain the aquarium. Possibly one of your pupils already has a still-usable tank that can be borrowed. If an aquarium tank has been dry for a long time, its seams should be treated with sealer before water is added. Once the aquarium is set up, individual pupils or teams can be assigned such tasks as feeding and cleaning.

The two main sources of trouble with aquariums are overcrowding and overfeeding. In the schoolroom, maintenance can be a problem on weekends and holidays. Before such times, the tank's top should be covered (to prevent excessive evaporation). Avoid excessive feeding before a weekend or holiday; it is better to add no extra food than to risk overfeeding that might result in a polluted tank.

Brain-Boosters

Mystery Photo. The tracks in the photo were made by a bulldozer. The curved part of the track was made when the bulldozer turned sharply.

If one of your pupils can bring in a toy bulldozer, you can let the class see the tracks it makes in a pan of wet sand. They can duplicate the ringed pattern in the photo by swiveling the toy around in the pan. This is how a real bulldozer turns. The track (or endless-belt "wheel") on the inside of the turn is locked in place, and the machine pivots on it. Perhaps it would be possible to visit a construction site where your pupils could see a real bulldozer in action.

What would happen if? If a small nail hole were made in the bottom and one in the side of an unopened juice can, the liquid would run out through the bottom hole. As it did so, a partial vacuum would begin to form near the top of the can. The atmospheric pressure outside the can would then force air in through the hole in the side of the can. This air would bubble up through the liquid to relieve the partial-vacuum condition.

Your pupils can easily try this at home, or in school if the materials can

(Continued on page 4T)

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

be provided (preferably a small juice can for each pupil). Let them experiment with different numbers and locations of holes. (If two holes are made in the side along with one in the bottom, the juice will run out of the bottom hole and the lower of the two holes in the side.) What do your pupils think will happen if a hole is first made in the top of the can (or if the top is removed)? Let them try it and see.

Can you do it? One way to make a rounded ice "cube" would be to fill a balloon with water, then put it in the freezer. Another way would be to freeze a teacupful of water, then place it upside down on top of another water-filled teacup in the freezer.

Can your pupils think of other ways to make rounded ice "cubes"? Let them try it at home and bring in their results wrapped in newspaper and aluminum foil, or other insulating materials. Who can make the roundest one? The largest? The smallest?

Fun with numbers and shapes. Let the children inspect the classroom globe to try to determine what place lies "on the other side" of the earth from their town. After they have made their guesses, have them figure it out more accurately by using latitude and longitude figures.

The place opposite the earth from your town will be at the same degree of *south* latitude (below the equator) as your town is of *north* latitude (above the equator). Thus, if your town is located along the 39° line of *north* latitude, the opposite place will lie along the 39° line of *south* latitude. To figure out the *longitude* of the opposite place, however, you must subtract the *west* longitude of your town from 180. This will give you the *east* longitude of the place opposite your town. Thus, if your town is at 83° *west* longitude, the opposite place will be at 97° (180 minus 83) *east* longitude. By running their fingers along the approximate latitude and longitude lines on the globe, your pupils can pinpoint the place where the lines intersect as the place opposite their own town.

For science experts only: Iron powder can be removed from the mixture with a magnet (wrap the magnet in a thin plastic film to avoid the tedious task of removing the powder from it). The remaining sand-and-salt mixture can be placed in water, and the salt solution poured off after the sand has settled to the bottom. Boil off the water or let it evaporate from the salt solution, leaving the salt crystals.

You might get some iron powder or filings from a machine shop (at the high school?) or make some by filing an iron nail. If you mix the materials and give each pupil a small batch in an envelope to work with, you might include some pepper or sawdust (which will float in the water and can be spooned off). Have a variety of things such as magnets, strainers, cups, spoons, funnels, paper towels (filter paper), and so on for your pupils to use in solving the problem.

nature and science

VOL. 7 NO. 2 / SEPTEMBER 29, 1969

Make a home for wet pets . . .

A POND IN YOUR LIVING ROOM

see page 13

We got close to big Weddell seals, both on the ice and below . . .

Diving with Seals in the Antarctic

see page 2

nature and science

VOL. 7 NO. 2 / SEPTEMBER 29, 1969

CONTENTS

PICTURE CREDITS: Cover, pp. 3-4 from Michael A. de Camp; pp. 5-7, 10-12, 14, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 7, left photo, Wide World Photos, Inc., right photo, United Press International; pp. 8-9, art by John Polgreen; p. 12, photo by David Webster; p. 13, Laurence Pringle.

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

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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.

A SCIENCE ADVENTURE

To find out how the Weddell seals live, we spent the spring with them on the ice and in the ocean.

■ The great roof of ice above us glowed with a soft twilight. We swam in deep blue water that looked black in the depths below. Seals glided by, their big eyes gazing at us unblinking. They made eerie chirps and trills that sounded like music from another planet.

By diving with these seals under the six-foot-thick Antarctic ice we were trying to learn about their underwater behavior, adding to what we had observed of the animals above the ice.

Camping at Turtle Rock

In October, the Antarctic spring, we set up camp at Turtle Rock *(see photo),* a cone-shaped hill that juts 200 feet above the ice near the base of towering Mount Erebus, an active volcano about 1,000 miles from the South Pole. Each spring Turtle Rock becomes a seal *rookery* (breeding area) where the females give birth to their pups. The rock provides shelter from the wind and a way to the sea below.

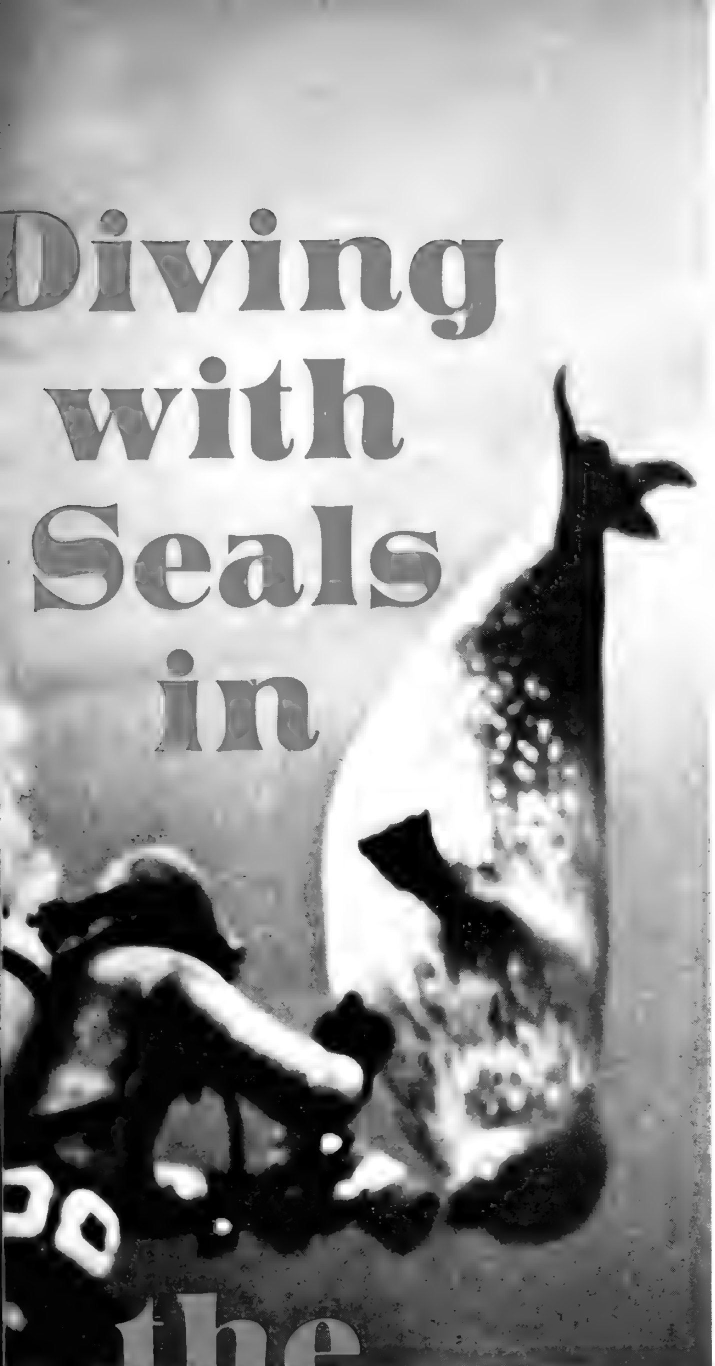
A crack in the ice, kept open by the tides, stretches from the north face of the rock toward Mt. Erebus. Seals gather along this crack, keeping holes in the ice open by sawing with their upper teeth through the soft ice that forms in the crack every night. Through the holes they must go to find fish to eat. The seals can dive to about 2,000 feet. They can stay underwater for as long as 45 minutes before coming to the surface for air. They must find a breathing hole in the ice or else die for lack of air.

The seals can't see far in the water, especially during the dark Antarctic winter. It seems as if they must depend on echoes to find their way around (as porpoises and bats do). The seals chirp and trill a good bit, sending out sound waves that bounce back through the water from a solid object such as ice. If a chirp directed up at the ice brings no echo, the seal may know there is a hole in the ice above. (Since the seals can't smell without breathing, and can't breathe underwater, it also seems possible that the seals depend on echoes to locate fish for food.)

The first seals had already gathered at Turtle Rock when we arrived in tracked vehicles that had crossed the ice from McMurdo Station. We used chain saws and dynamite to make holes in the ice so we could dive below. We lived in a wooden shack that was also used as a weather station and for recording underwater sounds. We could see most of the seal colony from the shack's big window.

A second shack had an opening in its floor. This shack

Diving with Seals in the Antarctic



by Michael A. de Camp

was put over our diving hole in the ice. The seals at Turtle Rock hardly noticed us as long as we kept a few yards away from them. If we came within 10 feet, they would roll on their sides, wave a flipper, and make clucking sounds or snap their jaws. If we came too close, they humped off across the ice or slithered through a hole into the water below.

The Weddell seal is the only ocean mammal that can be easily approached and observed in its own world. Unlike the Arctic, Antarctica has no land animals, such as polar bears and Eskimos, that kill seals. Whales sometimes kill Weddell seals, but the seals are usually safe when they are near shore. The seals are fearless of man, in or out of the water.

Into the Dark, Cold Sea

In order to study the seals, we decided to become as much like them as possible. To do this we put on rubber "wet" suits to protect us from the cold, and double SCUBA diving tanks so we could stay below an hour or so at a time. When we dropped through the deep layer of shredded ice in our ice hole, we entered an alien world.

The water temperature was 28.6 degrees Fahrenheit, just at the freezing point of salt water. It was dark, but clear enough for us to see 300 feet or so. Below us the black bottom was sprinkled with golden worms. Red starfish and purple sea urchins spread out before us in the deep blue darkness like stars in the Milky Way.

We had to swim some 200 feet from our hole under the shack to where the seals were swimming near their own holes in the crack. The intense cold of the water might freeze our air regulators; if it did, the hole was too far away and the ice was too thick for us to escape. So we

(Continued on the next page)

This aerial view of Turtle Rock shows the shacks (far left) used by biologists as they studied Weddell seals (the dark shapes on the ice). Turtle Rock is seven miles northeast of the United States' McMurdo Station in Antarctica.

This photo shows Dr. Carleton Ray measuring a young seal to check on its growth. The author, Michael A. de Camp (see cover), is a diver and photographer and teaches science at a private school in New Jersey.

Diving with Seals (continued)

stayed close together and watched each other carefully. The beauty of the scene was so overpowering that it kept us from feeling the cold and danger.

Suddenly a female seal appeared, swimming between us, inspecting our cameras and masks, and even bumping against us. Around and around we whirled with the curious seal, trying to stare her down with our faces only inches from hers. She stayed with us for most of the dive, leaving only to surface for air.

Never again were we so carefully inspected by the seals. It seemed as if the "scout" seal had "informed" the others that we were up to no harm. In our four-week stay at Turtle Rock, we spent over 23 hours under water. Our longest dive lasted 70 minutes.

A Pup Is Born

Each day when we went from our shack to count the seals, we found new pups all around us; but we had not yet been able to witness a birth. (Once we noticed a large seal waving its flippers in the air and straining its stomach muscles. We rushed up to it and found it was a male that must have been dreaming.)

In early October, after keeping an around-the-clock watch on the seals, we observed the birth of a pup and photographed it with a movie camera. The seal pup was born on the ice, soaking wet, into a world 102 degrees colder than the 99-degree temperature within the mother's body.

If the weather is very cold and the pup is exposed to the wind, it will die. However, we noted that pups born later in October when the weather was warmer sometimes died. They needed the cold air to freeze the moisture on their fur so the crystals of ice would break off and leave the pup dry. If the air is too warm the fur stays wet, so the pup is chilled too much by the cold wind and may die.

The Weddell seal lives in the harshest environment on earth for a warm-blooded animal. Both the cold air and the evaporation of moisture from its fur by strong winds take heat from the pup's body. We tagged, measured, and weighed each of the first 25 pups born, and kept track of their movements each day. We found that the

In some unknown way, seals find breathing holes in the ice after swimming underwater for as long as 45 minutes.

nes that stayed behind the rock, sheltered from the winds, rew more than 60 pounds heavier than the pups in more xposed areas.

loisy Nighttime Swimmers

By mid-November, 47 fat, squirming pups with their iothers and about 13 males made up the rookery popula-on. The seals were all around us, lying beside the shack nd underfoot as we made our rounds of the colony.

Underwater, the seals were making more noise now, iggesting more activity there. Our *hydrophone,* or under-ater microphone, picked up trilling sounds from other ɔokeries at Turks Head and Hutton Cliffs, as far as 10 iiles away. As we tried to sleep after our midnight dives, ie hut often shook with the trilling of nearby seals, and e could hear the breathing of others at the hole under ir diving hut.

When a mother seal took her pup for its first swim, at rst the pup would stay very close to its mother and near ie breathing hole. Soon they began to swim farther away id farther apart, and we could come up close to the pup. he baby would come right up to us and nibble on our and and arm or "dance" around us while its mother atched quietly from a few feet away.

The pups nurse for about six weeks, growing from ɔout 60 pounds at birth to 300 pounds or so on the rich iilk. The pup has to fatten up quickly in order to have food reserve for the difficult first winter. Its thick baby air provides little protection against the cold when it is et, but the seal soon develops a three-inch layer of *'ubber,* or fat, that helps hold heat in its body.

/inter in the Water

In December, the mother and pup separate. The seals robably mate at this time, though this has not been ɔserved. In March the sun drops below the horizon, id the ice—which had broken up in January and February begins to form once again. Where the seals go during ie long winter night in the Antarctic is not known for ire. They may go just a few miles from the rookery, aying in the water for weeks at a time and coming up ily to breathe. The water is cold, but it is much warmer ian the winter air above the ice.

We learned a lot about the Weddell seals while living their rookeries and swimming with them in the ocean. s a result, the seals in this barren and far-away place may ɛ the best understood marine mammals of all. But how do ie pups learn about the deep sea? How do they spend ieir first winter? How does the Weddell seal find a tiny fe-giving hole in the ice, which it cannot see from the cean depths or in the dark of the long Antarctic night? hese are just a few of the questions still to be answered ■

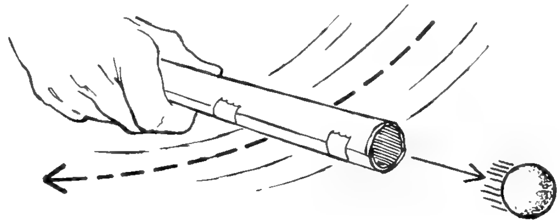
What Lifts an Airplane?

You can find out by investigating how to throw a curve ball.

by Robert Gardner

■ You can easily throw a "curve ball" by launching it from a cardboard tube. Use a ping-pong ball and a cardboard tube about a foot long and wide enough for the ball to roll inside it. (Two or three toilet-tissue tubes taped together will do nicely.)

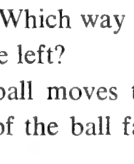
Flip the ball out of the tube by swinging the end of the tube from left to right with a snap of your wrist *(see diagram).* Which way does the ball curve? What happens if you swing the end of the tube from right to left?



As you swing the tube, the ball rolls along one side of it and keeps spinning as it leaves the tube. Which way is the ball spinning when you swing the tube from left to right? Can you throw the ball from your hand so that it spins in that direction? (Try to let go of one side of the ball a fraction of a second before you let go of the other side. Or shoot it with your fingers as you would to put "spin" on a marble.) Which way should you spin the ball to make it curve to the left?

When a spinning ball moves through the air, the air moves past one side of the ball faster than it moves past the other side.

The air next to this side of the ball is pulled along by the spinning ball.



Air next to this side of the ball is "held back" by the spinning ball.

Here are some projects that will help you find out how the different air speeds on opposite sides of the ball make the ball curve. *(Continued on the next page)*

nature and science | WALL CHART
September 29, 1969

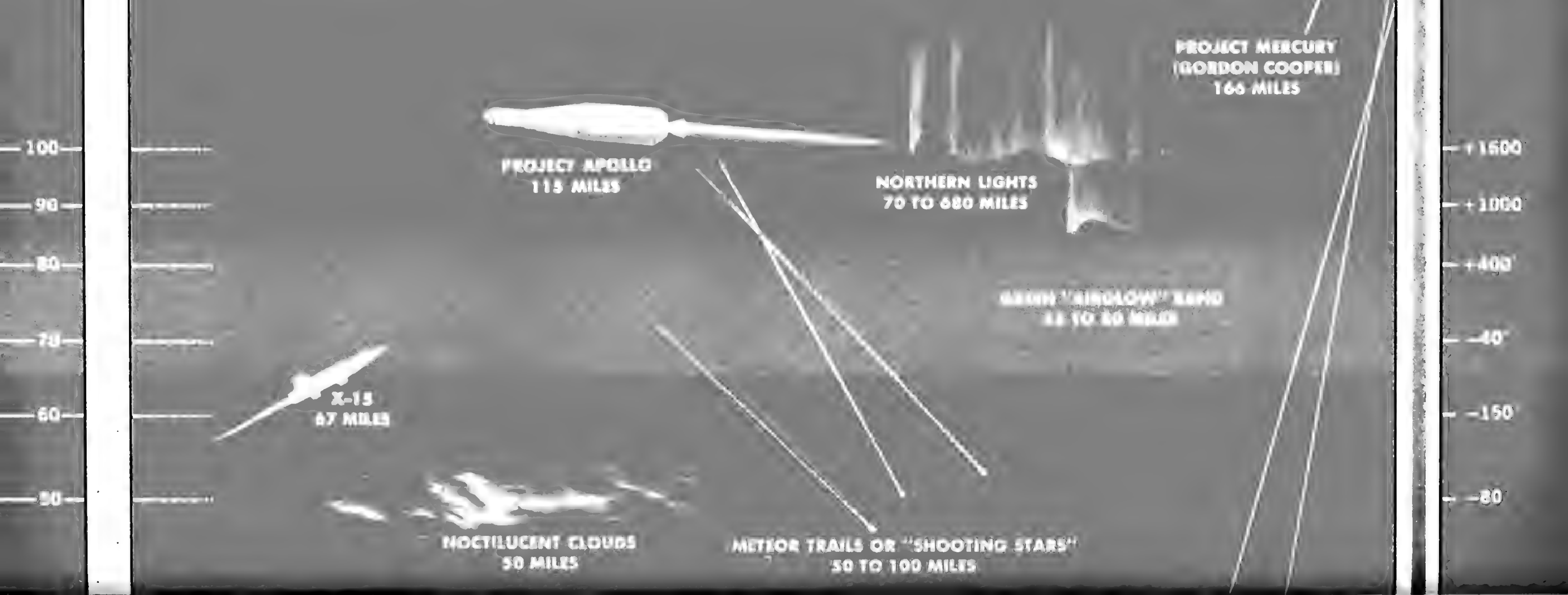
OUR OCEAN OF AIR

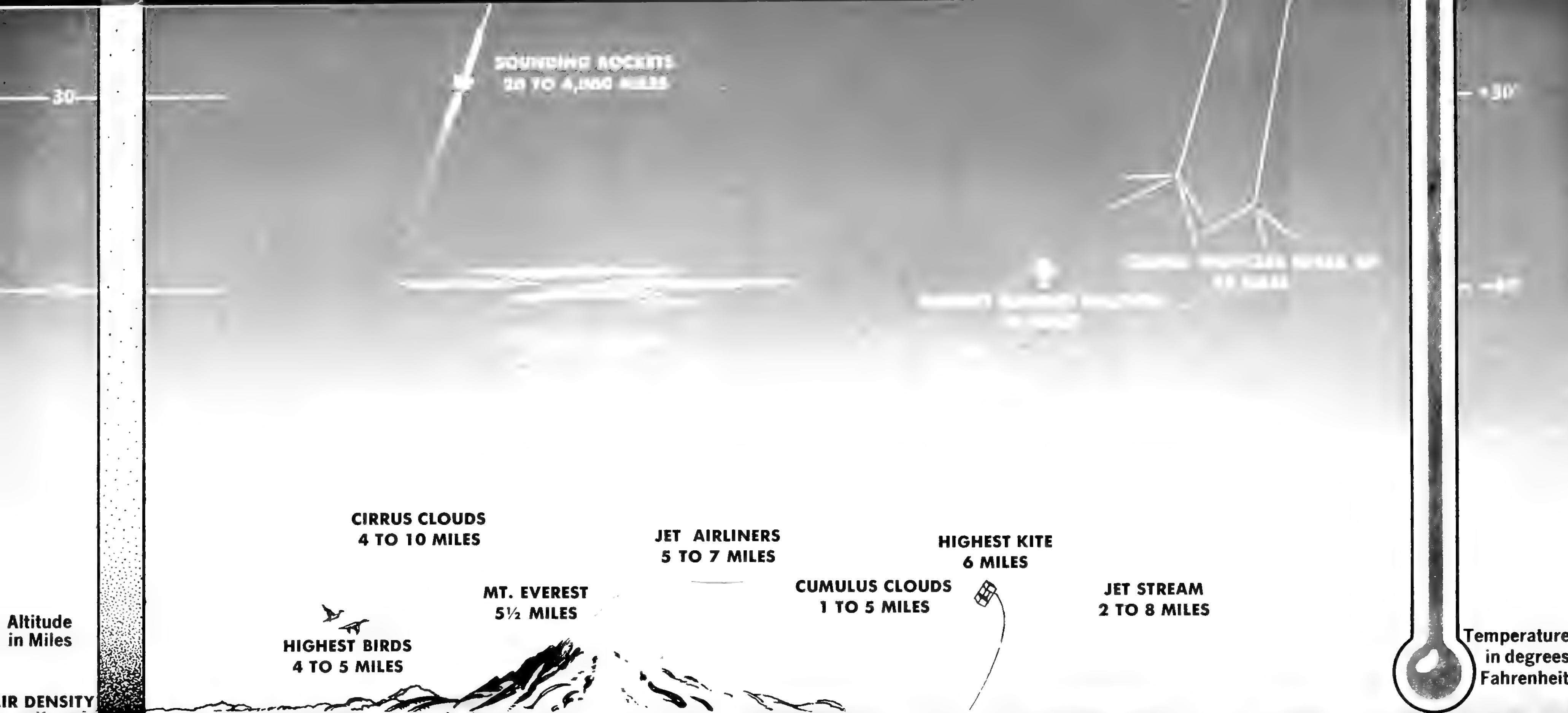
We live at the bottom of a deep ocean of air. Like the ocean, the air is changing constantly. Its temperature, pressure, and the things in it differ from hour to hour and place to place.

Ninety-nine per cent of the air is made up of a mixture of nitrogen and oxygen. In addition, there are several other gases in the air. Mixed with all the gases are dust, pollen, bacteria, soot, salt grains from the sea, and dust from space.

Unlike the sea, our ocean of air does not have a sharp boundary marking its upper surface. The higher we go, the less air there is. At ground level the air is the most dense (see chart, far left), with millions upon millions of molecules packed closely together. About half of the Earth's air lies below a height of three and a half miles. More than 95 per cent of the air lies below 20 miles. At what altitudes the last traces of air lie, no one can say for certain.

This chart of the atmosphere shows some of the things that we know about the air and some of man's attempts to learn more about it through the use of balloons, kites, aircraft, and satellites





- The highest-flying birds are geese that migrate over the Himalaya Mountains in Asia.
- The highest kite was used to investigate high-altitude winds.
- Jet stream winds move at speeds of 150 to 300 miles per hour.
- Cumulus clouds are made of water droplets. Cirrus clouds, and probably nacreous clouds, are made of ice crystals. Nacreous and noctilucent clouds can be seen after sunset. Noctilucent clouds are probably made of volcanic or meteoric dust coated with ice.
- The highest manned balloon was used to test the effects of high altitude and low air density on humans.
- Cosmic particles are tiny, high-speed particles from outer space.
- Sounding rockets bring or send back measurements of wind speeds and the density, composition, and electrical charges of the air in the upper atmosphere.
- Meteors by the millions enter our atmosphere every day. They burn up because of the heat of friction that builds up when they zoom into the dense air close to the earth.
- The X-15, a rocket-powered airplane, flew faster and higher than any other winged craft. It was used to study the atmosphere and test the effects of high altitude flight on humans.
- The glowing green band may be caused by charged oxygen atoms.
- Northern lights are caused by electrically charged particles that come from the sun and collide with particles in our atmosphere.
- Apollo spacecraft orbit the earth before heading for the moon.
- Weather satellites send pictures that help meteorologists track, forecast, and study storms over the entire globe.

Is "Pop Gas" Warming the Atmosphere?

We are pouring more and more carbon dioxide into the air, and the air's temperature has been rising. Scientists are trying to find out just how much these changes are connected.

■ A tiny part of the earth's "ocean of air" *(see page 8)* is *carbon dioxide*—the same gas that bubbles out of soda pop when you open the bottle. This gas is formed when one atom of carbon (C) combines with two atoms of oxygen (O_2), so chemists call it CO_2 (see-oh-two) for short.

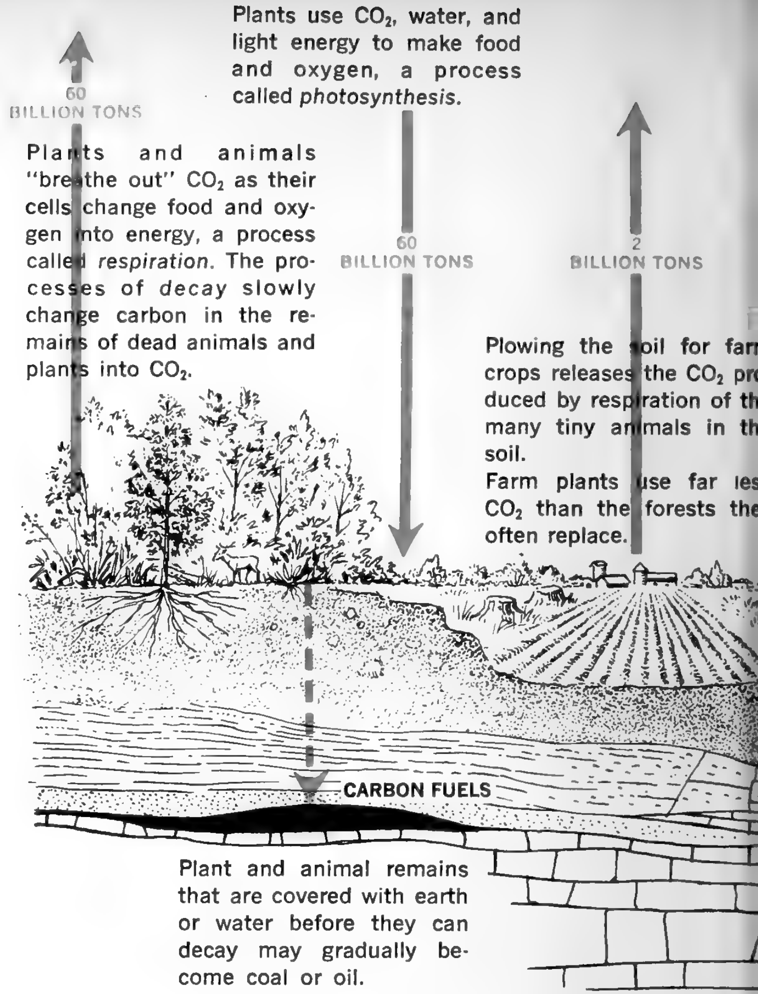
In a one-gallon jug of air from the atmosphere, there is only about one-quarter of a teaspoon of CO_2. But this is more than scientists found when they first began measuring the amounts of gases in the atmosphere 100 years ago. Since then, they have found that the amount of CO_2 in the air is growing, slowly but steadily. Scientists know why this is happening, but so far, no one knows just how it will affect us and other living things.

The Factories that Make CO_2

The diagram on these pages shows how the earth, the oceans, and living things—except for man—take about as much CO_2 out of the air each year as they put into it. The extra CO_2 in the air comes mainly from man's activities during the past 200 years or so.

After the steam engine was invented, men began to burn more and more carbon fuels—wood, coal, and oil—for energy to run factories, trains, steamships, and so on. If wood is allowed to decay, its carbon *oxidizes,* or combines with oxygen, little by little over a long period of time. If coal and oil are left in the earth, their carbon might never be oxidized. But *burning* means *fast oxidation,* and burning as much carbon fuel as we do now pours about six billion tons of CO_2 into the air each year. (In the past 100 years, we have probably added about 360 billion tons of CO_2 to the air in this way.)

Farming also adds CO_2 to the air—about two billion tons a year. Farm plants take less CO_2 out of the air than the forests they often replace. And soil that is cleared for farming releases large amounts of CO_2 that is produced mainly by tiny animals in the soil.



This diagram shows about how much carbon dioxi

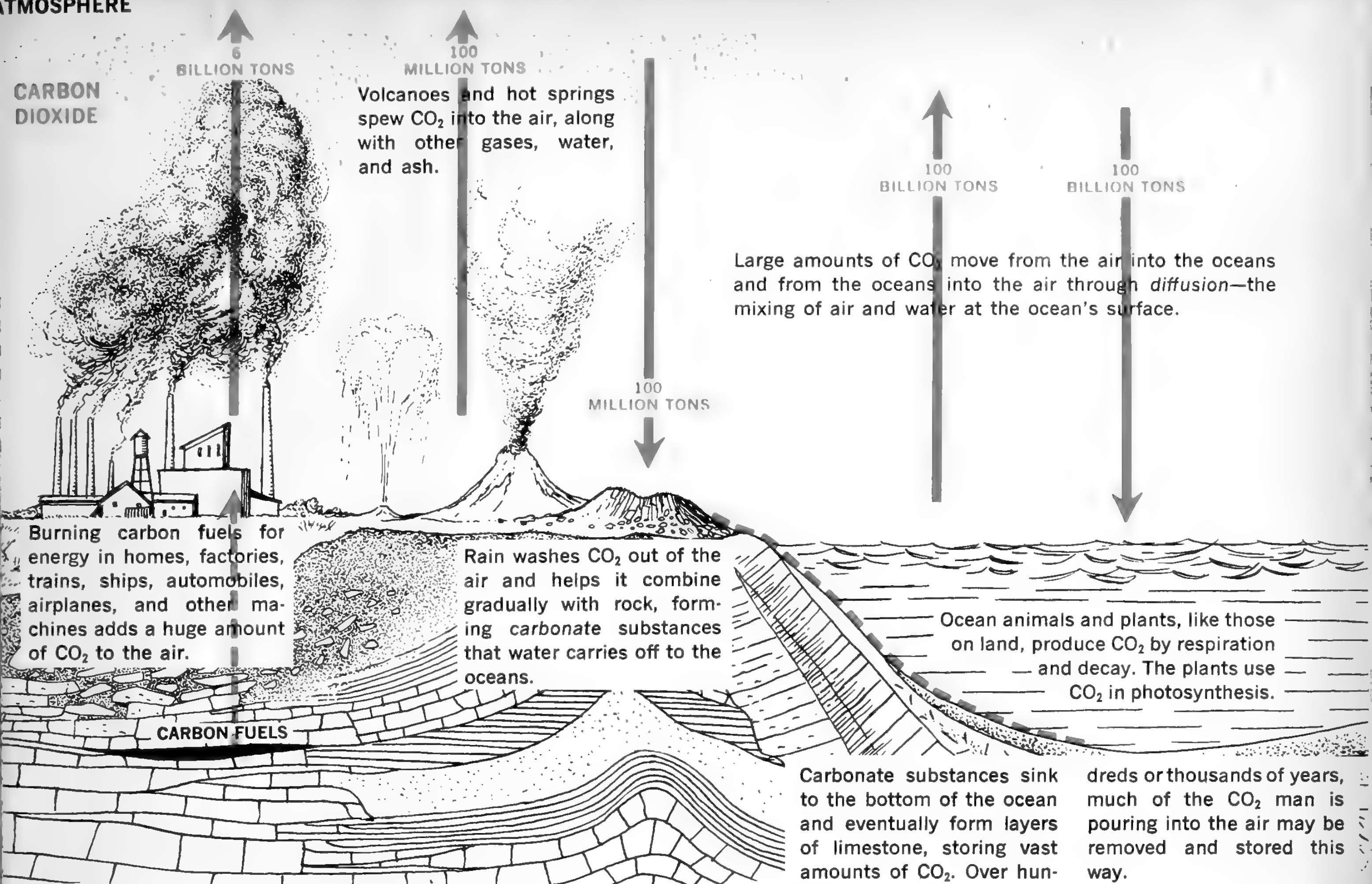
Some of the CO_2 we pour into the atmosphere is taken up by plants, making them grow faster. The oceans may also be taking a little more CO_2 out of the atmosphere than they are releasing into it. (Some scientists believe that the oceans might slowly soak up all of the CO_2 we have added to the air, but this would probably take hundreds, or even thousands of years.)

How CO_2 Warms the Air

The average temperature of the air in different parts of the world has gone up about one degree Fahrenheit in the past 100 years (though it doesn't seem to be rising now). At least some of this warming has probably been caused by the burning of carbon fuels.

For one thing, the burning of carbon fuels releases heat energy as well as CO_2 into the atmosphere. Probably more important, though, is the *greenhouse effect,* in which carbon dioxide in the atmosphere acts like the glass roof of a greenhouse.

You feel this warming effect when you step into a closed automobile that has been sitting in the sun. Sunlight passing through the windows is partly heat energy, which is soaked up by solid objects inside the car. These objects then *radiate,* or send out, heat energy in a different form



put into the atmosphere and taken out of it each year by natural processes and by man's activities.

from the heat energy in sunlight. This form of heat energy, called *infrared,* cannot pass through glass, so it is trapped in the car and warms the air inside.

In the same way, sunlight passes through the CO_2 in the atmosphere and warms the earth. But the infrared energy radiated by the earth can't escape through the CO_2, so it is trapped near the earth and raises the temperature of the air. The more CO_2 there is in the atmosphere, the warmer the air is likely to be.

Can CO_2 Change the Earth's Climate?

Some scientists think that the amount of CO_2 in the atmosphere may have changed the earth's climate in past times. During at least one long period of time—the Carboniferous period about 300 million years ago—plants covered much more of the land than they do today. Much of the land was marshy, and dead plants were often covered by water or earth before they could decay and return their carbon to the air as CO_2. This left less CO_2 in the atmosphere, and might have allowed the air to cool enough to start glaciers growing in the colder parts of the earth. In fact, much of the earth's land was covered by glaciers during the Permian period, which followed the Carboniferous period.

There are other such ideas, but none of them can be proved. And scientists know that the temperature of the atmosphere depends on other things besides CO_2. For example, the sun may be radiating more heat energy now than it has at other times in the past, and this would tend to warm up the earth's atmosphere.

Scientists can now measure how much heat energy the sun is radiating, as well as how much of this heat energy reaches the surface of the earth. This may help them find out within the next 50 years or so whether the increase of CO_2 is an important cause of the warming of the atmosphere. If it is, we can expect the air to keep getting warmer until we either run out of carbon fuels or stop burning them ■

Some Things To Think About

One scientist thinks that if we keep burning more carbon fuels each year, by the year 2000 the average temperature of the air may be 3½ degrees higher than now. Can you think of some ways this might affect you? Other animals? Plants? The Arctic and Antarctic ice caps and the level of the oceans?

BRAIN-BOOSTERS

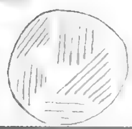
prepared by **DAVID WEBSTER**

MYSTERY PHOTO

What made these tracks?

WHAT WOULD HAPPEN IF . . .

. . . you punched a small nail hole in the bottom of an unopened juice can and another in the side of the can? Would the juice come out of both holes? Would it come out at all?



CAN YOU DO IT?

Can you make a rounded ice cube?

FOR SCIENCE EXPERTS ONLY

Suppose that some salt, iron powder, and sand were all mixed together. What could you do to separate them into three different piles?

JUST FOR FUN

See what you can find out by leafing through a telephone book:

Are more people in your area named Miller, Smith, Johnson, Taylor, or White?

Do more people have names beginning with the letters A through M, or N through Z?

Does anyone listed have the same name you have?

Can you find a last name with only two letters?

FUN WITH NUMBERS AND SHAPES

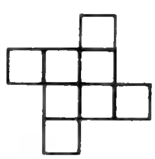
Suppose you dug a hole straight down into the earth under your house. Where would you come out? Would you be in China, in Australia, or in the Pacific Ocean? Use a globe to find out.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: Over the years, the soil around the tree has gradually eroded away. Roots that were once underground are left exposed.

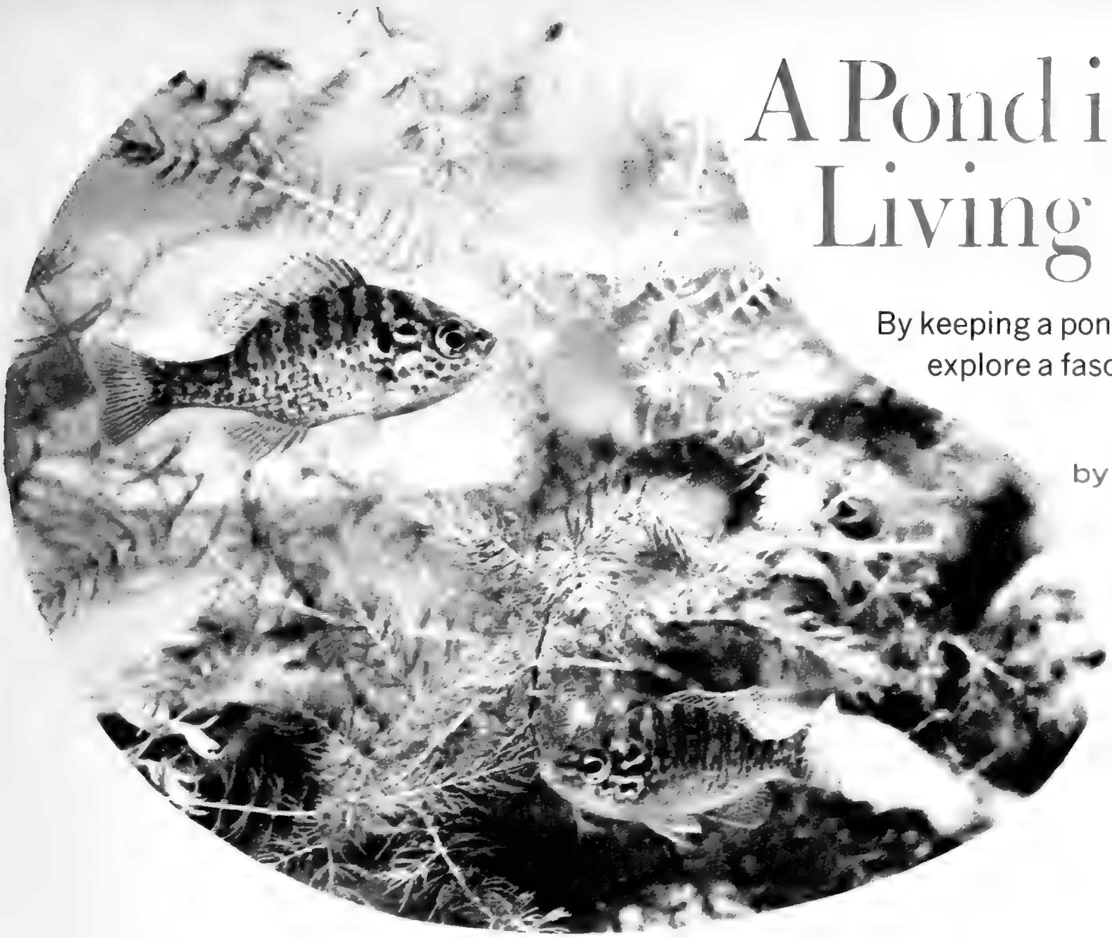
What will happen if? When soil is shaken in water then allowed to rest undisturbed, the different-sized particles of soil settle out in layers on the bottom of the jar. The largest particles fall to the bottom first; smaller particles drop out later on top of the other particles. The water will eventually become completely clear.

Can you do it? Mr. Brain-Booster was unable to find a way to keep a balloon completely inflated for several months. Did you find a way?



Fun with numbers and shapes: Here is how you can arrange eight sugar cubes so that each one is at the end of a line of three. Can you find other ways?

For science experts only: A large tree has more than 200,000 leaves. How could you estimate the number of leaves on a tree without counting each one?



A Pond in Your Living Room

By keeping a pond aquarium you can explore a fascinating underwater world at home.

by Laurence Pringle

■ Keeping an aquarium is like having a miniature pond in your home. Once your aquarium is set up, you can discover many things about how water animals and plants live and grow—how a fish moves its fins, or how a tadpole slowly changes into a frog.

Part of the fun of having an aquarium is deciding what kinds of plants and animals you are going to keep in it. There are several kinds of aquariums, including ones for tropical and ocean life. A good one to try first is a freshwater pond aquarium. Pond aquariums are inexpensive to set up and care for.

Starting Your Aquarium

To set up an aquarium you need a large glass container of some sort. A gallon jar can be used, but its curved glass causes the light to bend so that animals inside the jar will look distorted. A better kind of aquarium is a rectangular one that holds six to 10 gallons of water.

These tanks usually have metal frames, a slate bottom, and a removable glass top. The top is important. It keeps dust out and the fish in. You can buy such aquarium tanks at pet supply shops.

Once you have an aquarium tank, cover the bottom of it with one or two inches of fine gravel or coarse sand. (Coarse gravel traps food particles, which decay, and fine sand packs too hard to allow plants to grow.) Wash the gravel or sand (do not use soap) before you put it into the tank. Or buy washed gravel at a pet shop. Otherwise the aquarium water will be dirty and unhealthy for animals. If you add some small rocks and push some of the gravel into a mound at the rear of the tank, your aquarium will have a natural appearance.

Decide where you are going to keep your aquarium before you add any water to it. A full aquarium is heavy. Moving it may damage it. Put the tank in a place that doesn't receive any direct sunlight, or too much heat. Near a north window is best. Then fill it with water to within about an inch of the top.

You can use clear water from a pond or stream, or water from a tap. Before you pour water gently into the tank, cover the bottom with a piece of plastic, paper, or a plate so the stream of water will not move the gravel around. If you use tap water, let it stand in the tank for two or three days to allow the purifying chemicals that are added to drinking water to escape as gases into the air. Otherwise, these chemicals may poison your fish.

The aquarium is now ready for planting. You can get some small plants from a nearby pond, for example, duckweed, which is a tiny floating plant that does well in aquariums. You can experiment with others. However, the plants that are available from pet shops usually grow better than wild plants. *(Continued on the next page)*

Some water plants—like *Vallisneria* and *Sagittaria*—have roots that must be well covered with the gravel or sand of your aquarium. Other plants—like the waterweed *(Anacharis)* and water sprite—simply float in the water, although you should anchor their stems to the bottom with a small stone.

Plant the largest plants at the sides and rear of the tank. Then you will have an open area toward the front where you can easily watch the aquarium animals. Remember that the plants will grow and spread, so don't plant them too thickly.

The water may be a bit cloudy after you add the plants, so allow a few days for it to clear and the plants to begin to grow. In the meantime you can decide what animals are going to live in your aquarium.

Choosing Your Aquarium Animals

Many kinds of animals can be kept in an aquarium. They include fishes, insects, crayfish, snails, tadpoles, and salamanders *(see drawings)*. You can catch many of these animals from a nearby pond (use a small dip net and carry your catch home in water-filled plastic bags), or buy them from a pet shop. Don't take animals from fast-flowing streams. They will probably die in the still water of an aquarium.

You may be tempted to put many different kinds of

ANIMALS FOR YOUR POND AQUARIUM

Here is a list of some common animals that do well in aquariums, and some tips on how to care for them.

Small wild fish—like minnows, catfish, sunfish, suckers, and shiners—are interesting and active aquarium animals. Sunfish and some kinds of minnows do not mix well with other fish. They are fine if you want a single type in your aquarium, or if you make sure they are smaller than the other fish. Some good combinations are catfish and shiners, or catfish and black-nosed dace (a kind of minnow).

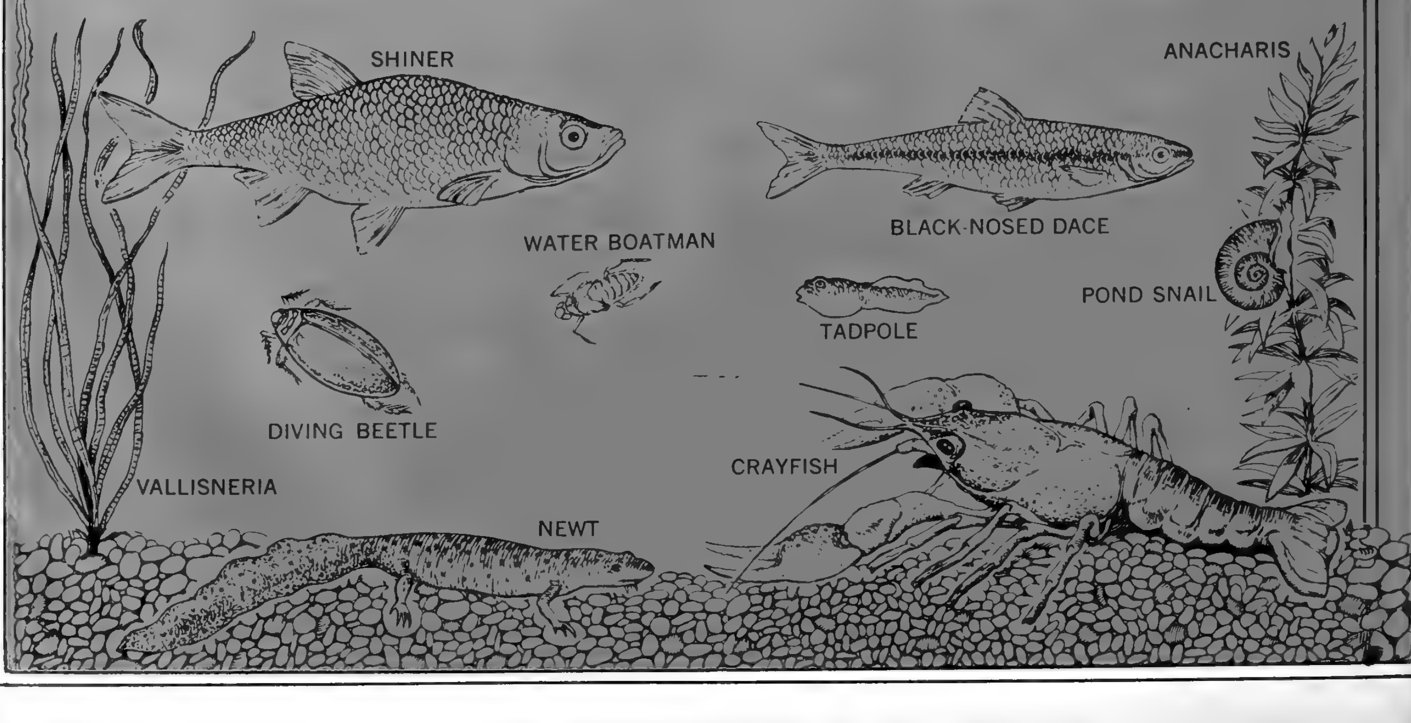
Water insects—like beetles, water boatmen, and dragonfly nymphs—are easy to catch with a small net or a kitchen strainer. Many of these water insects prey on other animals, and on each other. But some people find water insects so fascinating that they keep them in aquariums so they can watch them feed, swim, and hide.

Crayfish are related to crabs and lobsters, and can be found under stones in the shallow water of quiet streams. They do well in aquariums that have stones for them to hide under.

Snails sometimes lay their eggs on the glass sides of aquariums. Then you can watch young snails develop from the eggs.

Tadpoles—also called pollywogs—are young frogs and toads that live in shallow water along the edges of ponds. If tadpoles are well-fed, they gradually turn into adult frogs and toads.

Salamanders are active animals that do well in aquariums. One type—the spotted newt—is common as an adult in freshwater ponds. However, newts do not mix well with fish.



water animals into your tank, but some kinds of animals do not "mix" well. For example, a giant water bug may catch and eat small fish, and some kinds of fish also eat other fish. If several "meat-eating" animals are put in an aquarium, only one or two may be left after a little while. If you want your animals to last, choose animals of a type and size that will not try to feed on each other.

Before you add an animal to the aquarium, be sure that the water temperature of the animal's carrier-container is nearly the same as the water in the aquarium. One way to do this is to float the container in the tank for a half-hour. Otherwise, the shock of a sudden temperature change may kill the animal.

From time to time, you may have to add some water to the aquarium to replace the water that evaporates into the air as water vapor. Be sure that the new water is free of chemicals and is the same temperature as the aquarium water.

The "meat-eating" animals—some fishes, some insects, crayfish, and newts—can be fed bits of lean ground beef, chopped earthworms, small live insects, and prepared fish food. Snails should be fed bits of lettuce, to keep them from eating the aquarium plants. Tadpoles will eat lettuce, spinach, and meaty foods.

The animals should be fed lightly and only once or twice a day. You can skip a day or two without harm. Never give the animals more than they can eat in about five to ten minutes. Leftovers that collect on the bottom should be taken out of the tank every day or so. Aquarium shops sell gadgets that help remove food wastes easily.

Water animals can live without plants in an aquarium. Oxygen that the animals need enters the water from the air, and waste carbon dioxide goes into the air from the water.

How Many Animals?

To find out how many animals your aquarium can support, first measure the length and width of your tank. Then multiply the two measurements to find the number of square inches of water surface. Some aquarium keepers use the rule "an inch of fish for every 4 to 5 square inches of water surface." The surface area is important because this is where the gases enter and leave the water. Divide 4 or 5 into the number of square inches of your tank surface, and you will find the number of "animal inches" that your tank will probably support.

Keep this rule in mind when you put animals into the water, and then watch to see if the animals seem healthy. If fish come to the surface and gasp, there probably is not enough oxygen for them. The quickest temporary remedy is to dip out some of the water and replace it with fresh water. Then you should remove some animals so there is enough oxygen for all ■

■For more information about freshwater, tropical, and saltwater aquariums, look for these books: **Underwater Zoos,** by Millicent Selsam, William Morrow and Company, New York, 1961, $2.75; **Aquariums,** by Anthony Evans, Dover Publications, Inc., New York, 1952, 65 cents; **The Salt Water Aquarium in the Home,** by Robert Straughan, A.S. Barnes and Company, New York, 1969, $9.75.

INVESTIGATIONS

● After your aquarium animals have been living together for some time, notice if any one animal seems to "boss," or dominate, the other animals. If so, put this animal in another container for a few days. Then put it back in the aquarium. What happens? Is the animal still "boss?" If you add a new animal to the aquarium, watch how the other animals act toward the newcomer. Do they attack it? Do they ignore it? Do they seem to be afraid of it?

● Minnows have been trained to jump out of the water and grab a bit of food when a red light flashes. You can try to train, or "condition," some of your animals to come to a certain corner of the tank when you blow a whistle. Here is how to do it:

1. Give one fairly loud whistle (about two seconds long) just before you feed the animals. Be sure to give the same signal each time. Whistle before the animals can see you approaching the tank, or they may become trained to the sight of you, and not to your whistle "food signal." The animals will learn faster if you whistle the same way each time.
2. Always feed them at the same corner of the tank, so that they must come to that spot for food.
3. Don't overfeed the animals. (They will learn faster if they are kept slightly hungry.)
4. To speed the animals' training, never give the signal without feeding them, and never feed them without giving the signal.

Before long, the fish (and perhaps some other animals) will begin to learn that your whistle means "food." They will swim to the feeding corner when they hear the signal.

When they have learned this lesson, you can try to teach them to do other things. You might try to teach them to move to different corners when you ring a bell, or flash a light. Keep a record of your investigations and see how long it takes to train your animals. Do some learn faster than others?

WHAT'S NEW

by
B. J. Menges

Rooftop roads could help solve a city's traffic problems, says David Stephens, a British scientist. He suggests building roads on top of parallel rows of buildings, with connecting roads on top of "cross-buildings." Cars would be parked and serviced on the top floors of the buildings. Apartments, offices, and stores would occupy lower floors. Between the buildings would be parks, playgrounds, and other areas where people could walk, play, and relax. Result: plenty of roads, yet plenty of open spaces.

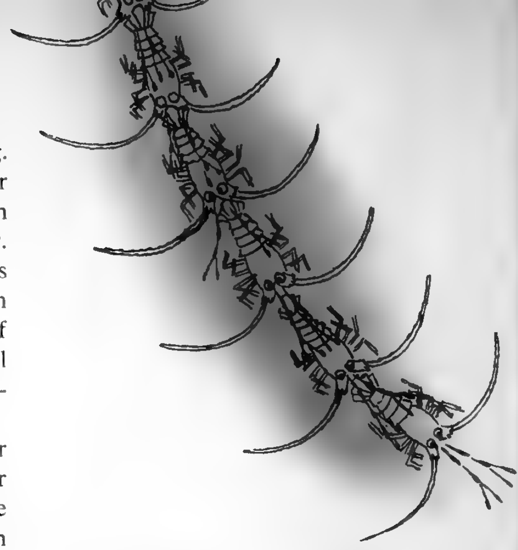
Wouldn't it be noisy to live beneath a road? Not at all, says Stephens. Traffic sounds traveling through the air would have to bend around backwards to go through the windows of the apartments below, and bending reduces the noise level. Furthermore, mounting the rooftop roads on rubber would help prevent noise and vibration from traveling through the buildings. Says the scientist: "Life two stories below a roof road could be more peaceful than in the suburbs."

A new planet may be in the making. Between the orbits of Mars and Jupiter are thousands of asteroids ranging from a few miles to 500 miles in diameter. Some atsronomers think these asteroids are the remains of a planet that was torn apart by the strong gravitational pull of Jupiter. But Dr. H. Alfven of the Royal Institute of Technology, in Sweden, disagrees.

Dr. Alfven recently studied a number of these asteroids known to have similar orbits. Within this group he found three smaller groups. The asteroids in each smaller group have almost identical orbits. This pattern could not have been produced by the breakup of a planet, Dr. Alfven believes. Instead, the pattern suggests to Dr. Alfven that a gradual buildup of space dust formed the asteroids and will eventually combine them into a new planet.

Slippery water is putting out fires in New York City. Small amounts of a special chemical are added to the water to make it flow more easily through a fire hose. Thus a standard-size fire hose can deliver a far larger volume of water than normal over a greater distance. Or a small-diameter hose can carry the same amount of water as a standard hose. The narrower hose is easier for firemen to drag up stairs in order to reach remote parts of a burning building.

Edward Blum, a scientist with the Rand Corporation, came up with the idea for slippery water, and the Union Carbide Corporation supplied the chemical. Slippery water has worked so well in early tests that it is expected to be used soon by fire departments elsewhere.



Spiny lobsters act strangely in the fall. Usually these clawless southern relatives of the American lobster spend their days hiding in rock crevices on the ocean floor. Only at night do they come out and feed. But in the fall thousands of these lobsters leave their hiding places in broad daylight, line up one behind another, and crawl single-file along the ocean bottom.

Why do spiny lobsters behave this way? Biologist William Herrnkind of Florida State University, in Tallahassee, has been observing these lobsters along Florida's east coast. He thinks they may be seeking better feeding grounds and shelter. Their yearly mass movements would help relieve overcrowding. By lining up in a single file, perhaps each lobster is able to protect the rear of the one in front.

"Undercover farms" may soon flourish on coastal deserts. Their success will hinge on a recent discovery made almost accidentally by Carl N. Hodges, a scientist at the University of Arizona, in Tucson. Hodges had found a new method of using sunlight to change sea water into fresh water. While testing this method on a desert beach in Mexico, he used the fresh water to irrigate the land and grow vegetables. He planted the vegetables inside long plastic tents to shield them from the full strength of the sun and to keep them moist by slowing down the evaporation of the water. With plenty of heat, sunlight, and water, the vegetables ripened much faster and grew more abundantly than under normal conditions.

A similar experiment will be tried next year on the Persian Gulf coast of the Arabian Desert. In the future, other parts of the 20,000 miles of desert coastlines of the world may be made productive in the same way.

nature and science
TEACHER'S EDITION

VOL. 7 NO. 3 / OCTOBER 13, 1969 / SECTION 1 OF TWO SECTIONS

◄ N & S REVIEWS ►

Recent Children's Books about Animals

by Barbara Neill

Bats, by Patricia Lauber (Random House, 77 pp., $1.95). The first few chapters of this book give a general introduction to the subject; then the book delves into descriptions of a few of the hundreds of species of bats. Nearly everyone knows that bats eat insects and use a kind of "sonar." But some bats have large eyes and have no need for sonar, while others do such unbatlike things as catch fish or eat the nectar of flowers. Remarkable photographs of these unusual bats and easy-to-read text make this a fascinating book for children in the fourth grade and up.

Wonders of Animal Nurseries, by Jacquelyn Berrill (Dodd, Mead, 63 pp., $3.25). Wild animals' accommodations for their young range from the kangaroo's snug pouch to nothing but a grassy plain where a zebra baby must join the herd shortly after its birth. In the chapter called "Hang-on Nurseries," children learn about the young of the bat, the sloth, and the monkey. There is no attempt at classification; this is simply a miscellaneous collection of animals having different methods of caring for their offspring. Although there are a few questionable statements, the information is generally reliable and the book will entertain nine-to-twelve-year-olds. Attractively illustrated by the author.

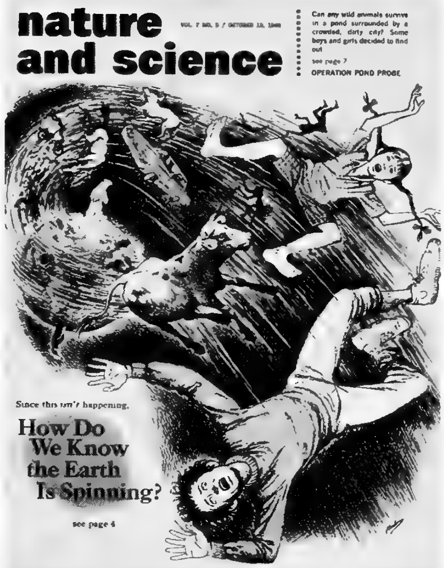
The Curious Raccoons, by Lilo Hess (Scribner's, 46 pp., $3.50). A troublesome female raccoon is removed from the suburbs and released in a woodland. In an old, empty barrel she finds the perfect place to raise a family. The story of this family is well told, and the accompanying photographs record the growth of the three babies. A great deal can be learned about raccoons from this book. Children below the fifth grade may have trouble with the vocabulary, however, and the book will have to be read aloud to most of them.

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

From Fins to Hands, by Anthony Ravielli (Viking, 47 pp., $3.00). This is the story of the human hand as it evolved from the fins of fishes that lived 300 million years ago. The basic five-fingered paw appeared 100 million years later, on the mammal-like reptile, *Cynognathus*. While some mammals became specialized with hoofs, flippers, or wings, primates retained the basic paw shape with only a few modifications. The well-written text helps make the book an excellent choice for science-minded 8-to-10-year-olds. The many fine drawings were done by the author.

Penguins, by Elizabeth S. Austin (Random House, 82 pp., $1.95). The author of this fact-filled and entertaining book is a Research Associate at the Florida State Museum. The book points out that while much is known about the penguin species in Antarctica, there are many gaps in the information we have about the four species found close to civilization, in South America and South Africa. (In fact, some ornithologists believe those four "species" may be simply one species with variations!) The author suggests that perhaps scientists feel it is more adventurous to study birds in far-away places. The book is illustrated with striking black-

(Continued on page 4T)



IN THIS ISSUE

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

● **Can You Draw Straight Lines on a Spinning Turntable?**
This SCIENCE WORKSHOP shows your pupils how different points on a spinning turntable move at different speeds, preparing them for . . .

● **How Do We Know the Earth Is Spinning?**
In finding out how this can be proved, your pupils discover how their frame of reference affects the way they see things move.

Operation Pond Probe
A group of boys and girls describe how they explored the ecology of a pond and discovered . . .

● **A Pond's Web of Energy**
The interdependencies among living things in the pond are shown in this WALL CHART.

Life in a Rotting Log
Your pupils can discover that life in a log goes on—even when the log is dying.

How Do Ewes Choose?
Solving the SCIENCE MYSTERY of how ewes recognize their lambs may help save the lives of some lambs.

Mystery Photo Contest

IN THE NEXT ISSUE

A special-topic issue on Rivers and Man explores some of the ways men have been affected by rivers and vice versa . . . The good and bad that dams do . . . Rescuing prehistoric remains from a dammed river . . . A SCIENCE WORKSHOP investigation of how rivers change their paths.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Spinning Turntable

Your pupils will enjoy trying to draw a straight line across a spinning turntable, and their findings will help them understand the article that follows on page 4.

Either a record player or the inexpensive "lazy Susan" described in the article will do for the turntable. Thin cardboard discs will protect it from marking pens. Have your pupils follow the suggestions in the article.

When they have drawn two circles at once, by touching pens to two points on the disc and rotating it once, have them measure the circumference of each circle *(see Project in "How Do Wheels Roll?"*, N&S, *Sept. 15, 1969).* Since the "longer" circle was completed in the same period of time as the "shorter"one, they should see that a point on the spinning turntable moves at a faster speed the farther it is from the center of the turntable.

Because of this, when a pen is moving in a straight line from the edge to the center of the spinning turntable, each point it touches is moving across the pen's path at a slower speed than the point the pen just passed over.

This makes the pen draw a curved line on the spinning disc. Have your pupils move the pen in straight lines across the disc when it is stationary, rotating slowly, then rotating faster. (The pen should be moved as close to the same speed as possible in each trial.) What happens to the shape of the curved lines drawn by the pen? How do the lines change when the disc is rotated in the opposite direction? Can your pupils figure out a way to move the pen so that it draws a (nearly) straight line on the spinning disc?

- *(Photo, page 3)* The curved line left by a felt-tipped pen moving from the center of the spinning disc to the edge is blurred near the edge of the disc because the parts of the disc it passed over were moving faster and faster, spreading the ink particles farther and farther apart.
- *(Diagram, page 3)* From a stationary position beside the turntable, you can see that the pen is moving in a straight line across it. But if you were an insect riding on the rotating turntable, your own motion along a curved path would be added to the straight-line motion of the pen, making the pen appear to be moving in a curved path.

Spinning Earth

Working with a spinning turntable as suggested above will help your pupils understand how the way we see things move is affected by the rotation of our *frame of reference*—the earth.

Suggestions for Classroom Use

After your pupils have read the first half of this article (down to the subtitle "A 'Swinging' Physicist"), you might have them stop and discuss the idea of a *frame of reference.*

Have each pupil tell the class where your desk is *from him*—straight ahead, to the left or the right, or behind; close, far, or somewhere in between. Their descriptions will vary, depending on where each pupil is sitting *relative to* (or compared to) the desk. Can they describe the position of the desk so that a person not in the room would know where the desk is located? A good answer might be "Standing on the floor near the front of the classroom, about half way between the outside wall and the inside wall." Point out that this locates the desk in a *frame of reference*—a room whose walls, floor, and ceiling are at fixed distances and directions from each other.

If your classroom were on a rotating merry-go-round, would the direction and distance of the desk from each pupil change as the room rotated? If anyone thinks they would change, have him draw a simple diagram of the room with marks to show the position of the desk and his seat, and test it on a spinning turntable. He will find that the marks on the rotating map do not change positions *relative to each other*. However, the marks on the rotating map do keep changing in direction and distance from an object or person *off* the rotating turntable, because the latter is in a different, stationary, frame of reference.

If your classroom were rotating, how would a tree or a fence seen through the window appear to be moving? Since the only thing you can see through the window that appears to be moving in a circle around the classroom each day is the sun (and other stars, at night), your pupils can assume that the earth is a kind of giant merry-go-round—a huge rotating frame of reference.

- *Why didn't people believe this could be so until about 400 years ago (even after Heraclides and then Copernicus had suggested it)?* The cover of this issue shows what people thought would happen if the earth were spinning. Not until the late 1500s did Galileo show that an object can be moving in more than one direction at once *(see "How High? How Far?"* N&S, *April 14, 1969)*, so things on or near the surface of the earth can be moving around with the earth while they are also moving in other directions over the earth's surface. The idea of *gravity* —a force pulling objects toward the center of the earth—was not suggested until the late 1600s, by Newton.

Viewed from the earth, other planets seem to reverse their direction of motion now and then, apparently following a zigzag path through the sky. The earth's rotation does not cause this

(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.

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

effect. The earth is traveling around the sun faster than Mars is, for example, and when earth "overtakes" and "passes" Mars, that planet's *apparent motion* reverses direction.

• Have your pupils read the rest of the article and test a model of a Foucault pendulum at the "North Pole" *(Diagram B, page 5).* Even though they are *off* the turntable, in a stationary frame of reference, your pupils can see that if they were standing on the turntable, the plane of the pendulum's swing would appear to rotate once as the turntable beneath it rotated once.

With the pendulum suspended a few inches from the "pole" *(Diagram C, page 5),* the same thing happens. Mark points under the center and each end of the pendulum's swing, along a line from the edge to the center of the disc. While the "end points" are moving in the *same direction* around the "pole," they are moving at *different speeds,* so they rotate once around the "center of swing" as the turntable rotates once.

The diagram on page 6 shows what happens when the pendulum is swinging at places located at different distances between the earth's North Pole and Equator. The earth is a sphere, instead of a flat turntable, so its center of rotation is a line—the earth's *axis*—instead of a point.

At place A, points under the north and south ends of the pendulum's swing are more nearly the same distance from the earth's axis (center of rotation) than are similar points under a pendulum swinging near the North Pole. At A, there is less difference between the speeds of points under the two ends of the pendulum swing, so the pendulum's plane does not appear to make one *full* rotation with each rotation of the earth.

For the same reason, the plane of a pendulum's swing at place B seems to rotate even more slowly. At the Equator, the plane of a pendulum's swing does not appear to rotate at all, because the points on the earth beneath opposite ends of the pendulum's swing are moving at exactly the same speed.

"Projects," "Things To Think About"

• *(Project, page 4)* Since the moon rotates once during its monthly trip around the earth, an astronaut would have to be on it about two weeks to see the sun "move" from one horizon to the other horizon.

• *(Project, page 6)* Divide the distance around a globe *at your latitude* by the distance around its Equator; multiply the resulting fraction by 25,000 miles per hour to find about how fast you are moving around with the rotating earth.

• *("Things" 1)* A rocket at the Equator must be launched in a northwest direction to make it pass over the North Pole *(see next-to-last paragraph of the article).*

• *("Things" 2)* Satellites are usually launched eastward to take advantage of the speed they already have in that direction because of the earth's rotation.

• *("Things" 7)* The ball would land slightly to the east of the point directly beneath where it was dropped. The top of the tower is farther from the earth's axis than the point on the ground beneath the ball, so the ball is moving eastward faster than the spot below where it was dropped.

• *("Things" 8)* Western Europe is warmed by water in the Gulf Stream *(see map, page 6),* whose northward flow is diverted eastward over the earth like the path of a rocket launched northward from the Equator.

A Pond's Web of Energy

The WALL CHART shows the flow of energy in a small pond, as determined by a brief study in the spring and early summer. A longer study, or one of a more varied body of water, might have revealed an even more complex web of energy.

Your pupils can investigate food webs like these in many kinds of natural communities—in a rotting log *(see page 12),* a field, a forest. In every case, all life depends on green plants and, ultimately, on the sun, since the sun's energy is needed by green plants in the food-making process of photosynthesis.

Although humans do not catch fish for food from "Orange Pond," man is part of many other food webs. Whether our food comes from meat, fish, fruit, grain, or vegetable, the energy we get from it can be traced back to the sun.

The WALL CHART shows the intricate nature of a food web, and suggests how interference with a single link in a food web can have far-reaching and unpredictable effects throughout the community. No wonder, then, that some scientists are concerned when they find quantities of the poison DDT in the tiny plankton of the oceans.

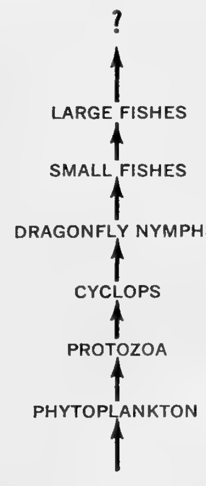
The food web is made up of individual food chains. You can use the chart and the diagram below to show your pupils how DDT and other long-lasting poisons become more concentrated as they pass through a food chain.

References

Pond Life, by George K. Reid, Golden Press, New York, N.Y., 1967, $1 (paper).

The New Field Book of Freshwater Life, by Elsie B. Klotts, G. P. Putnam's Sons, New York, N.Y., 1966, $4.95.

The Life of the Pond, by William H. Amos, McGraw-Hill Book Company, New York, N.Y., 1967, $4.95.



The DDT from many tiny plants becomes part of a protozoan when the protozoan eats the plants. In the same way, a cyclops that eats many protozoa gets all of the DDT that was part of them. The long-lasting poison passes through the food chain, with the organism at the end of the chain receiving DDT that was stored in the bodies of many organisms "below" it in the chain. In this example, the DDT in a large fish might be passed on to an otter, a fish-eating bird, or a human.

Recent Books about Animals
(continued from page 1T)

and-white photographs. It will be enjoyed by fifth-graders and up, including adults.

House Sparrows, by J. J. McCoy (Seabury Press, 126 pp., $3.95). It is hard to find information about house sparrows. Most bird books hardly describe them, on the grounds that everyone knows them. But as the author points out, this is not true; and for city children, observing house (English) sparrows is an excellent way to start learning about birds. In this lively, informative book, the author sets forth the history, habits, "virtues," and "faults" of these birds. Actually weaver finches rather than true sparrows, they have become common in temperate climates in many parts of the world, and are known in Hawaii and Australia as well as in Europe. The book has attractive illustrations and easy-to-read type, and should be just right for fourth grade and up.

Rats and Mice, by Alvin and Virginia B. Silverstein (Lothrop, 96 pp., $3.75). Norway rats and house mice are destructive, disease-carrying pests; but their counterparts in the laboratory are vital to scientific research. This book has a biologist's objective view of these and other species of rat and mouse, some of which live far from human habitation. There is also information about the roles of these rodents in history and legend, as well as a chapter on the care of mice as pets. Readers 8 to 12 will learn a good deal about the complexity of these rodents' place in natural ecology, as well as about their influence on human lives.

Dinosaurs and Their World, by Laurence Pringle (Harcourt, Brace & World, 63 pp., $3.50). A new book on dinosaurs is always good news to the many dinosaur fans in the elementary grades. This one will be especially welcome, with its lucid writing and its accurate drawings and photographs. It is packed with scientific facts about dinosaurs, from the first discovery of their fossil teeth and bones in England in 1822 to the latest findings about the hollow-crested duckbills. The author's concluding thought is noteworthy: although dinosaurs have disappeared, they can hardly be called "failures," since they dominated the earth for 140 million years. Man has existed for about one million.

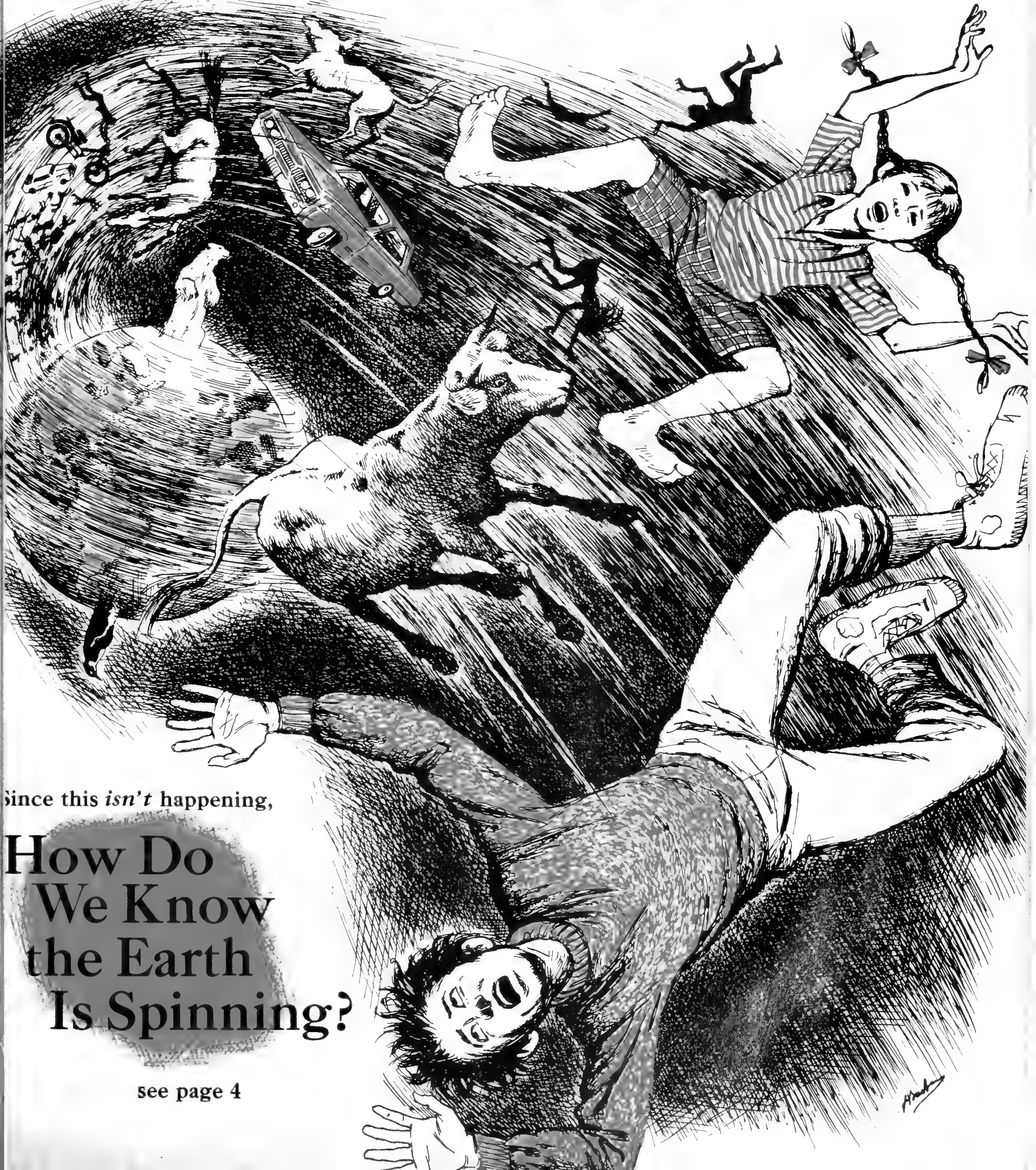
nature and science

VOL. 7 NO. 3 / OCTOBER 13, 1969

Can any wild animals survive in a pond surrounded by a crowded, dirty city? Some boys and girls decided to find out.

see page 7

OPERATION POND PROBE



Since this *isn't* happening,

How Do We Know the Earth Is Spinning?

see page 4

nature and science
VOL. 7 NO. 3 / OCTOBER 13, 1969

CONTENTS

PICTURE CREDITS: Cover, Juan C. Barberis; pp. 3, 5-9, 12-13, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, photos by Robert Gardner; p. 4, photo courtesy of the United Nations; p. 7, 10, photos courtesy of The American Museum of Natural History; p. 11, 1. Larry Evans, 2. Jay Elinsky, 3. Carol Judd, 4. Jeff Haase, 5. Jim Butzbach, 6. Ned Finkel; pp. 12, 13 (left), 14 (right), photos by Rod Cochran; pp. 13 (right and bottom), 14 (left), photos by Laurence Pringle; p. 15, photo by Grant Heilman; p. 16, Thomas Eisner.

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

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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.

SCIENCE WORKSHOP

Can You Draw Straight Lines on a Spinning Turntable?

by Robert Gardner

■ Did you think of a merry-go-round as one kind of wheel when you read "How Do Wheels Roll?" in *Nature and Science (September 15, 1969)*? The floor of a merry-go-round is a round, flat platform that spins, or *rotates*, around a center point like the turntable of a record player. Have you ever tried to walk in a straight line across a spinning merry-go-round?

If you figured out a way to do that, perhaps you can also draw straight lines across a spinning turntable. Does that seem easy to do? Try it and see.

If you don't have a record player, use a turntable that you can spin by hand. A piano stool or kitchen stool with a spinning seat will do. Or a "lazy Susan" turntable that brings such things as a bottle of catsup or mustard within reach in a kitchen cabinet or on the table. You can buy a plastic "lazy Susan" (*see photo above*) at most variety stores for less than $1, and your mother can use it when you have finished with it.

Cut a piece of cardboard to fit on the turntable. If the cardboard doesn't spin with the table, fasten it down with sticky tape. With the turntable spinning, use a pencil, a crayon, or a marking pen to try to draw a straight line on the cardboard. What happens? Can you explain *how* it happens?

You can probably figure out a way to draw a circle on the spinning cardboard without moving the tip of your pencil. When you have done that, try using *two* pencils to draw a small circle and a larger one at the same time without moving either pencil. How do the *circumferences*, or distances around the two circles, compare in length? How do the lengths of time it took to draw the two circles compare? Under which pencil was the turntable moving faster? Does this help explain what happened when you moved the pencil in a straight line across the spinning turntable?

From what you have found out so far, try to predict

This photo shows cardboard disks mounted on a record-player turntable *(left)* and on a plastic "lazy Susan" turntable *(on box at right)*. How were the circles drawn without moving the felt tip of the marking pen?

vhat the pattern will look like if you try to move a pencil traight across the diameter of a cardboard-covered turnable as it spins. Use another round piece of cardboard o draw the pattern you expect to get.

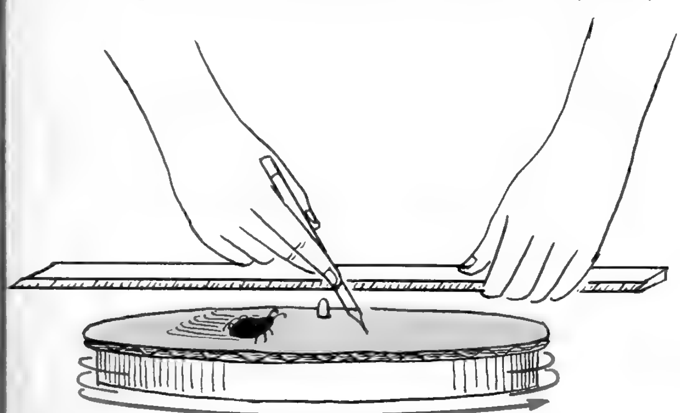
When you test your prediction, be sure to press the encil down lightly so it doesn't slow the spinning table ery much. You might have someone hold a ruler or yardtick just above the spinning cardboard disk to make ure you are moving your pencil in a straight line *(see liagram).*

What will happen if you move the pencil across the ardboard faster? Slower? Try changing the speed of the encil. Slow it down or speed it up as you move it over he spinning cardboard. What will the pattern look like if ou change the speed at which the turntable rotates?

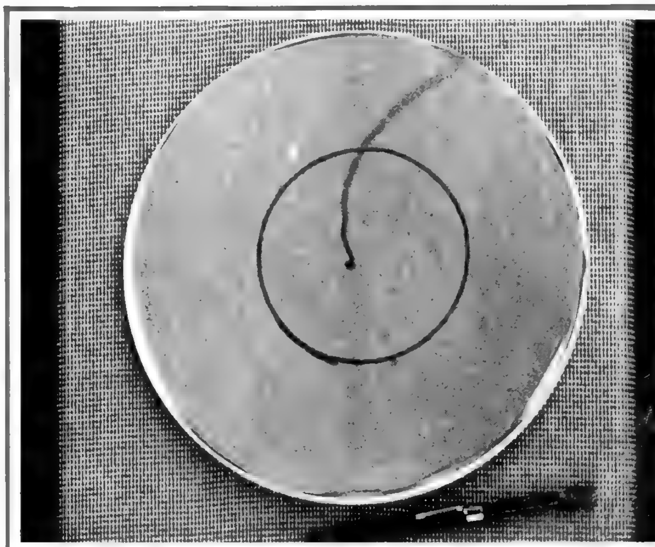
If the patterns you draw this way are different from he patterns you predicted, try to figure out how changing he speed of the pencil or the turntable caused the diferences.

Can you predict what the line will look like if you try to draw it straight from the center to the edge of the spinning platform? From the edge to the center?

If you have figured out how a pencil moving in a straight line draws curved lines on the spinning cardboard, perhaps you can guess how to move the pencil to draw straight lines on the spinning cardboard. With the disk spinning fast, try to draw a line that runs straight from the center to the edge, one that runs straight from the edge to the center, and a line that runs straight across the cardboard ■



A ruler held above the spinning turntable will guide your pencil in a straight line. How would the pencil's path look to a tiny "bug" standing on the turntable?



The felt-tipped marking pen was moved in a straight line across the spinning turntable to draw the line between the center and edge of the cardboard platform. If the pen started from the center, in which direction was the turntable spinning? Can you guess why the line is blurred near the edge but not at the center?

How Do We Know the Earth Is Spinning?

With a pendulum like the one shown in this photo, a French scientist proved it only about 100 years ago. You can use a ping-pong ball and a spinning turntable to find out how he did it.

by Robert Gardner

This 200-pound gold-plated sphere, 1 foot in diameter, hangs by a steel wire from the ceiling 75 feet above the floor of the United Nations Building in New York City. An electromagnet in the center of the six-foot ring keeps this Foucault pendulum swinging back and forth.

■ Watch the sun and the other stars from any place on the earth, and you might think they were revolving, or moving in a circle, around the earth once each 24 hours. Until about 500 years ago, most people—including astronomers—believed that was what was happening. They thought the earth was standing still at the center of the universe, and the sun and stars were revolving around it.

What they didn't know, of course, was that the earth is *rotating,* or spinning around, like the turntables you investigated in the article on page 2. You probably understand now that things look different from a spinning turntable than they look from a point off the turntable.

For example, when you moved a pencil along a ruler above the spinning turntable *(see diagram on page 3),* the pencil appeared to you to be moving in a straight line. But you were not on the turntable. To an insect sitting *on* the turntable and spinning with it, the pencil would seem to be moving in a different path (shown by the line the pencil drew on the cardboard disk).

PROJECT

Standing on the earth, you see the sun "move" across the sky from one horizon to the other in a period of about 12 hours. During its monthly trip around the earth, the moon rotates just once, keeping its same "face" always toward the earth. Can you figure out about how long an astronaut would have to be on the moon to see the sun "move" from one horizon to the other one?

The View from a Merry-go-Round

The way you see things depends on where you are—that is, on your *frame of reference.* When you are standing on a rotating merry-go-round, for example, your frame of reference is a spinning platform. Another person standing on the same platform doesn't appear to be moving at all, because he is *inside* your frame of reference. But people who are standing beside the merry-go-round are *outside* your frame of reference. If you didn't know the merry-go-round was turning, you would think they were revolving around you. (Of course, from their frame of reference, they would see you going around in a circle.)

When you look at the sun and other stars, your frame of reference is the earth—a huge rotating sphere. But if you don't know that the earth is rotating, it's easy to believe that the sun and stars are revolving around the earth.

The ancient Greeks had figured out that the earth is ball-shaped, and about 2,300 years ago an astronomer named Heraclides suggested that the earth is spinning. That, he said, is why the sun and stars seem to move around the earth in a circle.

Heraclides couldn't explain, though, what kept people and other loose objects from flying off the surface of the earth into space if the earth were really spinning. Also, the Greeks could see some objects in the sky (other planets) that seem to move in zigzag paths. If the earth were spinning, why didn't these objects seem to be circling the earth? Such questions went unanswered, and astronomers paid little attention to the "spinning earth" idea until about 1,800 years later.

Then, in the early 1500s, the Polish astronomer Nicolaus Copernicus decided that it was easier to think of the earth as rotating than to explain how the whole universe revolves around the earth. This helped him to work out ways in which the earth and the other planets might be revolving around the sun.

This idea, and the invention of the telescope, led astronomers to observe the motion of the sun, stars, and planets more carefully than ever before. What they saw convinced them that the earth and the other planets are revolving around the sun, and that the earth must be rotating. But no one was able to *prove* that the earth is rotating until 1851—only 118 years ago.

A "Swinging" Physicist

A French physicist named J.B.L. Foucault first performed the experiment that shows that the earth really does rotate. He used a *pendulum*—a weight hanging by a long wire from a high beam (*see photo*).

Foucault knew that if you start a pendulum swinging in one direction, it should keep swinging back and forth through the same *plane*, or flat "slice" of space (*see Diagram A*). If the plane of the pendulum's swing should appear to be rotating, it would be because the earth is turning beneath the pendulum.

At the North Pole, the plane of the pendulum's swing should seem to rotate 360 degrees (a full circle) in 24 hours. (Can you explain why?) You can see how this works by making a simple pendulum and using a turntable in place of the earth. Tape a ping-pong ball to a piece of thread and hang it from a cardboard frame as shown in Diagram B. Cover the turntable with a cardboard disk, and draw a line straight across the disk through the center. Place the pendulum on the turntable with the ball hanging over the center of the turntable. (The center represents the North Pole, and the rest of the turntable represents the land a few inches around the North Pole.)

Start the pendulum swinging back and forth along the line you drew on the turntable. Now *slowly* rotate the turntable by hand. If you have trouble seeing that the plane of the pendulum's swing is not really turning, place a pencil on either side of the turntable to mark the plane of the pendulum's swing. From the rotating turntable as your frame of reference, how does the plane of the pendulum's swing seem to be moving?

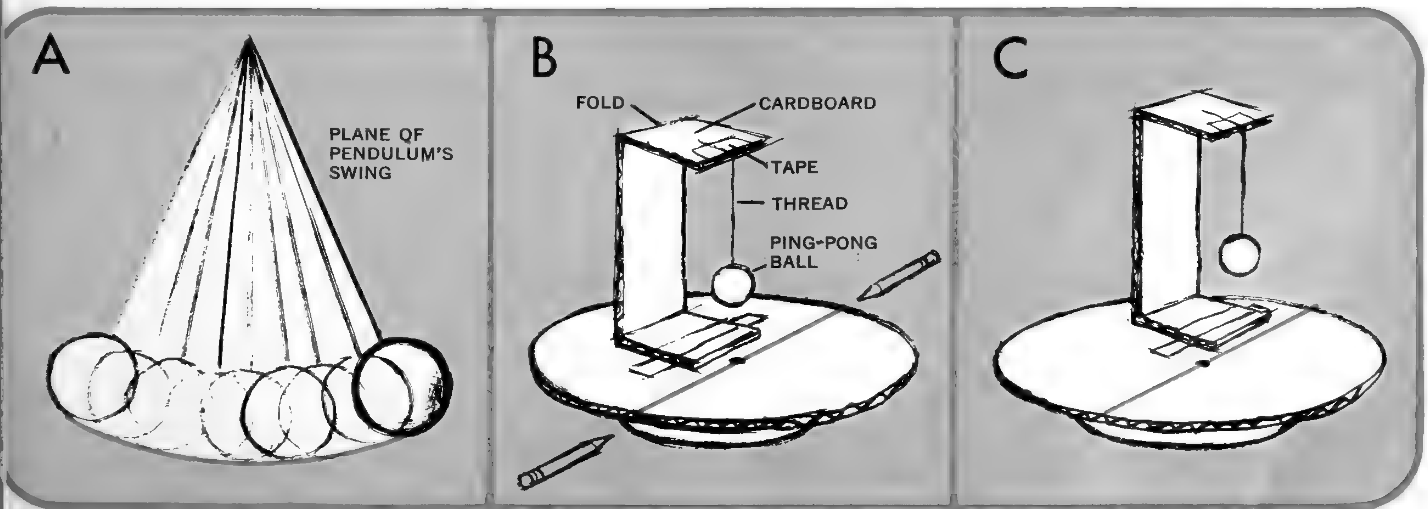
What do you think will happen if you start the pendulum swinging over a different part of the spinning turntable? To find out, move the pendulum so that it hangs over the line on the cardboard disk, somewhere between the center and the edge of the disk (*see Diagram C*). Set the pendulum swinging along the line, then slowly rotate the turntable. Use the line as your frame of reference and watch how the plane of the pendulum's swing seems to move. Can you explain what you see? (Hint: Are all parts of the line moving at the same speed?)

Swinging in Paris

You have seen what would have happened if Foucault had done his experiment at the North Pole, or even within a few inches of it. But Foucault did the experiment in Paris, and Paris is roughly halfway between the North Pole and the Equator on the earth's curved surface. As Foucault had predicted, the plane of his pendulum's swing appeared to rotate only about two-thirds of the way around during each rotation of the earth. It took about 36 hours to "turn" through a complete circle.

This happened because the earth is a huge sphere, and it rotates around a center line, or *axis*, running through the earth from pole to pole. The speed at which a point on

(Continued on the next page)



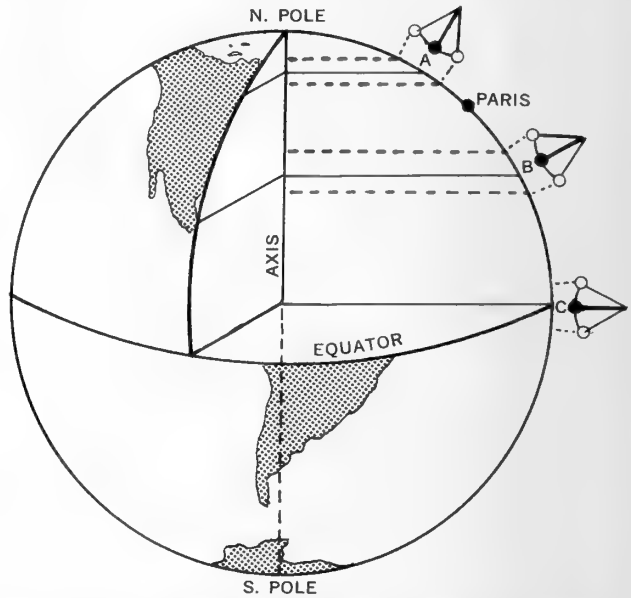
the earth is moving depends on its distance from the axis (*see diagram*). The places on the earth that are farthest from the axis—and therefore are moving fastest as the earth rotates—are places along the Equator. If you live on the Equator, you travel a 25,000-mile path once each day. This means that the ground you are standing on there is moving at a speed of a little more than 1,000 miles an hour! How fast do you move if you are at the North or South Pole?

PROJECT

Can you figure out about how fast the ground moves where you live? (Hint: Use a globe and a tape measure to compare the "circumference" of the earth's latitude at the place where you live with its circumference at the Equator.)

Because objects near the Equator move faster than objects closer to the poles, strange things happen when air, water, and rockets move north or south. A rocket on its launch pad at the Equator is already moving eastward at a speed of more than 1,000 miles an hour. When it is launched northward, it keeps its eastward speed as well as its northward speed. As the rocket moves northward, each "new" part of the earth it passes over is moving eastward more slowly than the part it just passed over. Because of this, if you were watching the rocket from a point in the Northern Hemisphere it would seem to drift eastward while it moves north.

For the same reason, a mass of warm air moving northward from the Equator follows a path that curves eastward over the earth. Can you guess what kind of path an air mass moving southward from the Equator would follow? ■



Points A and B on the earth's curved surface are spaced at equal distances between the North Pole and the Equator. By comparing the distances (solid color lines) of A and C from the earth's axis, you can tell that point A is moving at half the speed of point C as the earth rotates. The dotted color lines show you the difference in speed between points under the north and south ends of a pendulum's swing at A and B. Can you see why the plane of a pendulum's swing seems to rotate more slowly the closer the pendulum is to the Equator? (What happens to the plane of a pendulum's swing at the Equator?)

Some Things To Try or Think About

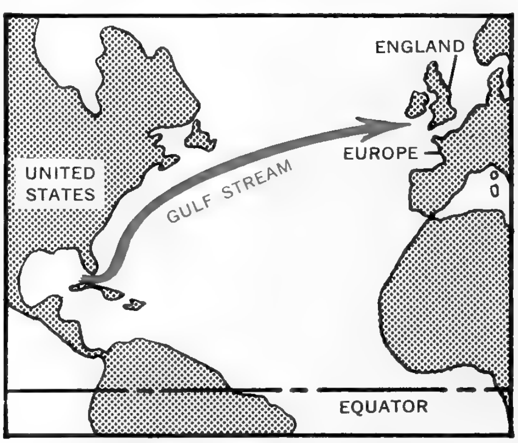
1. If you wanted to launch a rocket from a point on the Equator so that it would pass over the North Pole, in what direction would you launch it?

2. Why are satellites usually launched toward the east?

3. Drop a ball as you ride along on your bicycle. What does the ball's path look like from your frame of reference? What does it look like to someone who is standing still?

4. Try to draw a straight line on a piece of paper while someone pulls the paper out from under your pencil. Now try to draw a circle while someone pulls the paper. Can you predict the patterns you'll get?

5. Next time you ride in a car during a rain storm, watch the drops in front of the car. In what direction do they seem to be moving? When you get out of the car, look again. How do the drops appear to be moving now? Can you explain the difference?



The Gulf Stream is an ocean current that flows northward out of the Gulf of Mexico. Can you explain why it follows the path shown on this map?

6. Try to play catch with a friend by rolling a marble across a spinning turntable.

7. If a ball were dropped from a very high tower, would it land directly below the point from which it was dropped, or would it land slightly east of that point? Or slightly west?

8. Western Europe, including England, enjoys a rather mild climate even though England is as far north as chilly Labrador. Can you explain this? Would England's climate be different if the earth spun from west to east?

Eighteen boys and girls decided to find out what pond "wildlife" they could find in the midst of crowded, dirty New York City. Their results may surprise you.

Operation Pond Probe

This report on some of the findings of "Operation Pond Probe" was written by Eric Atkin, Michael Atkin, Mitchell Browning, John Cohen, Sydney Gaddy, Clinton Goss, William Howard, Jeffrey Hurtt, Andy Kane, Denise McMorrow, Richard Nastasi, Wade Rawluk, Scott Rechtschaffen, Daniel Richman, Daniel Ruberman, Steven Sherman, Vicki Sherman, Richard Siman, and Mrs. Janann Jenner.

■ To the one million, five hundred eighty thousand people who live in Manhattan, the busiest part of New York City, Central Park is an oasis. In summer people can escape from the hot, crowded streets and walk on grass, sit under a tree, feed squirrels, and fish and go boating on the Central Park lake.

Many thousands of people—and their pets—visit the park every day. Most of these people never realize that there are many other kinds of living things in the park. This past spring, a group of boys and girls—18 of us—decided to find out more about the secret world of Central Park. We spent many hours investigating the life in one small part of the park, a pond at the northwestern end of the lake (*see map*). We were helped by Mrs. Janann Jenner, an instructor at The American Museum of Natural History, which is a short walk from the park.

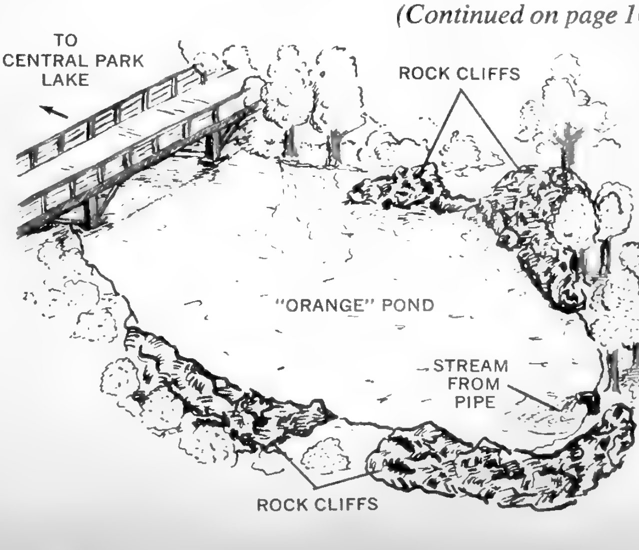
Mapping and Measuring

We met at the Museum on Saturday mornings in April, May, and June, coming "armed" with boots, lunches, raingear, buckets, nets, jars, pans, notebooks, and books to help identify the animals and plants we found. With help from Mrs. Jenner, we planned how we would go about investigating the life in the pond. Then, in teams of two or three, we set out for the park.

One of our first projects was to make a map of the pond and the area surrounding it. By looking at the map and photos you can get an idea of what the pond is like. We began calling it Orange Pond—simply because it was colored orange on our map.

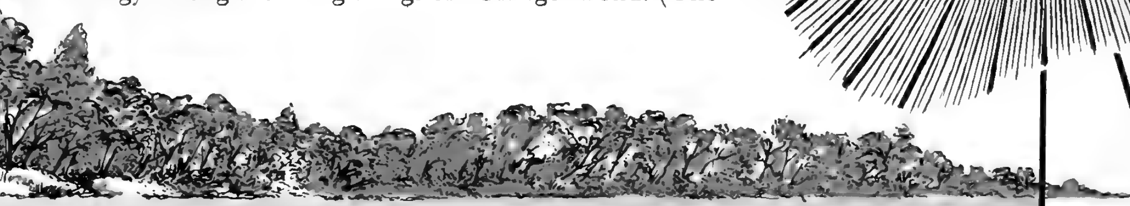
The banks of the pond are mostly bare earth. The weeds and shrubs that would normally grow there have been beaten down and killed by people scrambling down the banks. Because there is little plant cover, soil is easily washed down the banks by rain. Fine particles of soil, called *silt*, cover the bottom of the pond and are mixed with a thick layer of rotting oak and willow leaves.

(Continued on page 10)



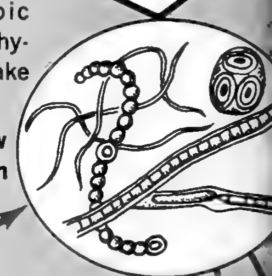
■ When 18 boys and girls investigated the life of "Orange" Pond in New York City *(see page 7)*, they found that the plants and animals there are all part of a *community*. Each member of the pond community has a job. Some members are food-producers, some are plant-eaters, others are meat-eaters, and still others have the job of ridding the pond of dead and decaying material.

The boys and girls found that the animals and plants all depend on each other for energy, which they get from their food. The drawings on this WALL CHART show the flow of food energy among the living things of "Orange" Pond. (The

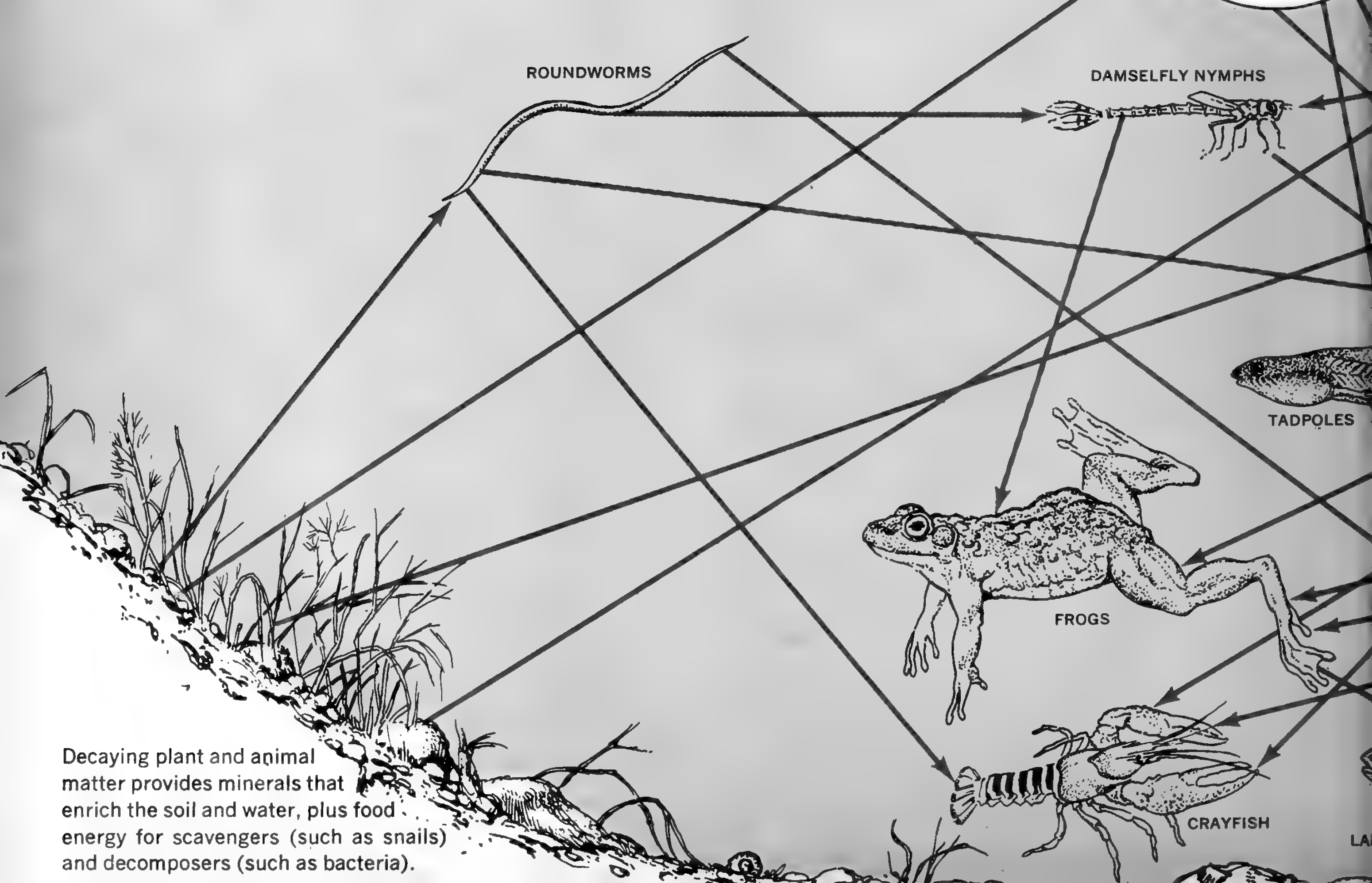


A POND'S WEB OF ENERGY

Energy from the sun is used by microscopic green plants (called phytoplankton) as they make food.



enlarged view of some phytoplankton

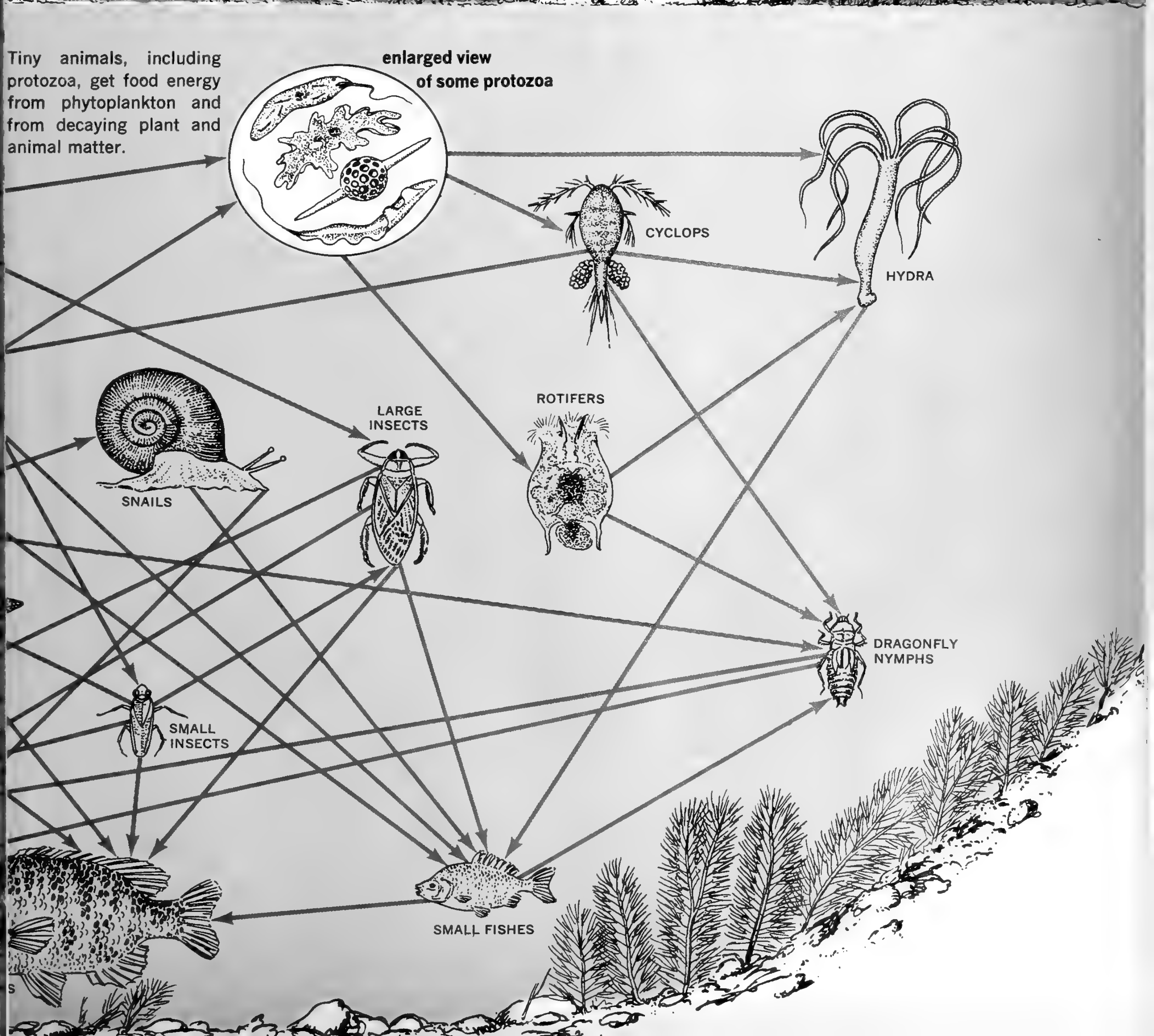


Decaying plant and animal matter provides minerals that enrich the soil and water, plus food energy for scavengers (such as snails) and decomposers (such as bacteria).

animals and plants are not drawn to scale.) The same sort of pattern exists in other ponds, in lakes, and even in the oceans.

The arrows point in the direction in which energy flows—from the "eaten" to the "eater." Trace the flow of food energy back to its source. What might happen to the big fish if the tiny plants (called *phytoplankton*) were all killed by pollution? What source of energy is shared by every plant and animal in the pond?

See if you can figure out a web of food energy in a pond near your home. Do you suppose that there are food webs like this on land, as well as in the water? ■



Operation Pond Probe (continued from page 7)

We found that the pond was nearly 200 feet long, and 70 feet wide at its widest point. From rowboats we measured the depth of the water.(We did this by tying a weight to the end of a measuring tape and lowering the tape until the weight touched bottom.) The pond was 52 inches at its deepest; the average depth was a little under four feet. However, if you wade into the water, it seems much deeper because you sink into the silt and leaves at the bottom. Daniel Ruberman got stuck in the mud while standing in just 12 inches of water. Every week some unlucky person fell into the muddy, smelly water.

Besides investigating the depth of the water, we studied its temperature, how clear it was, and the life in it. Each team concentrated on a 10-foot-long stretch of the pond's edge, taking temperature readings at different depths of water and in the mud. We kept notes on our findings, and later made graphs and charts from the notes.

Vicki Sherman measures the water temperature at different depths (1), while Richard Nastasi, Sydney Gaddy, and Jeffrey Hurtt look at the claw of a crayfish (2). Later, the boys and girls returned to the lab (3) to identify the animals they had collected.

We also kept a list of the types of litter found in the pond. Here is what we found: beer cans, soda cans, soup cans, cigarette butts and packages, bottles, comic books, newspapers, an old tire, magazines, paper wrappers, books (including a Bible), a blanket, egg cartons, wooden boards, oars from rowboats, partly-eaten sandwiches, foam rubber and plastic, an upholstered chair, and a tricycle. There were also two of the Park Department's wire trash baskets—that did not contain any trash.

Life in the Litter

What animals could live in water that was so littered and dirty? To find out, we collected samples of water and of decaying leaves from the pond. Then, loaded down with buckets, pans, and jars filled with the samples, we walked back to the laboratory at the Museum. There we identified and counted the different kinds of animals in the samples.

We learned that the pond animals all affect one another in a *food web*—a complicated pattern that shows how the animals depend on each other for food, and how they all depend on plants for food. The WALL CHART on pages 8 and 9 shows the food web we found in our pond.

Although there are several kinds of fish in the lake, we found only two species—pumpkinseeds and goldfish—in the pond. The goldfish move about in a school of about 150 fish.

We were surprised to find many crayfish of all sizes in the pond. After thinking for a while, though, we decided that the pond was a fine home for crayfish. They like to hide in mud and eat small insects, fish, and decaying plant and animal matter. All of these things abound in the pond. We kept crayfish in the lab and found that a hungry crayfish will eat another crayfish.

We also caught many tadpoles at the pond. They were all bullfrog tadpoles. Every Saturday we would look for adult bullfrogs, hoping to catch one, but they always seemed to know just where to sit, out of reach of our nets. In the lab, we are watching some of the tadpoles change into frogs. After they change we will return them to the pond.

One of the things we have learned about the pond is that it is slowly being filled in. Water plants, dead leaves from nearby trees, litter, and soil washed in from the banks are helping to make the pond more shallow. Also, grasses are growing at the northern end, making what will become a marsh. As the pond gets shallower, the animals will die off, or move to the deeper waters of the lake.

We found more than 1,200 water animals of 20 different kinds in the pond, and it is just a small part of Central Park. Why don't you investigate the animal and plant life in a park near your home? ■

Mystery Photo Contest

Dear Reader:

I am sure that you are familiar with the Mystery Photos (like these photos) that appear on the Brain-Booster page in each issue of *Nature and Science*. Now I would like you to send me a Mystery Photo that you have taken. To qualify for prizes, you must mail a real photograph that you have taken yourself, not just a picture cut from a newspaper or magazine. A $10 award will be made to each of the 10 readers who submit the best Mystery Photos.

I will write to everyone who enters the contest. If I know what your Mystery Photo is, I'll give you the answer. If I don't know, I'll have to ask you to tell me. Then I'll select the 10 best photos from among the ones I couldn't guess.

To enter the Mystery Photo Contest, send your photograph to:

Mr. Brain-Booster
Todd Pond Road
Lincoln, Massachusetts 01773

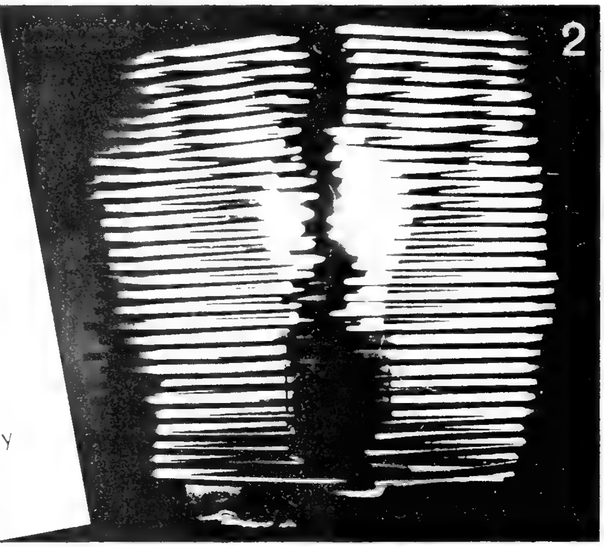
Entries must be mailed by November 15, 1969. Be sure to give your address, age, and grade in school, or tell me if you are an adult. We will publish the names of the winners and some of their photos in the February 16, 1970 issue of *Nature and Science*.

I'll bet you can't stump me!

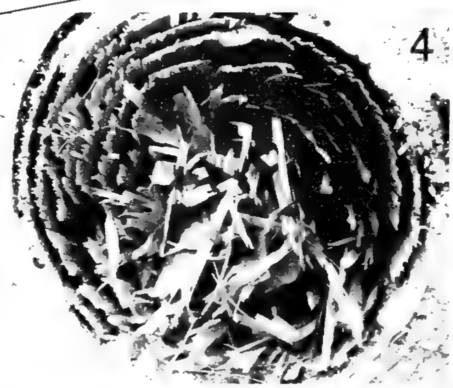
Mr. Brain-Booster

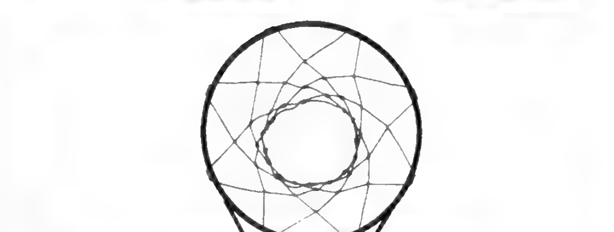
P.S.—Look on page 16 to find out what the Mystery Photos on this page are.

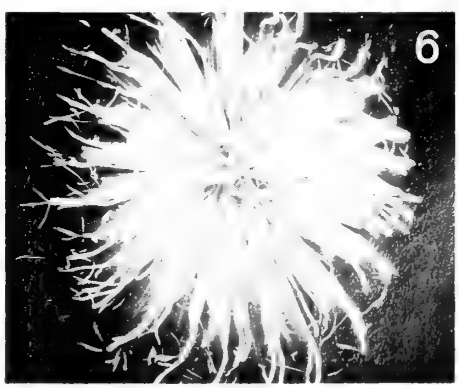
1


2


3


4


5


6


Can You Top These?

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

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

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

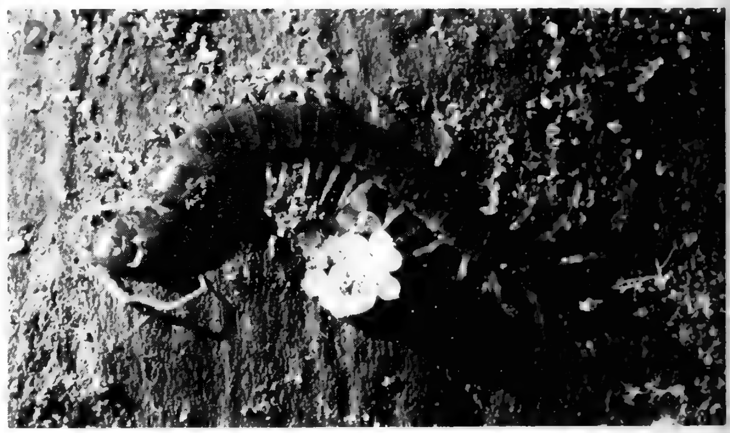
An important point to remember is that all kinds of life—lichens, mushrooms, tree seedlings, sow bugs, carpenter ants, centipedes, deer mice—do not rush all at once to live in a fallen log. Nature is more orderly than that. There are waves of inhabitants, and each wave paves the way for the next group.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

Getting Started

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

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

Take along a shovel or trowel to loosen chunks of wood. I find that a garden cultivator (a claw-like hand tool) helps in scratching my way through a log. You should have a can or jar and some plastic pill bottles along to collect



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

Life in a Rotting Log

specimens. Later you will want to identify them. Bring a notebook and pencil to keep a record of your findings.

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

Layers of Life in a Log

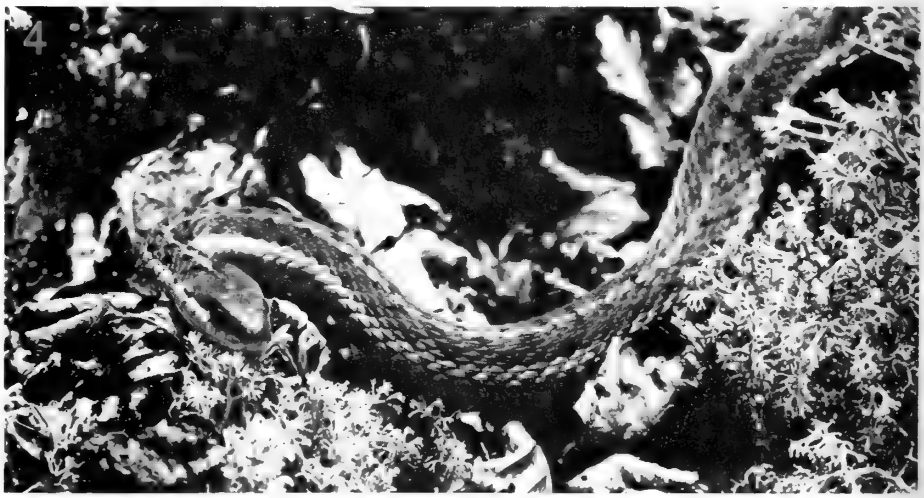
Once I have rattled a log, kicked it, and poked sticks into its hollow (if it has one), I start a closer examination, beginning on the outside. Mosses and fungi grow on a log's surface, except in very dry climates. You may find several kinds of each. Certain kinds of mushrooms will not grow on a newly-fallen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

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

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

Now strip away a slab of rotten bark. If the bark is all gone, remove the first layer of loose wood. Here you are likely to find sow bugs, members of the *Crustacea* class of animals. Sow bugs are related to crayfish and crabs. You also may find spiders, representing the class *Arachnida;* millipedes (with a "thousand" legs) from the class *Dip-*

(Continued on the next page)



Among the animals that hide, hunt, or raise their young in rotting logs are green frogs (1), centipedes (2), land snails (3), garter snakes (4), and deer mice (5).

by Rod Cochran

lopoda; centipedes (with a "hundred" legs) from a class called *Chilopoda;* and beetles, representing the class *Insecta.* Where else could you find such fertile hunting grounds—five classes of animals represented in the first layer of a rotting log!

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

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

As you dig your way toward the middle of a hollow log you will discover signs of mammals or reptiles that left earlier. You may see the dry, leaf nests of chipmunks, or maybe the shed skin or white oblong eggs of a black-snake.

Where the Log Meets the Soil

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

Eventually you will come to the point where the log touches the soil, but the trick is to find this point. There is no clear-cut surface of either soil or log, unless the dead tree has just fallen. The log begins to merge with the soil. The rotting action of a log usually works fastest from the ground up. Moisture in the soil helps the growth of the bacteria and fungi that bring about decay. When you reach the soil, look for other animals and signs of them—a mole tunnel, earthworms, mites, and springtails. The soil is also teeming with life!

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

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

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

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

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

To identify the animals and plants you find in and on a rotting log, look for these books in your library or bookstore: **Field Book of Insects,** by Frank Lutz, G. P. Putnam's Sons, New York, 1948, $4.50; **Fieldbook of Natural History,** by E. Laurence Palmer, McGraw-Hill Book Company, New York, 1949, $11.95 **Insects, Mammals, Reptiles and Amphibians, Flowers,** and **Non-flowering Plants,** are all titles of Golden Nature Guides, published by Golden Press, New York, and costing $1 each (paperbound).

Plants that grow on rotting logs include mosses, mushrooms (left), and wildflowers such as false Solomon's seal (right).

How Do Ewes Choose?

In a flock of penned-up sheep, some females do not nurse their lambs. Scientists are trying to find out why.

■ Ranchers in Australia usually keep a large flock of sheep together in an enclosed field that may be several hundred acres in size. In this large pen, the *ewes* (female sheep) give birth to their lambs. But within three days after birth, about one lamb out of every five dies.

Often, the mothers in the large pens do not nurse their lambs. This causes many of the deaths. No one knows for certain why a ewe doesn't nurse her lamb, but it might be because she can't tell which of the many lambs in the pen are hers.

Two Australian biologists, Dr. D. R. Lindsay and Mr. I.C. Fletcher, decided that the first step in solving this problem was to find out how a mother sheep usually recognizes her young. (It might be by the smell of the lamb, for example.) Then scientists could find out whether something has gone wrong with this way of recognizing lambs in the larger flocks.

Decisions, Decisions

Dr. Lindsay and Mr. Fletcher built a T-shaped pen and brought several ewes, one at a time, to the center of the two arms (*see diagram*). A lamb waited at the end of each arm, about eight feet from the ewe. Both lambs were very young, and about the same size—but the ewe in the middle was the mother of only one of them.

The biologists tested each ewe 15 times, over a period of several weeks. Sometimes the ewe could hear the lambs bleat, smell them, and see them. Sometimes she could only hear and smell them, because the biologists had blocked her view with canvas screens. Sometimes she could only see them, because the biologists blocked their sounds and smells from the ewe with glass walls.

In each trial, the scientists kept the ewe between the two lambs until each of the lambs had bleated once. Then they brought her to the far end of the pen and let her loose. They watched to see whether the ewe ran to her lamb, or to the other one.

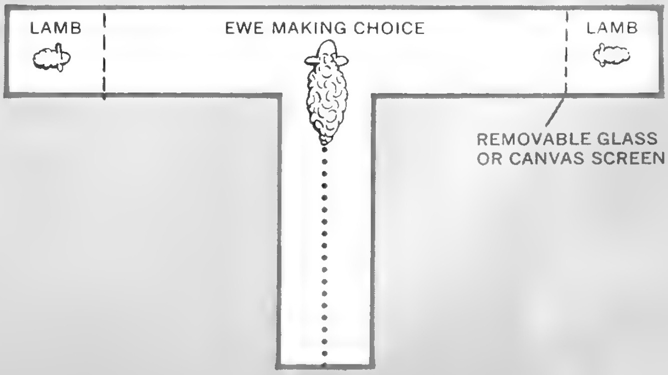
In trials in which the ewe was let loose after she had *seen* the lambs, she ran to her own lamb most of the time and nursed it. But in trials in which she could only hear or smell the lambs, she chose the "wrong" lamb just as often as she chose her own. Even though the ewe was just eight feet from the lambs, she didn't recognize her lamb unless she saw it. So it is the *look* of the lamb, and not its smell or sound, that tells a ewe which lamb is hers.

After a ewe made the wrong choice and ran to the wrong lamb, she did not nurse it. When she was very near it, some clue "told" her that the lamb was not hers. Perhaps touch, smell, or taste are other clues that help the mother to recognize her young at close range.

Now that scientists know that ewes can recognize their lambs by sight, they may be able to figure out what goes wrong in the large pens on sheep ranches. Perhaps they may be able to prevent some of the lamb deaths.

—SUSAN J. WERNERT

To discover how a ewe recognizes her lamb, the biologists used a T-shaped pen with glass walls or canvas screens to keep a ewe from seeing, hearing, or smelling the lambs.



WHAT'S NEW

by
B. J. Menges

Evidence is piling up in support of the theory of continental drift. This theory holds that the land areas of the earth were originally a single large mass. The mass broke up, and the pieces slowly drifted apart over millions of years, becoming the continents. The slow drift is still supposed to be taking place, but no one has been able to measure it because the continents are so far apart and the movement is so slow.

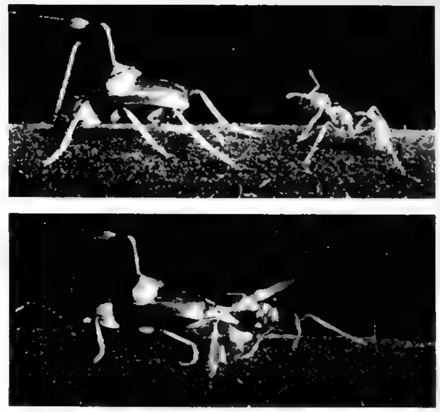
About five years ago, a scientist suggested that Iceland is being pulled apart by the same forces that are separating the continents. To find out whether this is so, Professor R. G. Mason of Imperial College, in London, England, set up many concrete surveying posts in Iceland. For over two years, he has been using special equipment to measure the distances between posts. He now reports that Iceland is indeed being torn apart —that some posts are moving apart at the rate of a third of an inch a year.

Mars watchers can hardly wait till 1971, when the red planet will again be close to the earth. Two spacecraft will then be sent by the United States into orbit around Mars. They will take a closer look at mysterious features first seen in the spectacular pictures of Mars sent back last summer by the Mariner 7 spacecraft as it passed within 2,200 miles of the planet.

Among other things, the pictures showed what looked like huge clouds. The atmosphere of Mars is believed to be too dry to produce clouds, but some scientists think that hot springs could be cloud-makers. Hot springs on Mars could be especially interesting to scientists. For although most of the planet may be too dry and cold to support life, areas near hot springs might have the conditions necessary for living things.

Safety belts for beds have been suggested by a West German medical doctor. Ridiculous as it may sound, the suggestion apparently has some merit. According to a survey, 600 West Germans died last year of injuries caused by falling out of bed. The survey also revealed that eight out of every 10 West German adults fall out of bed two or more times a year, often while dreaming.

That's why Dr. Wolfgang Littek of the Bavarian Chamber of Insurance Companies, in Munich, wants beds to be equipped with safety belts. Old people, especially, he says, should be sure to fasten their sleep belts.



An ant attacking a bombardier beetle *(top)* is met by the beetle's hot chemical spray *(bottom)*. In these photos you can see the wire used by the scientists to hold the beetle.

The bombardier beetle is well named. When threatened by an enemy such as an ant or spider, the beetle shoots a spray from an opening at the rear of its body *(see photos)*. The spray contains substances that irritate the eyes and other sensitive parts of the enemy's body. Usually the enemy retreats.

Recently, four scientists at Cornell University, in Ithaca, New York, discovered another reason why the spray works so well. When it leaves the beetle's body, it is as hot as boiling water. So it can be painful even to parts of an animal's body that are not sensitive to the chemicals in the spray. No wonder that a person holding even a small bombardier beetle in his fingers feels a burning sensation when the beetle fires away.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The tracks were left by a bulldozer. The curved part of the track was made when the bulldozer turned sharply.

What would happen if? When a small nail hole is punched in the bottom and in the side of an unopened juice can, the liquid runs out of the bottom hole. Air enters the can through the hole on the side. What would happen if you punched two holes in the side and one in the bottom?

Can you do it? One way to make a rounded ice cube is to freeze a balloon filled with water. Can you figure out another way? How could you do it with two cups?

Fun with numbers and shapes: By looking at a globe, you should be able to see what place is on the opposite side of the earth from your house. How can you use latitude and longitude lines to figure out the location more accurately?

For science experts only: The iron powder could be removed from the mixture with a magnet. The sand and salt can be put into some water so the salt dissolves. The sand will be left when the salt water is poured off. When the water evaporates, the salt will be left. Suppose the mixture had some pepper in it also. How could you recover it?

ANSWERS TO THE MYSTERY PHOTOS ON PAGE 11

1. Close-up view of the fruit of an Osage orange tree, sometimes called a hedge apple *(from Larry Evans, Decatur, Illinois)*; 2. a light bulb inside an ice-cream-stick "building" *(from Jay Elinsky, Brooklyn, New York)*; 3. close-up view of mold growing on salad dressing *(from Carol Judd, Berkeley, California)*; 4. the inside of a log damaged by ants *(from Jeff Haase, Chester, Nova Scotia)*; 5. a basketball net seen from underneath *(from Jim Butzbach, Lafayette, California)*; 6. fireworks *(from Ned Finkel, Philadelphia, Pennsylvania)*.

nature and science

TEACHER'S EDITION

VOL. 7 NO. 4 / OCTOBER 27, 1969 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Rivers and Man

Rivers began when the earth's atmosphere first formed. No one knows when that occurred. The oldest known fossils of living things are 3.3 billion years old, and since life evolved in the seas, this means that rivers were flowing before that—possibly four billion years ago.

As late as the mid-1700s, educated people believed that rivers were forced up out of the earth's crust, and flowed through ready-made valleys to the seas, from which they traveled through tunnels back to the mountains. It was nearly 1800 before men began to realize that water from rain and melted snow ran off the land in trickles, rivulets, and creeks to form rivers. Gradually, the workings of the *water cycle (see diagram on page 2T)* were discovered.

Topics for Class Discussion

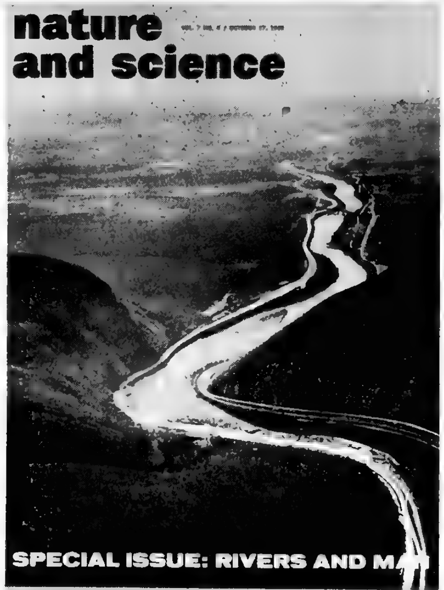
• *How do we know that rivers are changing the face of the earth?* The soil-brown water of "mini-rivers" *(see pages 14-15)* and bigger streams after a rain hints at the role of running water in shaping the earth's crust. But the process is slow and undramatic. One example your pupils might suggest is the wearing away of rock at Niagara Falls *(see "Niagara Is Falling!",* N&S, *Sept. 29, 1969).*

We look at a river and tend to think only of its effect on the area immediately surrounding its course. But a river and its tributaries collect water from many square miles, and the moving water in this drainage basin *(watershed)* carries many tons of soil. Scientists estimate that the Mississippi River deposits about a million-and-a-half tons of sediment in the Gulf of Mexico each day. The formation of deltas is one of the most obvious results of water erosion.

• *Isn't this erosion "bad"?* The weathering of rocks and transport of soil by water is a natural process, part of a cycle of changes, including mountain building, that shapes the earth's crust *(see "Shaping the Earth's Crust,"* N&S, *Oct. 28, 1968).* The process is often speeded up by changes humans make in their environment. Soil is carried away more easily from cultivated fields than from areas covered with thick vegetation. If care is taken, this loss of soil can be reduced, but water is bound to carry away more soil when it is "working" on soil unprotected by a cloak of dead leaves and living plants. Erosion, in a geologic sense, can't be stopped, but man-caused erosion can be reduced.

• *What are the possibilities of cleaning up polluted rivers and keeping them clean?* In the past few years, government and industry have been spending more money on pollution control. But the amount of money committed so far is trifling compared with what is needed. The Potomac River, which flows through Washington, D.C., was supposed to be a model of pollution cleanup, but it is as dirty now as it was 10 years ago. The growth of population in the Potomac basin has increased so much as to wipe out any

(Continued on page 2T)



IN THIS ISSUE

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

Special-Topic Issue: RIVERS AND MAN

• **Rivers and Man**
Rivers have contributed much to human survival and culture; today, our "contributions" to rivers are threatening these vital resources.

• **Brave Men on a Raging River**
Takes your pupils on Major Powell's first expedition down the wild Colorado River.

• **A River Dammed**
This WALL CHART will help your pupils compare the advantages and disadvantages of damming a river.

A Race into the Past
How archeologists uncovered the oldest human bones yet found in America, just before a dammed river flooded the site.

• **Exploring Mini-Rivers**
By exploring back-yard rain streams and making model rivers, your pupils can find out how rivers and the land they flow over shape and reshape each other.

• **Brain-Boosters**

IN THE NEXT ISSUE

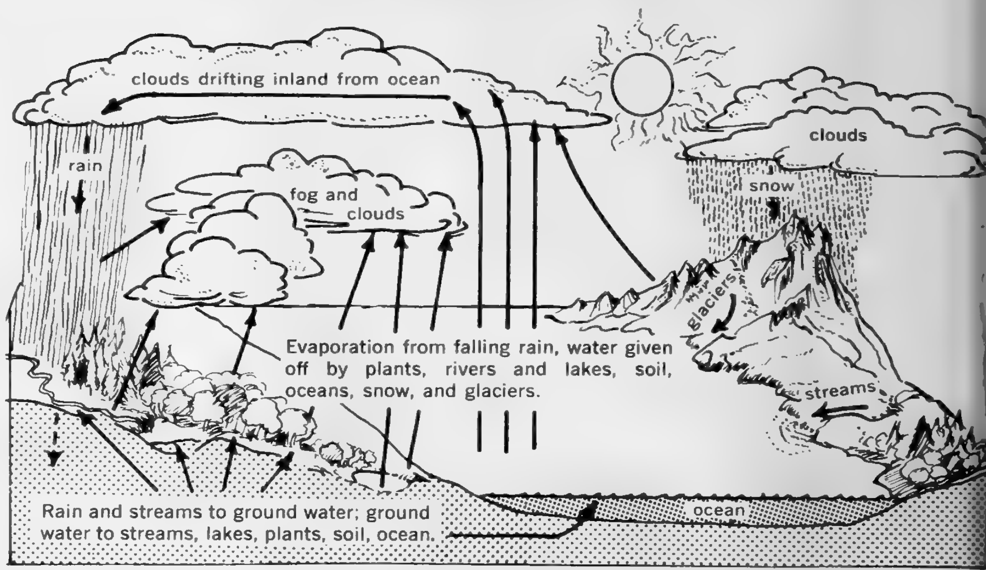
Beginning a three-part series on Man the Measurer . . . How a scientist got wild bees to help farmers raise alfalfa . . . SCIENCE WORKSHOP investigations of dripping water and where growth takes place in plants . . . A WALL CHART explores why animals change their color.

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

gains made by construction of sewage treatment plants.

Many more billions of dollars will have to be spent before water pollution is reduced significantly. One need is for more research. Scientists have to find ways to remove from water the viruses and other harmful substances that pass through present-day sewage treatment plants. And as long as the human population continues to grow, the cost of controlling water pollution will grow too.

THE WATER CYCLE



Brave Men on a Raging River

Have your pupils compare Powell's first trip through the Grand Canyon with the Apollo 11 astronauts' trip to the moon exactly one century later. Both trips were dangerous for their times, and both had similar motivations—exploration of a place where man had not been before, and the search for clues to its origin. (International competition also played a part in the Apollo flight.)

Both Powell and the astronauts returned as heroes, and Powell got funds from the U.S. government to make more detailed studies of the Colorado River and Plateau, just as the government is paying for investigations of the moon. Powell's findings enabled him to explain how the Grand Canyon was formed by the eroding waters of the Colorado River. Right now, scientists are studying samples of the moon in an attempt to find out how it originated.

For Your Reading

- *Exploration of the Colorado River,* by John Wesley Powell, University of Chicago Press, 1957, $3.95.
- *Time and the River Flowing: Grand Canyon,* by Francois Leydet, Sierra Club-Ballantine Books, New York, 1968, $3.95 (paper).
- *Grand Canyon, the Story Behind the Scenery,* by Merrill D. Beal, KC Publications, 2115 N. Talkington Drive, Flagstaff, Arizona, 1967, $1 (paper).

A River Dammed

On the subject of dams, some texts and other books read as though they were prepared by the Bureau of Reclamation or the Army Corps of Engineers—the two main dam-building agencies of the United States government. Dams have some important good effects, but, like any major change in the environment, they often cause unforeseen problems.

The wisdom of building big dams is being questioned more and more. For flood control, several small dams in a drainage basin may be more effective than a single big dam. Also, engineers now realize that some floods are inevitable, and that damage may be more economically controlled by preventing construction on flood plains than by building dams.

In recent years, plans to build dams have been altered or halted on several rivers, including the Colorado where it flows through the Grand Canyon. Often, the arguments against a dam are esthetic ones, hard to put a price tag on. The dam-building agency, on the other hand, is usually able to offer figures showing expected benefits, such as so many kilowatts of electricity generated.

In discussing the WALL CHART with your pupils, point out the difficulty in placing a value on a moose, or on a canoe ride down a free-flowing river. Under pressure from conservation groups and court decisions, government agencies are now beginning to consider such intangibles when planning dams, highways, and power plants.

For Your Reading

- *Rivers and Watersheds in America's Future,* by Elizabeth Helfman, David McKay Company, Inc., New York, 1965, $4.95.

Exploring Mini-Rivers

By investigating streams of rainwater and experimenting with a stream table as suggested in this SCIENCE WORKSHOP article, your pupils can see

(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.

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

how rivers and the land are constantly shaping and reshaping each other.

Suggestions for Classroom Use

Observing, mapping, and describing a mini-river is an outdoor rainy-day project that your pupils can probably do best on their own time. You might encourage them to work together in small groups of two or three, and to take turns measuring, mapping, writing down descriptions, and holding the umbrella.

Experimenting with a stream table makes an excellent class project, and once the stream-table box is made, you can use it over and over. (Remember to set it up near a water outlet, and—if possible—over a drain to catch the overflow.)

Close-up photographs of the stream table taken at the start of a particular experiment, at regular intervals while it is in progress, and at the end, make a revealing record of how the land was being changed. (A camera that produces "instant" pictures is particularly handy for this purpose.)

Topics for Class Discussion

• *How does flowing water* erode, *or wear away, rock and soil?* Mainly by *friction,* as the water rubs off tiny bits of rock or soil and carries them downstream. A swiftly flowing stream can also push pebbles and small stones along its bed. Water dissolves many substances from rock and soil and carries them off as part of the water. A stream can also lift small particles from its bed in the same way that flowing air "lifts" a sheet of paper *(see "What Lifts an Airplane?",* N&S, *Sept. 29, 1969).*

Solid materials carried in the flowing water increase the friction between the stream and the land, speeding up the erosion process.

• *Where does flowing water get the energy it takes to do* work, *such as moving bits of earth and turning turbine wheels to generate electric power?* Originally from the sun, whose heat energy is changed into *potential,* or stored, mechanical energy in the water as the water is lifted from the earth into the atmosphere *(see "The 'Spirit' That Moves Things,"* N&S, *April 10, 1967, or enlarged* N&S WALL CHART). When the water vapor condenses and forms drops of water that are pulled downward by the earth's gravity, this potential energy is changed into *kinetic* energy, or energy of motion. This is the energy the water uses to wear away and move bits of the land on its downhill course to the sea. The higher the water is above sea level, the more energy it has.

• *Why do mountain streams cut deep, V-shaped valleys in the land, while lowland streams have shallower, wider channels?* Stream-table investigations show your pupils that the steeper the land is tilted, the faster water flows downhill over it, and the faster the water flows, the faster it erodes rock or soil directly *beneath* it. So water flowing from mountain heights cuts deeper and deeper into the land, leaving high, steep banks on each side, and carrying off rock or earth that may slide down the banks into it. Geologists call a river that is energetic enough to cut a deep, V-shaped valley (and keep its slim shape in this way) a "young" river, even though it may have been flowing for thousands of years.

An "old" river, to geologists, is one that flows slowly, over nearly flat land, using what little energy it has left to erode the sides, rather than the bottom, of its channel. Such a river has lost its "youthful vigor" and tends to get wider instead of deeper, wandering over the land by the easiest path to the sea instead of cutting its way down a fairly straight path.

• *How does a river* meander, *or form snake-like curves in its channel that gradually change in shape and location?* An "old" river, flowing over nearly flat land, tends to deposit sand and *silt* (fine bits of soil) where the flow is slowest (at the inside of a bend in its channel), and erode the edge of its bank where it is flowing fastest (at the outside of a bend). As the inside of the bend builds up and the outside wears away, the channel becomes more and more curved. It may even double back on itself, then break through the land between the beginning and end of the curve and leave a curved body of water—an *oxbow lake*—completely cut off from the river. (Your pupils can watch this happen on the stream table.)

Activities

• Have your pupils explore the land around the school for signs of erosion by run-off water and mini-rivers. From their stream-table investigations and class discussion, can they explain how mini-hills and mini-valleys were probably formed? How do man-made things such as buildings, sidewalks, roads, and so on affect the flow of run-off water over this land? Do they help rain erode the land faster, or do they slow or block rain erosion?

• Can your pupils figure out how the land where your community is located has been shaped by rivers?

Brain-Boosters

Mystery Photo. The tracks were made by a bicycle that was ridden through the puddle. The straighter of the two tracks was made by the rear tire of the bicycle; the wavier track was made by the front tire as it swept from side to side. If your pupils have difficulty in understanding how one bicycle can produce two different tracks, you might take them outside after a rain and let them watch as one pupil rides a bicycle through a puddle.

What will happen if? If a glass of water at 100° Fahrenheit is mixed with a glass of water at 40° F., the resulting mixture will have a temperature of 70° —the arithmetic average of the temperatures of the two component liquids. Similarly, if one glass of water at 100° were mixed with *two* glasses at 40°, the mixtures would have a temperature of 60° (180° divided by three).

If you can obtain some laboratory thermometers and paper drinking cups, you might let your pupils perform some mixing experiments with water at various temperatures. (Be sure that they stir the mixture slightly, and take its temperature immediately.) Can anyone discover the rule for predicting the temperature of each
(Continued on page 4T)

(continued from page 3T)

proposed mixture?

Can you do it? To fill a glass with air while it is held underwater, turn the glass upside down and hold it just under the surface of the water. Then place one end of a drinking straw under the open end of the glass, and blow bubbles underwater so that they rise inside the glass. The rising air bubbles will displace the water in the glass, filling the glass with "breath air."

You might demonstrate this method to the class, then challenge them to see whether anyone can think of a way to fill a glass underwater with "room air." This can be done by holding a glass upside down underwater, then pushing another upside-down glass straight down into the water, so that the air remains trapped inside it. If the air-filled glass is then placed beneath the water-filled glass and tipped, the air will be transferred to the water-filled glass while the air-filled glass becomes filled with water. Distribute some large pans and clear plastic cups or pill bottles, and see whether your pupils can come up with this method, or some other method.

Fun with numbers and shapes. Let your pupils measure a nickel and see whether they can calculate the length of a line of one million nickels (about 13 miles). It might be interesting for your pupils to compare notes on how they went about their calculations.

After your pupils have figured out the answer to this problem, they might enjoy thinking up some similar problems for their classmates to solve.

For science experts only. Bring one hard-boiled and one uncooked egg to class, and let your pupils experiment with them to try to tell which is which. One sure way to differentiate the eggs from one another is to try to spin each one on its narrow end. The hard-boiled egg, since it is solid inside, will spin for a while like a top. But the liquid inside the uncooked egg will not be set in uniform motion when you try to spin the egg, and the egg will simply fall over. Can your pupils find another way to tell the eggs apart without damaging them?

nature and science

VOL. 7 NO. 4 / OCTOBER 27, 1969

nature and science

VOL. 7 NO. 4 / OCTOBER 27, 1969

CONTENTS

PICTURE CREDITS: Cover, Grant Heilman; pp. 2-5, 8-9, 11, 13-14, 16, drawings by Graphics Arts Department, The American Museum of Natural History; p. 3, *Cleveland Plain Dealer*; pp. 6-7, photos from U.S. Geological Survey; p. 8, left from Standard Oil Co. (N.J.), right photos from U.S. Bureau of Reclamation; p. 9, top to bottom left, Joe Monroe from Photo Researchers, U.S. Bureau of Reclamation, U.S. Bureau of Commercial Fisheries, top to bottom right, U.S. Forest Service, Charles Ott from National Audubon Society, United Nations World Food Program; pp. 11-13 (except p. 13 bottom), photos by Ruth and Louis Kirk; p. 13, bottom photo from Washington State University; p. 15, Charles F. Stafford; 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.

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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 present condition of rivers spells trouble for man, who has depended on them for food, water, and power since his beginning, a million or more years ago.

■ Rivers have been working on the earth for at least three billion years—gradually carving valleys through rock, carrying soil to the sea, wearing away and reshaping the land. Full of power and life, their flowing waters are perhaps the earth's greatest force for change. When man evolved, it was natural that rivers would play a big part in his survival.

The life of early men often centered around rivers, but not just because they needed water to drink. Humans were food-gatherers then. They caught fish from rivers, collected berries and nuts from the rich land along rivers, and hunted the birds and mammals whose lives depended on rivers and their valleys.

When humans first learned to grow plants for food, river valleys were the easiest land to farm. Man's first settlements were built along rivers. Scientists estimate that at least 80 per cent of all ancient Indian villages in North America were on or near rivers. Today, when scientists want to learn about early man, they search for evidence in river valleys *(see page 10)*.

Explorers used rivers for quick—if not easy—traveling *(see page 4)*. Rivers were the first highways, carrying travelers and traders. Cities grew up alongside rivers, espe-

RIVERS AND MAN

by
Laurence Pringle

cially where two rivers joined, or where a river entered the ocean. Look at a map of North America, or at a globe, and see how many cities you can find at such places.

Trying To Tame Rivers

Gradually, men learned how to control a river's flow with dams *(see pages 8-9)*. They learned how to tap a river's power with water wheels and turbines. They even made their own rivers—canals—for transporting goods.

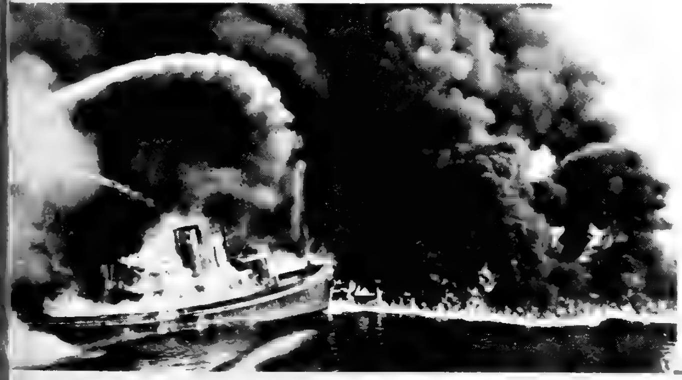
Rivers have been useful to man in another way. A million or more years ago, for the first time, a man threw wastes into a river. It was a handy way to get rid of things then, and it still is today. A running stream can clean itself

(Continued on the next page)

A Burning River

It's hard to pick the most polluted river in North America. Perhaps the "winner" is in your area. One leading contender for the title is the Cuyahoga, near Cleveland, Ohio. Before it flows into Lake Erie, the Cuyahoga River is loaded with many kinds of wastes, including oil and chemicals from industrial plants. Sometimes so much oil and debris coat the water that people have jokingly called the Cuyahoga "the only river in the world that is a fire hazard."

This past June the joke came true. Oil floating on the river caught fire *(see photo)*, and $50,000 in damage was done to two bridges and to buildings along the shore.



Earlier this year, several high school seniors from Cleveland were brought to Washington, D.C., to tell Congressmen about water pollution in their area. Ronald Traub, 17, said, "Big business, one of the greatest offenders in water pollution, fails to understand one basic idea—that water courses are public property." The state of Ohio, nevertheless, permits industries to dump wastes into the Cuyahoga.

Virginia Robinson, also 17, suggested that "pollution control should be as important as the defense budget, or the space program, or highway construction."

In the past few years, there has been a great deal of talk about cleaning up rivers and lakes. But the Federal government, in particular, has failed to back its words with deeds and money. The Clean Water Restoration Act, passed in 1966, committed the United States government to spend $20 billion over several years to control water pollution. The government is already more than a billion dollars behind schedule. Yet, a recent poll conducted for the National Wildlife Federation showed that most people are willing to pay higher taxes if the extra money is used to clean up rivers and lakes.

if its load of wastes is not too great. The wastes are thinned out as they mix with the water. Then the wastes decay as tiny plants called *bacteria* break them down into harmless substances. Or the wastes are eaten by worms, some kinds of fish, and other animals.

In this way, a river can "digest" wastes that are dumped into it. But in many rivers today, the load of wastes is just too great for the water to "digest." As bacteria decay the tons of garbage and human body wastes, they use up most of the oxygen in the water, making it impossible for fish and other animals to survive. Also, waste chemicals from factories kill some living things outright.

Many rivers have become open sewers, gathering wastes from city after city and carrying them to lakes or *estuaries* (places where rivers meet the sea). These waters die a little each day as more wastes are carried into them by polluted rivers.

The Future of Rivers—and Man

Man did not *plan* to pollute rivers. The story of waste-filled rivers is an example of how we humans go about changing our world without much thought or understanding of what might happen once the change is made. A river is polluted, or dammed, or its course is changed—and *then* we find out the effects. Often there are unexpected, bad effects, but it may be impossible, or very expensive to correct them.

Right now, for example, there is a suggested plan to change the course of rivers in the northwestern United States and bring their waters to the dry southwest. But no studies have been made of the long-range effects of such a change. Another plan suggested building 67 reservoirs in Texas that would have flooded an area almost the size of Connecticut. Texas voters rejected the plan, mostly because of its cost, but also because so many miles of river valley would have been destroyed, and because the reservoirs might have affected the state's climate.

People are beginning to learn that dams can have bad effects *(see pages 8-9)*. Conservationists are trying to protect some rivers from dam-building and to keep them free-running and as unspoiled as possible.

The story of rivers and man is like the story of man and the entire earth. Humans have "tinkered" with the land, water, air, and with other living things. As a result, we have lost tons of topsoil, polluted the air and water, and wiped out dozens of kinds of animals. We seem to be slowly learning from our mistakes. If humans are to survive, however, we must learn more about the nature of our Spaceship Earth.

Rivers existed long before man evolved. A thousand or a million years from now, rivers will still be making their way to the sea. Will humans be living with them? ■

One hundred years ago, John Wesley Powell led the first expedition down the unexplored Colorado River through the Grand Canyon. His diary tells a story of . . .

Brave Men on a Raging River

■ In 1869 John Wesley Powell, a college professor, set out to map the last great unexplored region of the United States—the Colorado River country. Indians and other explorers told him the journey down the Colorado River through the Grand Canyon was impossible. But on May 24, 1869, Powell and nine other men set out in four wooden boats from Green River Station, Wyoming.

Powell carried instruments for finding latitude, longitude, and altitude of various places along the Canyon. He also planned to collect rock samples and fossils. The first part of the trip, down the Green River to its junction with the Colorado *(see map)*, was filled with mishaps. One boat was destroyed *(see drawing)* and one man left the expedition.

But the most dangerous part of the journey lay ahead—in the unknown depths of the Grand Canyon. Here is Powell's own story of this part of the trip, as written in his diary:

August 13—We are now ready to start on our way down the Grand Canyon. Our boats are tossed by the river. We have only a month's rations. We have an unknown river yet to explore. With eagerness and anxiety we enter the canyon and are carried along by the swift water that reaches to the walls.

August 14—When the canyon walls are made of hard rock, we have rough water; when they are made of soft rock, we have smooth water. Now the rocks of the walls are harder than any we have seen.

About 11 o'clock we hear a great roar ahead. The sound grows louder, and we find ourselves coming to a long, broken fall. We land just above it, but there is no path on either side of the river over which we could carry the boats and go around it.

We do not stop. We step into our boats; push off and away we go, first on smooth but swift water. Then we strike waves, and a breaker rolls over our little boat. The open part of the boat is filled with water, but it does not sink. At the bottom of the falls we bail our boat and on we go again.

Prisoners of the Canyon

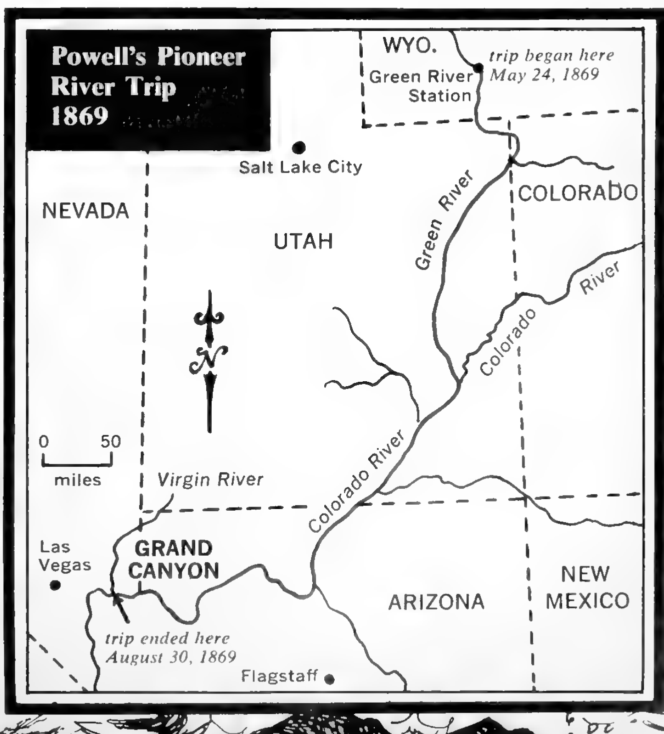
August 16—We must dry our rations today, and make oars. While we are camped, I discover the ruins of two or three old houses that were made of stone. Only the foundations are left. In one room I find an old stone used for grinding grain. A great deal of pottery is scattered around, and old trails are deeply worn in the rocks.

Why did ancient people seek such hard-to-reach places for their homes? They must have been farmers, but there are no lands here for them to cultivate. Perhaps they built little plots of land on the cliff. They must have come to escape the Spanish conquerors who invaded Mexico. Perhaps they preferred being imprisoned within the canyon walls rather than by the Spanish.

August 17—We have now only enough musty flour for 10 days, a few dried apples, but plenty of coffee. If we lose any more food, we may have to give up the expedition and try to reach settlements to the north. Our barometers are damaged and useless. Not one of us has an entire suit of clothes, or a blanket. We gather driftwood, and build a fire; but after supper the rain puts out the fire and we sit all night on the rocks, shivering.

August 19—After dinner, in going over a rapid, our boat is upset by a wave. We are ahead of the larger boats, the river is rough and swift, and we are unable to land. We cling to the boat and are carried downstream. The men in the other boats see our trouble, but they are caught in whirlpools and it seems a long time before they come to

(Continued on the next page)



This photo shows Powell's second expedition setting out from Green River Station, Wyoming, in 1871. (The first expedition also started there, but without a photographer.) Powell is the sixth man from the left, standing in the second boat.

our rescue. At last they do come. Our boat is turned right-side-up, bailed out, and on we go. Soon we have sunshine again.

August 24—We are anxious to find out how far we have come every time we stop, now that our food consists of plenty of coffee, very little spoiled flour, and very few dried apples. It has come to be a race for dinner.

August 25—We make 12 miles this morning, when we come to rocks of lava standing in the river. Then just over a fall we come to a "dead" volcano on the very edge of the canyon. Long ago, vast floods of lava must have poured down into the river from the volcano. Just imagine a river of hot, liquid rock running down into a river of melted snow. What a seething and boiling of the waters!

August 26—About 11 o'clock today we discover an Indian garden at the foot of the canyon wall. There are some nice green squashes. We carry 10 or a dozen of these on our boats, and leave in a hurry, excusing ourselves because we need food so badly. We go down the river to where we feel certain no Indians can follow; and what a kettle of squash sauce we make!

Trapped on a Cliff

August 27—About 11 o'clock we come to a fall that seems much worse than any we have been over before. I climb the canyon wall high above the river in order to see the roaring fall. But I go too far on the cliff wall, and cannot go forward or backward. I am caught here, 400 feet above the river. I will fall if my footing fails. I call for help and the men throw me a rope, but I cannot let go of the rock long enough to take hold of it. Then they bring two or three of the largest oars. They use an oar to press me against the wall and another for me to step on. So I get out.

I decide that it is possible to get over this part of the river, and I announce to the men that we will do it in the morning. After supper one man asks to have a talk with me. He thinks that we had better abandon the river here. With two other men, he has decided to go no farther in the boats.

In a direct line, we must be about 45 miles from the Virgin River, our destination. But this 45 miles will probably be about 80 or 90 on the winding river. I show the man where I suppose we are and where several settlements are on a map. He lies down to sleep, but all night long I pace up and down. Is it wise to go on?

I feel sure we can get past the danger just ahead; but I do not know what there may be after that. I am not certain we could climb out of the canyon here. And if we got to the top of the canyon, I am certain there is a desert of rock and sand between this and the nearest town, at least

Powell's men often had to pull their heavy boats up on land to repair them. The boats were built of oak, had airtight compartments at both ends, and could carry 4,500 pounds apiece.

75 miles away. There has been a lot of rain and we would probably find water along the way. I almost decide to leave the river.

But for years I have been planning this trip, and I am determined to go on. I wake the five other men and they promise to go on with me.

Separation and Success

August 28—After breakfast, two rifles and a shotgun are given to the three men who are leaving. I ask them to help themselves to a fair share of the rations, but they refuse.

Before starting, we take our barometers, the fossils and rocks we collected, and some ammunition from the boat, and leave them. We want the boats to be as light as possible to go over this rough place. We leave the smallest boat behind. It is a rather serious parting; each group thinks the other is taking the dangerous way.

The three men climb a rock to watch us off. We are scarcely a minute in running over the rough place. It looked bad from upstream, but we have passed many places that were worse.

We land and fire our guns, as a signal to the three men that we are safe. We hope that they will follow in the smaller boat. We wait until their coming seems hopeless, and push on.

Just after dinner we come to another bad place. I tell the men to take a rope from each boat to the top of the cliff, and let the boats down over the fall. Bradley stays in the boat to keep it from being dashed against the rocks. The men let the boat drift to the head of the fall. The boat is in swift water and they cannot pull it back. They are not able to let the boat go farther on the line because it is not long enough to reach to the higher part of the cliff.

We start to pass another rope down to Bradley, and I see him take his knife to cut the line. He has evidently decided that it is better to go over the fall with the boat than to wait for it to be dashed to pieces on the rocks. The boat goes over the fall and is lost in the mad, white foam. Bradley is gone, so it seems. But now we see something coming out of the waves. It is the boat and we see Bradley standing on deck swinging his hat to show that he is all right. We run to the other boat, jump aboard, push out, and away we go over the falls. The boat rolls over, and tumbles and tosses. Then Bradley is picking us up, and we are soon all right again.

August 29—At 12 o'clock we come out of the Grand Canyon of the Colorado. The relief from danger and the joy of success are great. Every waking hour passed in the Grand Canyon has been one of work. Now the danger is over and the work has ended. We sit till long after midnight talking of the Grand Canyon, talking of home, but mostly talking of the three men who left us. Are they wandering in the canyon unable to find a way out? Are they searching over the desert lands above for water? Or are they nearing the settlements?

August 30—We hope every minute to discover the mouth of the Virgin River. Soon one of the men exclaims: "Yonder's an Indian in the river." We see two or three persons, and we pull toward them. There are three white men and an Indian. We are at the mouth of the Virgin River. As we come near, the men seem less surprised to see us than we do to see them. They tell us that we were reported lost long ago, and that some weeks before, a messenger had been sent from Salt Lake City with instructions for them to watch for any remains of our expedition that might drift downstream.

Powell and his men became national heroes after their trip. They later learned that the three men who had gone overland had been killed by Indians, who thought the men had killed a squaw.

This first trip down the Colorado had been so hurried that Powell decided to make other trips to get more scientific information. In his travels he pieced together the story of how the Colorado River had worn away the layers of rock over which it flowed, helping to form the Grand Canyon ■

Here is Powell in 1873, talking to a Paiute Indian in Arizona. The "Major," as Powell was often called, lost his right arm when he was wounded in the Civil War.

The lakes that form behind dams provide opportunities for boating and water-skiing. Swimming is sometimes permitted, but there are few beaches because the water level of reservoirs changes so often.

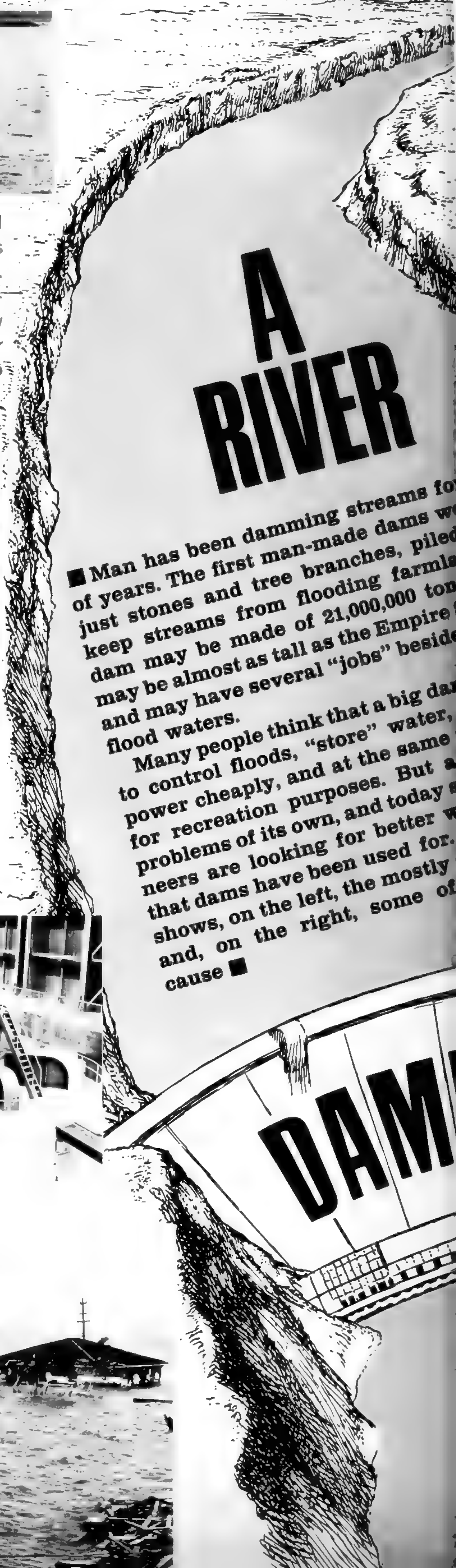
A dam traps water when the river is high. Then the water is slowly released, keeping water routes deep enough for ships all year. The stored water may also be used by cities, industries, and farms, such as this one in Saudi Arabia.

The reservoir above a dam provides a living place for the kinds of fish that thrive in deep, still water. The fish provide fun and food for many people.

A RIVER

■ Man has been damming streams fo
of years. The first man-made dams we
just stones and tree branches, piled
keep streams from flooding farmla
dam may be made of 21,000,000 ton
may be almost as tall as the Empire
and may have several "jobs" beside
flood waters.

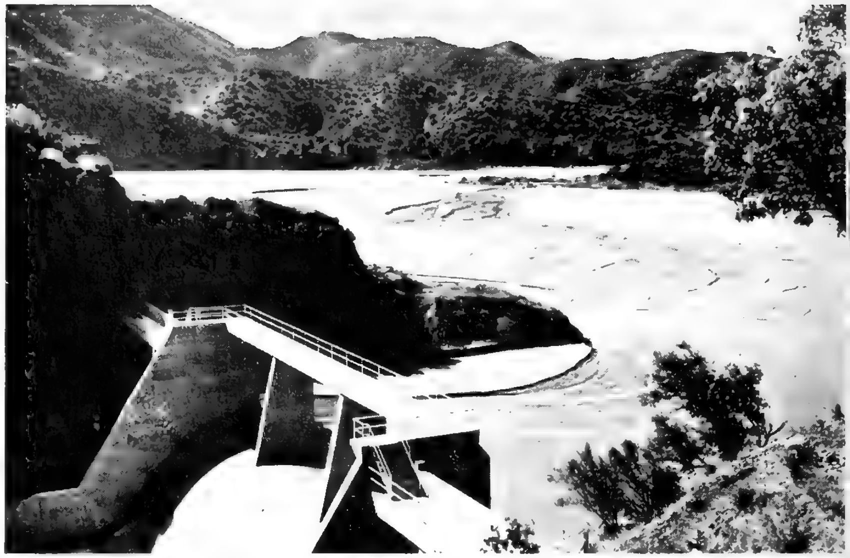
Many people think that a big da
to control floods, "store" water,
power cheaply, and at the same
for recreation purposes. But a
problems of its own, and today s
neers are looking for better w
that dams have been used for.
shows, on the left, the mostly
and, on the right, some of
cause ■



At many dams, the energy of falling water is used to produce electricity, and transmission wires sometimes carry it hundreds of miles to homes and industries. These *hydroelectric* plants don't pollute the air or water with chemicals.

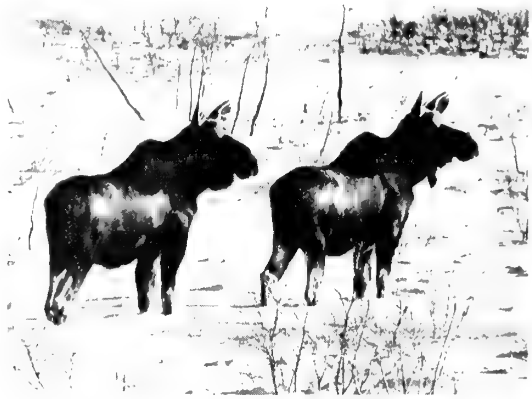
By storing water during times of heavy rains and melting snow, dams help control floods. But, despite dams, flood damage is still great. This is mostly because so many homes and industries have been built on low areas that are easily flooded. If these *flood plains* were used for farming and recreation, not for building, there would be less damage during a flood.

"Taming" a river with dams wipes out some kinds of recreation, such as white-water rafting and canoeing, and some kinds of fishing. Dams destroy the uses and beauty of a flowing river and of the land that is covered by the reservoir.

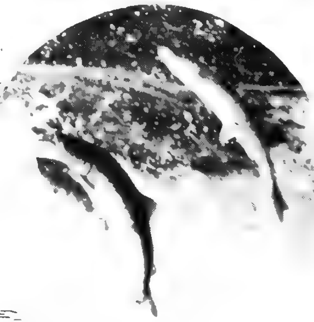


When a river reaches a reservoir, it slows down and drops much of its load of *silt*—fine particles of soil and rock. This small dam in California became completely filled with silt in just three years. Bigger reservoirs have much longer lives, but all are expected to eventually fill with silt and hold no water.

The water stored behind a dam is spread over a large area, and millions of gallons of water evaporate from the surface each day. Scientists are investigating ways of reducing this loss. The photo shows a harmless chemical being sprayed on an Arizona reservoir. A thin film of the chemical on the surface may keep the water from evaporating.



The living place *(habitat)* of many animals is destroyed when a reservoir forms. A dam suggested for Alaska would have formed a lake larger than New Jersey, destroying the habitat of a million birds, thousands of moose, and many other animals.



Salmon from the seas must travel upstream to reproduce. Dams blocking salmon "runs" on many rivers in eastern North America have helped reduce the numbers of Atlantic salmon. Elsewhere, some dams have "fish ladders" that enable fish to swim up and over them.

Along the Nile River and in many parts of the world, farmers depend on annual floods to water their crops and to deposit a layer of rich silt on their lands. When a dam is built, the silt no longer reaches the farmer's fields. Water from the reservoir is released gradually to the farms through irrigation ditches. But the ditches are living places for snails that carry diseases of man, and dams built in Africa have led to serious outbreaks of such diseases.

A Race into the

Photos and Text by Ruth and Louis Kirk

■ Last year the United States Army Corps of Engineers finished building Lower Monumental Dam across the Snake River in the State of Washington *(see map)*. When the dam gates were closed, water began to back up in the canyon behind the dam *(see photo)*. The lake that quickly formed spread up the Snake River valley to where the Palouse River joins the Snake, and up the Palouse to where scientists had been digging for seven years for the remains of people who lived thousands of years ago.

Twenty years before, when the dam was being planned, scientists had discovered evidence of early man near an old Indian village in the canyon country where the Palouse and Snake Rivers came together. In 1962, with work beginning on the dam, money became available through the National Park Service to pay for an investigation of the abandoned village and other nearby places where early men might have lived.

That summer, Dr. Richard Daugherty and a group of college students set up camp near the village site. Dr. Daugherty is a Professor of *Anthropology* (the study of man) at Washington State University, in Pullman. The students were taking a field course in *archeology* (the study of how ancient peoples lived).

In the United States, 300 large dams have been built or planned in the last 20 years *(see pages 8 and 9)*. Many of these dams, and the reservoirs of water they produce, have destroyed or threaten to destroy archeological sites such as the Marmes site, wiping out chances to learn how the earliest Americans lived.

"Every time we add another dam to the progress of today, we lose a little more of the past," says Dr. Richard Daugherty, who led the Marmes dig. "You can't excavate—dig up remains layer by layer as they were laid down in the past—when a burial ground has been blasted and paved for a road. And you can't trace the outline of a village that is beneath 500 feet of water. The only solution is to dig before the bulldozers and the blasting crews come."

Fortunately, this is happening. In the Mississippi River valley, archeologists from the Smithsonian Institution, in Washington, D.C., are tracing numerous ancient Indian villages and recovering remains in areas that will be flooded by new dams. In Egypt, the new Aswan Dam on the Nile River brought experts and gifts of money from many nations to help salvage temples and other treasures. Wherever possible, archeologists are working hard to recover what they can of man's past before it is flooded or bulldozed into a meaningless rubble.

Digging into the Past

Digging at the village site, the students found stone spear points and scrapers, mixed up with broken china plates and rusted nails. Railroad construction had caused the disturbance, and the jumble was useless, because no one could tell in what order the objects had been left.

The diggers had better luck, though, in a nearby "cave" —the Marmes Rock Shelter, they called it, because it is on the Marmes Ranch and it has a wide entrance but is not very deep *(see photo)*. There they began to uncover human remains that had not been disturbed for centuries. Dr. Daugherty decided to concentrate on digging in the small shelter, for the work was urgent. In a few years the dam would be completed, and a reservoir would flood this and about 70 other places close by that had been used by early men *(see "Salvaging the Past")*.

Dr. Daugherty and the students kept digging deeper each summer, and by 1964 they had uncovered skeletons and tools from periods reaching back nearly 10,000 years. This showed that humans had been living and burying their dead in the Marmes Rock Shelter far longer than at any other site so far discovered in the Americas! The National Park Service named the rock shelter a National Historical Landmark.

A Little Find that Turned Out "Big"

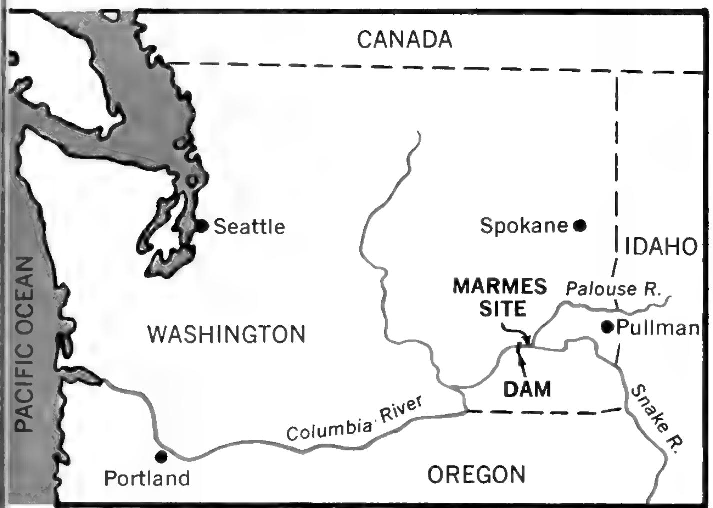
That same year, a Washington State University geologist named Roald Fryxell was studying bands of river silt and volcanic ash at Marmes Rock Shelter. He had worked with Dr. Daugherty from early in the dig, and had helped to date the objects found in the cave. Now he was trying to piece together a description of how the land there had been formed and changed down through the ages.

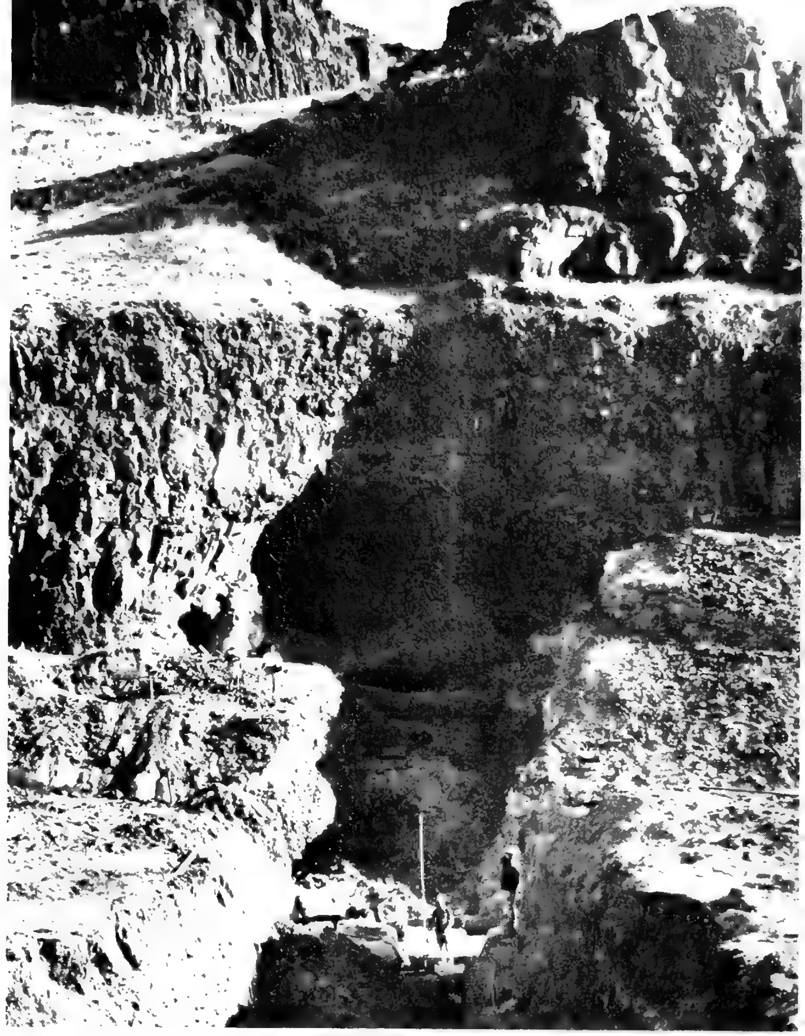
He summoned a bulldozer to cut a trench so he could study the layers of earth at different levels. Walking behind the clanking monster, he suddenly saw its blade scrape loose a fragment of bone. It seemed to lie deeper within the earth than any bones from the cave. If so, it would be the

(Continued on page 12)

Past

In a dusty canyon near /here the Palouse River joins the Snake River in the tate of Washington *(see map)*, scientists dug for seven ears to recover remains of early Americans before the ower Monumental Dam *(below)* was completed and /ater spread back from it to flood the site. At the larmes Rock Shelter *(right)*, they found the Western lemisphere's oldest human bones whose age can be neasured, along with tools and animal bones left by eople who lived in the shelter thousands of years ago.





Student archeologists, digging through hot summers at the Marmes site, made careful measurements to record where each piece of bone or tool was found.

Students scraped earth away, a tiny frac tion of an inch at a time, looking for clue to the life of Marmes Man.

Dirt from the dig was washed through fine screens to separate tiny pieces of bone or shell.

Dr. Daugherty *(left)* is shown sorting material from the water screen with Dr. Junius Bird, an anthropologist from The American Museum of Natural History.

oldest find yet. But Fryxell could not be sure, because the 'dozer had knocked the piece of bone from its original position in the earth. He got down on hands and knees to look for pieces of bone undisturbed by the bulldozer. He found enough for scientists at the university laboratory to identify them as human bone. For two more years researchers scraped and dug by hand, slowly gathering other bits of human bone, tools, and bones from butchered animals.

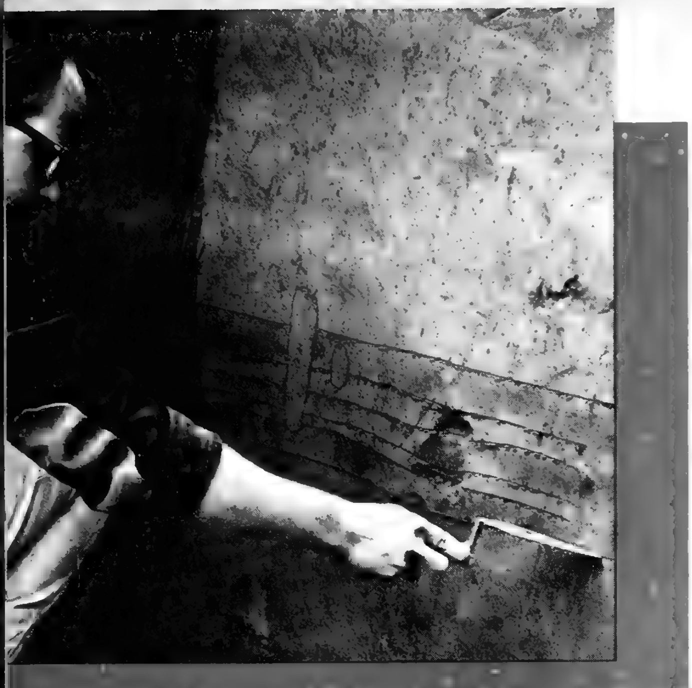
Back in the laboratory, the bones were pieced together. They formed part of an ancient human skull. Parts of such ancient skulls have been found elsewhere in the Americas—in Mexico; near Midland, Texas; and at Laguna Beach, California, for example. But all of these bones came from places that had been disturbed, so there is no sure way to tell how old they are.

The skull found near Marmes Rock Shelter was different, though. It lay undisturbed in the middle of what Fryxell calls a "sandwich in time." The layer of earth in which the bones were found is topped by a layer containing mussel shells from the river. These shells were dated *(se "Dating Plant or Animal Remains with Carbon-14")* an were found to be about 10,000 years old. The bottom c the "sandwich" is a layer of earth containing ash from volcano known to have erupted about 13,000 years ago

Thus, in the spring of 1968, Fryxell and Daugherty wer able to announce that they had found the broken skull c "Marmes Man," a nomadic Indian who had lived and die near the rock shelter sometime between 10,000 and 13,00 years ago. This meant that it was the oldest skull found s far in the Americas that can be positively dated.

Meantime, Back at the Dig . . .

The archeologists worked day and night through th spring, summer, and fall of 1968 to remove as many re mains of past life from the site as they could before it wa flooded. One find quickly followed another. There wer fragments of three more skulls, including one of a smal child; the bones of a giant elk larger than any alive today



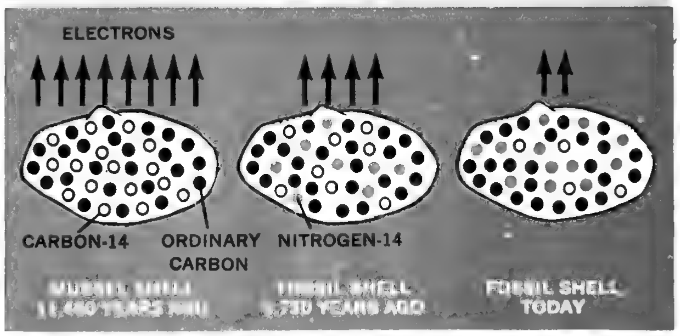
ieologist Roald Fryxell races ancient layers of arth exposed in the wall of n excavation. (The ovals epresent holes dug by ro- ents more than 10,000 ears ago.) Below, Fryxell olds a skull cap of Aarmes Man, pieced to- ether from bone frag- nents found sandwiched etween rock layers that vere formed 10,000 and 3,000 years ago.

Dating Plant or Animal Remains with Carbon-14

A certain tiny fraction of the carbon in the earth's atmosphere *(see "Is 'Pop Gas' Warming the Atmosphere?", N&S, September 29, 1969)* is a special kind of carbon called *carbon-14* (C-14). Living plants take in carbon from the atmosphere, and living animals get carbon from the plants—or from the plant-eating animals—they eat. So C-14 makes up the same fraction of the carbon in living plants and animals as it does of the carbon in the atmosphere. When a plant or animal dies, however, it stops taking in carbon. The fraction of the carbon in its remains that is C-14 gradually gets smaller as atoms of C-14 *decay,* or give off an electron, and change into atoms of a different element, called *nitrogen-14.*

It takes about 5,730 years for half of the C-14 atoms in an animal's remains to decay. (This period is called the *half-life* of C-14.) Then it takes another 5,730 years for half of the remaining C-14 atoms to decay, and so on *(see diagrams).*

To date a mussel shell, for example, scientists compare the number of electrons being given off by a piece of the shell 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 shell was part of a living mussel.



ive bone needles older and finer than any others known in he Americas; a hearth where men had cremated their dead onger ago than experts had previously believed.

Time was running out, though, even faster than the ırcheologists could dig. The Marmes Site held the most letailed record of early man ever found in North or South America, but Lower Monumental Dam was nearly complete and its lake would flood to the roof of the rock shelter.

Mere weeks remained. An order came from the White House for a levee to be built to protect the archeological renches from the advancing lake. The levee was built, out by February 1969, water had seeped along a layer of gravel far beneath the levee. The earth layers that still held evidence of Marmes Man were now at the bottom of the leepening reservoir *(see photo).*

"This site is so rich, we found only about half of what is here," Fryxell and Daugherty say. Perhaps pumping, or a owering of the water level behind the dam, will someday permit the archeologists to return to their work ■

This photo shows the Marmes site as it looks today, flooded by water that seeped through a layer of gravel beneath the bow-shaped levee that was built to shield the site.

How does a river get its shape? How does it shape the land? You can get some ideas by exploring a back-yard rain river, then test your ideas by experimenting with a model mini-river.

EXPLORING

■ From rivers—or pictures of them—that you have seen, you probably know that streams can be quite different in size, shape, speed, and sometimes even color. You have to go pretty far along a large river to see such differences, but a small stream may reveal many surprising and sudden changes to you in a few hours' hike along its banks.

Even if you don't live near such a stream, there's a way you can explore a river from its *head,* or starting place, to its *mouth,* or end, in a single afternoon! You can observe and record how different it is from one part to another, and form some good ideas about how a river makes its way. Then you can make a model river and test your ideas about how larger rivers work.

Exploring Mini-Rivers

Some day during or just after a heavy rain, put on your boots and raincoat, take a notebook or pad with 8½-by-11-inch paper, a pencil, and a ruler, and go out into your back yard, a vacant lot, or a nearby park. (If rain is still falling, you might take an umbrella and a friend to hold it as you write down your observations.)

Look for mini-rivers—streams of rainwater flowing from high ground to lower ground under the pull of the earth's gravity, as all rivers do. If possible, find one that flows over different kinds of ground surfaces, such as grass, soft soil, bare earth that is hard when dry, sand, gravel, and rocks or pavement. (You may have to explore several mini-rivers to see how they flow over different kinds of ground.)

Travel upstream until you reach the head of the river. What is the *source* of the stream? Water falling out of a rainspout or drainpipe? A mini-lake, or puddle, that is overflowing? A number of mini-creeks that join up to form the mini-river? Or something else?

Draw a small, simple sketch of the river's source at a top corner of a notebook sheet to begin your map of the river. Number the source "1", and on another sheet of notepaper write "1. Source:" followed by a brief description. Is there a mini-falls there? How high? What kind of ground is it falling on? Is it digging up the soil and carrying some off, making a pool at the base of the falls? Measure and note the width and depth of the river at its source.

Is the water there flowing fast or slow? (This is just a guess until you have compared its speed at the head with its speed at other places. Watching the stream carry off a blade of grass will help you judge its speed.)

Is the mini-river picking up any *debris*—leaves or twigs, for example—or grains of sand or soil from its source?

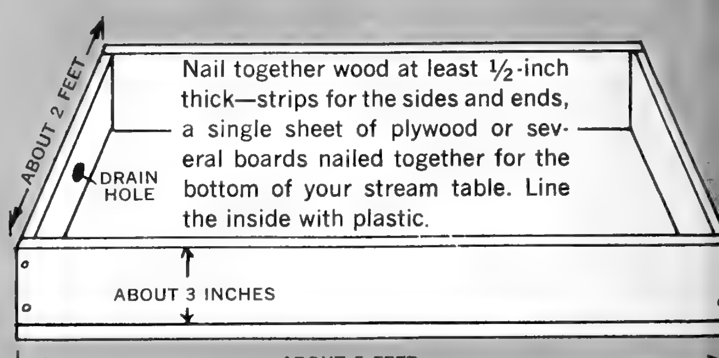
INVESTIGATING RIVER

The diagram shows how to make a simple stream table—a long, shallow box of wood lined with plastic film. (Rest it on a table, if possible; it will save bending over, and you can place a bucket beneath the drainhole to catch the water.) Place enough sand or fine soil at the end of the box opposite the drainhole to almost reach the top. Put some bricks or other objects under this end of the box to raise it a few inches.

Now hold a garden hose just above the end with the sand and turn on the water so that it comes out very slowly, forming a small waterfall. Does it dig a pool? Soon a stream will form at the surface and begin flowing toward the other end. Watch it wear a channel through the sand. Does the channel get wider, deeper, or both? Is it straight or curved? Can you explain what happens at the edge of the sand, where the river flows onto the "floor" of the stream table? Try moving the hose to start another river, and see what happens when it reaches the first channel.

Raise or lower the head end of the stream table to speed up or slow down the flow of water. How does this change the river's channel? Can you find a way to make the stream wander over the sand in snake-like curves? (This is called *meandering;* by watching a stream meander for a while, you can probably figure out *how* it does it.)

Try making hills and valleys in the sand to see how the stream behaves. Place a few pebbles in the stream bed. Can the water move them? Bury a rock and watch the stream dig



MINI-RIVERS

by Franklyn K. Lauden

Make a note, and look for places downstream where the water drops this material.

Map the River as You Go

Work your way slowly downstream, surveying the river with your ruler and mapping it as you go. Wherever the stream changes noticeably in width, depth, direction, speed, or color, put a number on the map and describe the changes on your note sheet. (If the map runs off the page, continue it at the top of another.) Be sure to describe any changes in the land the river is flowing over at that point, such as a change in the kind of ground surface, the shape and slant of that surface, or the kind of material making up the riverbank there.

Look for places where the river seems to be washing soil away from its sides. (Are they bare or grass-covered?) You may find some mini-islands, or even see one being made as the river "splits" and flows around a bit of higher ground. Do any other streams join your mini-river? Show on your map how the rivers meet, and look for changes in the rivers. Is anything happening to the land where they meet?

Is your river polluted with any man-made wastes—oil, or scraps of paper, for example? Can you figure out where and how they got into it?

How does your mini-river end? In a mini-swamp of soft, grass-covered soil? In a mini-lake that will last only a little longer than the river when the sun comes out? In a drain sewer that carries it to a larger river or lake?

You can see that the river takes the shape of the land it is flowing over, just as any liquid takes the shape of its "container." Does a river tend to take the same shape when flowing over land of the same kind and slant? What, besides the shape of the land, determines the width and depth of the river at a particular place? Why is it clear in some places and muddy in others? What kind of ground surface is worn away fastest by a river? Slowest?

You can probably find some possible answers to these questions by comparing the conditions you found at different places along the river. Then you can test your ideas, as scientists do, by making a stream table and experimenting with "model" mini-rivers (*see instructions below*). With a stream table, you can control the kind, shape, and slant of the "land," as well as the amount and speed of the water flowing over it. Then, by changing one of these things at a time, you can find out how a river and the land it flows over affect each other ■

down and uncover it. Dam up the stream and see what happens.

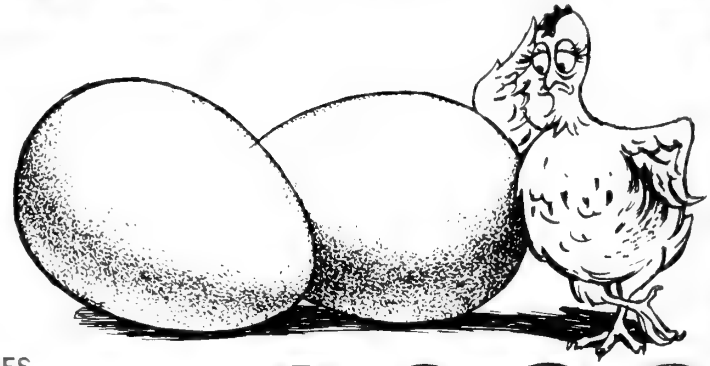
After you have become familiar with how running water behaves on sand and soil with no vegetation, dig up some moss and small plants with soil attached and plant them in your stream table. Repeat some of the experiments you did before, and find out how vegetation affects the behavior of a stream.

You can probably think of many other experiments to perform. Keep careful notes about each investigation—the kind of "land" you use, how it is arranged, how high the table end is raised, where you held the hose, and so on. You might even take photographs of the table before you turn the river "on" and at regular intervals of time as it is flowing. (Be sure to record when each photo is taken, so you can arrange them in the proper order.) —Fred and Lynda Stafford

How does flowing water erode, or wear away, hills of bare sand in your stream table *(left photo)*? Where does it build them up? How does mossy or grass-covered soil *(right photo)* change the stream's effect on the land?

BRAIN-BOOSTERS

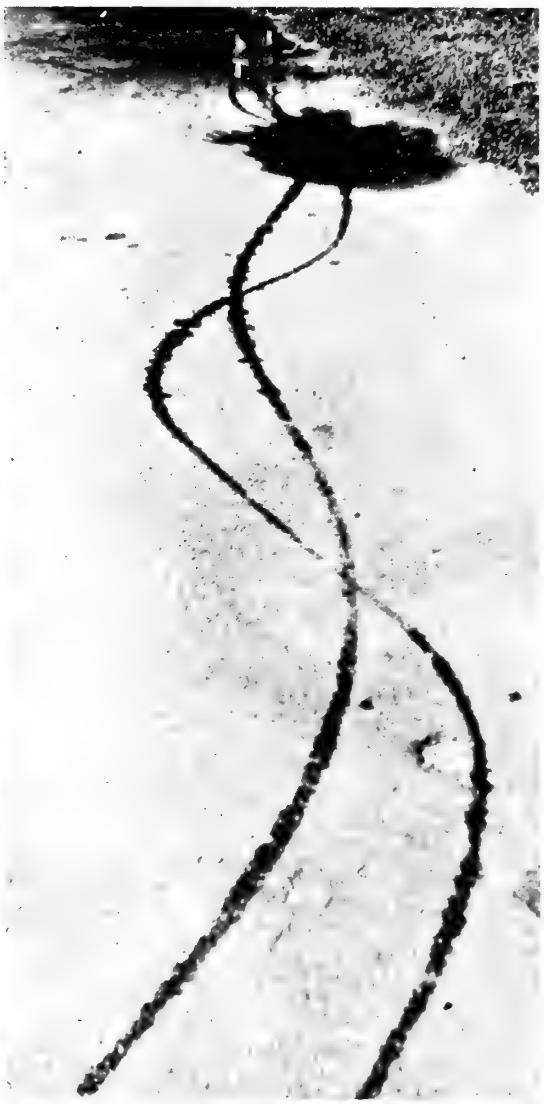
prepared by **DAVID WEBSTER**



FOR SCIENCE EXPERTS ONLY
How can you tell a hard-boiled egg from an uncooked egg without cracking them open?

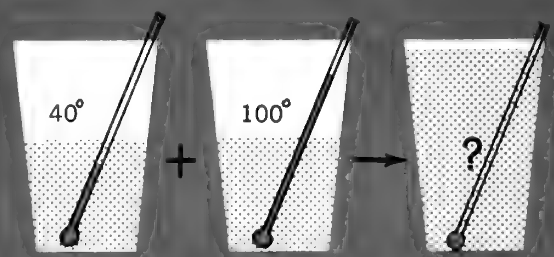
FUN WITH NUMBERS AND SHAPES
Suppose one million nickels were placed side by side in a long line. How many miles long would the line be?

Submitted by John Herman, St. Louis, Missouri



MYSTERY PHOTO
What made these tracks?

WHAT WILL HAPPEN IF . . .
. . . you mix a glass of water at 100 degrees Fahrenheit with a glass of water at 40 degrees F.? What will be the temperature of the mixture?



CAN YOU DO IT?
Can you fill a glass with air while it is held under water?

JUST FOR FUN
Float an ice cube in a glass of water and give the glass a quick twist. How does the ice cube move? How can you make the ice spin around without touching it or the water? Can you make the ice cube move around the side of the glass?

nature and science
TEACHER'S EDITION

VOL. 7 NO. 5 / NOVEMBER 10, 1969 / SECTION 1 OF TWO SECTIONS

THE IMPORTANCE OF MEASURING—PART 1

If You Can't Fight It, Measure It

Children learn to make measurements intuitively. The teacher's job is to sharpen that skill.

by Roy A. Gallant

■ Unfortunately, many teachers tend to shy away from quantitative science. The reason they give themselves is simple, and too often erroneous—namely, that they will be required to operate with a degree of precision they feel is beyond them or that will send their charges fleeing with the heebie-jeebies.

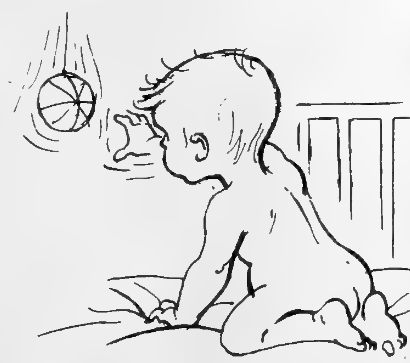
Everyone a Measurer

When a scientist makes observations during a field or laboratory study, he is doing essentially the same thing that a spectator does when he watches a football game or a horse race. Both are engaged in the skill and art of measurement.

Like the scientist, the spectator at the football game is keeping track of and relating a number of constants and variables: how many (total number, or number density), how far (distance), how quickly (rate), and how much (mass or volume).

In and out of the classroom, a child, too, is endlessly engaged in measurements of one sort or another. While some are intuitive and acquired through the empirical process of trial and error, others are taught on a formal level. Both, however, operate in an important regulatory way. "I'll race you to the corner," challenges the child (but he adds, silently to himself, "not to the end of the street, because I know I can't run fast enough to win over a distance of more than 100 yards"). Or, "I must convince Miss Smith that I am trying harder in social studies, because I need those two extra points." In both cases, the child is measuring, carefully estimating the quantity and quality of effort he will have to spend to achieve a goal.

Throughout our lives we are required to perform many different kinds of measurements. On its own level, even the infant must do so whenever it reaches for its rattle or teething ring. Eventually, neurophysiological



feedback mechanisms enable the infant to grasp an object without overshooting or undershooting the target. But there is a world of difference between that intuitive measurement and the physicist's ability to tell us that the

(Continued on page 4T)

Roy A. Gallant, Consulting Editor to N&S *and well-known author of children's science books, has collaborated with Clifford R. Swartz in the preparation of the Quantitative Science Program,* Measure and Find Out, *recently published by Scott, Foresman and Company for the middle elementary grades.*

IN THIS ISSUE

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

IN THE NEXT ISSUE

Man the Measurer—Part 2, shows how units of measurement are chosen for precision or convenience. . . . A WALL CHART shows the ecology of a coral reef; a SCIENCE MYSTERY explores the exploding starfish population that threatens to wipe out the reef builders . . . An investigation of swirling and whirling things leads to an examination of centripetal forces.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Man the Measurer

Part 1 of this three-article series describes the origin of many units in the English system of measurement, the establishment of standard units, and how the metric system was devised.

Part 2, in the next issue, will sample a variety of things we measure—from atoms to galaxies—and describe various units to do various jobs.

Part 3 will examine advantages of the metric system over the English system and problems (other than psychological ones) of switching to the metric system in the United States.

Suggestions for Classroom Use

The most important idea for your pupils to grasp from Part 1 of this series is the concept of a *standard unit* —something everyone agrees to. Here is a way to test the importance of this concept:

Divide your class into three groups and have each group "invent" a unit of measure and give it a name. The unit should not be so small that it will be difficult to measure the length of, say, the classroom. Suppose that one group decides to make the length of a specific chair leg their standard unit, and call it a *gel*. Each member of the group should next make a ruler 1 gel long out of cardboard, then mark it off into "mini-gels," or whatever the group decides to call the smaller units. They can do this by marking the midpoint of the ruler, then marking the midpoints of the resulting smaller divisions, and so on until they have a manageable number of mini-gels to the gel.

When their rulers are ready, have each pupil measure several things in the room—for example, the length of the room, the height of a classmate, the height of a table or the chalk tray, the width of a window, and so on. Be sure to include short things *and* long things. All pupils should measure the same objects.

Have the members of each group compare their measurements and report their findings to the class. (List measured items on the chalkboard, and beside them, in tabular form, the measurements obtained by each group in the unit it selected.)

• *Is one group's standard any "better" or "more accurate" than the others?* Probably not, though one group may have divided its standard unit into more mini-units, enabling those pupils to make more *precise,* or exact, measurements than pupils using larger mini-units.

• *Do measurements made in one group's standard units "mean anything" to members of the other two groups?* Not unless or until they understand what was used for the standard unit of measurement.

• Have your pupils try to work out conversion factors for each of the three units. By measuring a *gel*-stick with a *nep*-stick and a *retniop*-stick, for example, they might find that

1 gel = $3\frac{1}{2}$ neps = $\frac{1}{2}$ retniop

1 nep = $\frac{2}{7}$ gel = $\frac{1}{7}$ retniop

1 retniop = 2 gels = 7 neps

With this information, they can convert a measurement in any one unit into a measurement in either of the other units.

This project should convince your pupils that what they use as a standard unit of measurement is not important; what is important is that all agree to the length of the unit to be used as a standard—otherwise, no one's measurements mean anything to anyone else.

• *Is the metric system of measurement any "better" than the English system?* As a standard unit, the meter is not "better" than the yard or foot, but the way the meter is divided into smaller units and multiplied for larger units makes metric units easier to use than English units. Your pupils will discover this if they again measure each of the objects they measured in their own "new" units, first in yards and/or feet and inches, then in meters and "fractions" of meters. (If you don't have a meter stick, you can make one of a straight stick or strip of cardboard at least 40 inches long. Use the 25-centimeter scale at the edge of this page to mark off 100 centimeters on the stick, then cut off the remainder of the stick. You might divide the first centimeter into 10 millimeters.)

• Some of your pupils may ask why we use the English system instead of the metric system, since the latter is simpler. As soon as the metric system was introduced, scientists the world over saw its advantage as an international "language," and many began using it. (Today virtually all scientists use it.)

Thomas Jefferson, president of the U.S. 1801-1809 and himself a scientist, was in a good position to press for adoption of the new system, but he did not. Perhaps he felt there would be too much psychological resistance to it (as, of course, there is today). His predecessor, John Adams, strongly advocated adoption of the metric system.

Eventually, the U.S. Congress came to see the advantages of the metric system, and in 1866 passed an act making it *legal for use* in the U.S. But it has not been *adopted as the official system* of measurement here.

The fanatical diviner, astrologer, and numerologist, Charles Latimer, from Cleveland, Ohio, who died in 1888, seems to have been a most persuasive propagandist against adoption of the metric system. His arguments, which have been described as emo-

(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.

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

tional, irrational, and quite ridiculous, "seem to have attracted enough attention to have prevented the legal adoption of the metric system in the United States," according to the AAAS book listed below.

For Your Reading

• *Systems of Units,* by Carl F. Kayan (ed.), Publication No. 57 of the American Association for the Advancement of Science, 1959, $6.75.

• *A Dictionary of English Weights and Measures from Anglo-Saxon Times to the Nineteenth Century,* by Ronald Edward Zupko, the University of Wisconsin Press, 1968, $10.

Why Animals Change Color

Winter is approaching, and the color changes of ermine and snowshoe hares described in the WALL CHART might make a good introduction to the chart's topic.

Animal color is changed in three main ways: 1) by rearrangement of pigment particles in cells; 2) by production of pigment in existing cells (*e.g.,* in crab spiders); 3) by pigment production in new cells (*e.g.,* in plumage of birds and coats of mammals).

Your pupils can probably think of other examples of color changes for concealment (by both predator and prey) and for "advertising" (to warn away or attract). Another possible advantage of color change, still being investigated, is temperature regulation. Color changes in some lizards help them to hide, and may also affect the rate at which they are warmed by

LAURENCE PRINGLE

A flounder changes color and pattern to match a natural background in a few minutes, but takes longer when placed against a background like this.

the sun—an important factor in the lives of these cold-blooded animals.

Color changes help the survival of a species; the ability to change color is an adaptation that has evolved over a long period of time. For information about how animals become adapted through natural selection, see pages 1T-2T, *N&S,* April 14, 1969.

Brain-Boosters

Mystery Photo. The wires were nailed to the tree some time ago for a fence. The tree then grew around the wires over the years. The photo suggests that the wires have been carried higher above the ground by the growing tree. By investigating where growth takes place in a plant *(see "How Does Your Beanstalk Grow?", page 14),* your pupils can tell that this is not so. The wires droop because their other supports are missing.

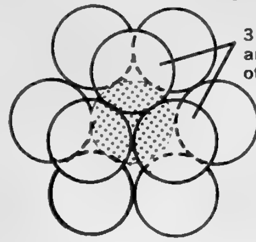
Take the class outside and see whether you can find any trees that have grown around other objects. You may find a tree that has grown around a rock, or around part of another tree.

What will happen if? The jar that is completely filled with water and capped will probably be the only one to break in the freezer. The salt water will probably only freeze into a soft slush.

You can demonstrate the force of freezing water dramatically with a section of threaded pipe from a hardware store. Get a six-inch-long piece of one-inch black iron pipe, with caps to fit on both ends. Fill the pipe completely with water by placing it in a water-filled basin and screwing the caps on underwater. Tighten the caps with pliers, and place the pipe in the freezer. After a few hours, the pipe will have been split open by the freezing water.

Can you do it? Because food is normally pushed back into the esophagus by the tongue, it is almost impossible to swallow when the tongue is blocked by a spoon. It would also be difficult to swallow if you did not have muscles in your esophagus to force the food down the alimentary canal. A bird has no such muscles, and that is why it must tip its head back in order to swallow. The esophageal muscles allow a human to swallow even against the force of gravity, however—as one of your pupils could demonstrate by swallowing some food or water while standing on his head.

Fun with numbers and shapes. If they are all the same size, 12 spheres can be made to touch another sphere, no matter what size they are *(see diagram).* It may be easier for your pupils



to experiment with cubes, however (building blocks or sugar cubes), since the cubes will not roll around or fall off one another.

Cubes can be arranged so that only a part of the face of each cube touches a central cube. In this way, 14 cubes can be made to touch another cube. If one makes a "cube of cubes"—27 cubes arranged three wide, three deep, three high—then six cubes will touch the center cube face-to-face, 12 will touch it edge-to-edge, and eight will touch it corner-to-corner.

For science experts only. An ice cube with a hole in it has more surface area exposed to the surrounding liquid than an ice cube without a hole has. The increased surface contact between the liquid makes the liquid cool faster (and the ice cube melt faster).

Crushed ice presents an even greater surface area to a surrounding liquid than does an ice cube with a hole in it, and your pupils could have some fun comparing the amount of time it takes for the same quantity of ice in crushed and cube form to melt in air or water.

Just for fun. If you can find a very large balloon at a toy store, it might be fun for the class to see just how far the air in a bicycle tire will inflate the balloon.

You could also collect the air from the tire by the method of water displacement. Simply run a plastic or rubber tube from the tire valve to a large jar inverted in a pan of water. The air coming through the tube will displace the water in the jar, and your class can count how many times the jar can be filled with air.

MEASURE IT
(continued from page 1T)

van der Waals' radius of an oxygen atom is 1.40 Angstrom units.

Qualifying and Quantifying

Science is both qualitative and quantitave. When a chemist is given a compound to analyze, he identifies the unknown ingredients by finding out whether they react in a predictable way with certain known substances. To do so means making precise measurements. And equally skillful measurements are required to determine the amounts of each substance making up the compound. The biologist, too, must be a skilled quantifier, whether he is estimating the cranial capacity of a pre-man by measuring a skull fragment, or determining the metabolic rate of a psychotic laboratory rat. These two basic skills in measurement–qualifying and quantifying–are as essential to the scientist as the ability to read musical notation is to the musician.

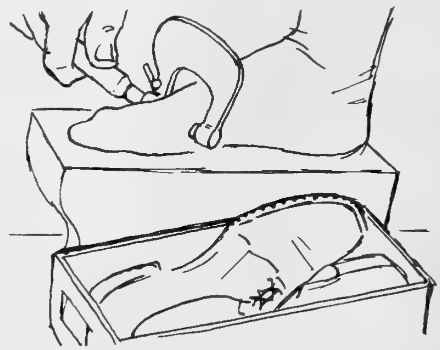
Recently, this writer collaborated with the physicist Clifford E. Swartz in preparing a quantitative science program for children of the middle elementary grades. To us, it seemed important to make the following points about quantitative science to teachers at those grade levels, who sometimes tend to shy away from activities requiring measurements:

"It is impossible to observe or classify or do anything else in science without making use of measurement in its broadest sense. In specifying the attributes of an object, we must be able to compare them with some standard–larger than a bread box, as blue as the sky, hotter than boiling water. Such comparisons are basically rough measurements. The child learns to make them intuitively, and scientific training merely sharpens the skill and defines the operation more precisely.

Precision and Accuracy

"Some of the fear of, or even distaste for, measurement and quantitative analysis stems from the belief that scientific measurement must be precise, usually to the point of fussiness. Nothing could be further from the truth. Science is preeminently an exercise in common sense. For most measurements, in science as in everyday life, precision is not required. There is a great difference between *precision* and *accuracy*. You could measure the length of a room with a meter stick to a precision of a few millimeters and still be inaccurate by one whole meter because you had miscounted the number of times that you had laid the meter stick end to end. Accuracy is a matter of not making mistakes. It can be obtained only with care and reasonable procedures of repetition and checking.

"Precision is another matter entirely. Before any measurement is attempted, you should ask, *Why do I need this information?* If, for some very unusual reason, you really want to know the length of a room to a few millimeters, then, indeed, you should go to the trouble of carefully using a meter stick.



"For many purposes, however, such a technique would be silly and wasteful of time. You might want to know the length of the room only for the purpose of comparing it to another much different room, in which case it would probably be appropriate to find the length by pacing it off. For some other purposes, even that precision might not be required. An adult could estimate the length of a room to an accuracy of better than 80 per cent just by looking at it, if the room were not more than 30 or so feet long.

"Each of these three methods–the meter stick, pacing, looking–is appropriate under some circumstances, but not under others. Part of the training of science is learning how to judge the precision required in any particular case..."

When Precision Becomes Fussiness

We can carry the discussion of precision in measurement even further, and it is important to let the child in on this aspect of measurement. If we don't, there is a real danger that he will somehow inherit the false notion that it is possible to make measurements that are error free. There is, of course, no such utopian quantity.

For example, we can measure the length of an object by comparing it with some standard unit such as the meter. But how much truth is there in my statement that the copper tube resting on the back seat of my car is 874 mm long?

Here is what I must keep in mind when I measure that length of tubing and tell you my results:

1. On a hot day, the tubing will be longer than on a cold day.
2. In a minute but measurable amount, plastic deformation on a hot day, in addition to expansion due to increased molecular motion of the copper, will make my results different from what they will be on a cold day.
3. The degree of straightness of my measuring instrument could also introduce an error factor.
4. My psychological state at the time I do the measuring must also be taken into account.

Now, surely, *that* is fussiness in measurement. Yes and no. If I intend to use that length of copper tubing to replace a defective pipe in my basement, then I am being fussy. But if I intend to use that length of tubing as a standard unit for measuring the accuracy of rulers I want to manufacture for scientific use, then it is not fussiness. Again, it is important to know the degree of precision that is adequate to do the measuring job at hand. Precision beyond that point *is* fussiness.

If you are among those teachers who tend to shy away from quantitative science because of the precision you fear may be involved, you will do well to reevaluate that notion. Chances are pretty good that you are trying to operate with more precision than the job calls for, and that may be a big part of your problem ■

nature and science

VOL. 7 NO. 5 / NOVEMBER 10, 1969

Mark the stem of a young bean plant and find out . . .

HOW DOES YOUR BEANSTALK GROW?

see page 14

As its "mood" and actions change, an octopus also changes from one color to another —in seconds. To find out how, see page 8.

WHY ANIMALS CHANGE COLOR

nature and science
VOL. 7 NO. 5 / NOVEMBER 10, 1969

CONTENTS

PICTURE CREDITS: Cover, adapted from drawings by E. V. Cowdry, in "The Colour Changes of *Octopus Vulgaris* LMK," University of Toronto Biological Series No. 10, 1911; pp. 2-16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 3, photo by Robert Gardner; p. 7, photo from Museum of Northern Arizona; p. 8, top photos by Laurence Pringle, others by Leonard Lee Rue III; p. 10, photo by Charles E. Mohr, from National Audubon Society; pp. 12-13, photos by William P. Stephen; 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.

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

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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.

When you can't get a leaky faucet turned off, and the *DRIP, DRIP, DRIP* is keeping you awake, there are at least two ways to quiet the noise. Here's how to find them.

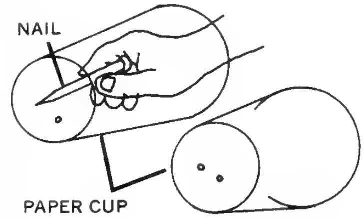
■ Look carefully at a thin stream of water coming out of a faucet. You'll see that it flows smoothly at the top, but then breaks up into bead-like drops *(see photo)*. You might say that the stream suddenly begins to *bead* as it falls.

Do all falling streams of water bead this way? You know that if you turn on a faucet "full blast," the water starts to swirl and gets mixed with air before it leaves the pipe, so that the stream of water is broken up.

But suppose you look at some smoothly flowing streams of falling liquids. Do they all bead the same? To find out, you'll need a few paper or styrofoam cups and a couple of nails of different thicknesses (4d and 10d finishing nails are good). If you don't have nails, you can use a sharp pencil to punch different size holes in the bottoms of the cups.

Wide Streams, Narrow Streams

Does the width of the stream affect the beading? Use the nails or pencil to punch two holes, one about 1/16 inch in diameter and the other about 1/8 inch, side-by-side in the bottom of a cup *(see diagram)*. Then compare the two streams of water as they flow from the cup. Do the narrow

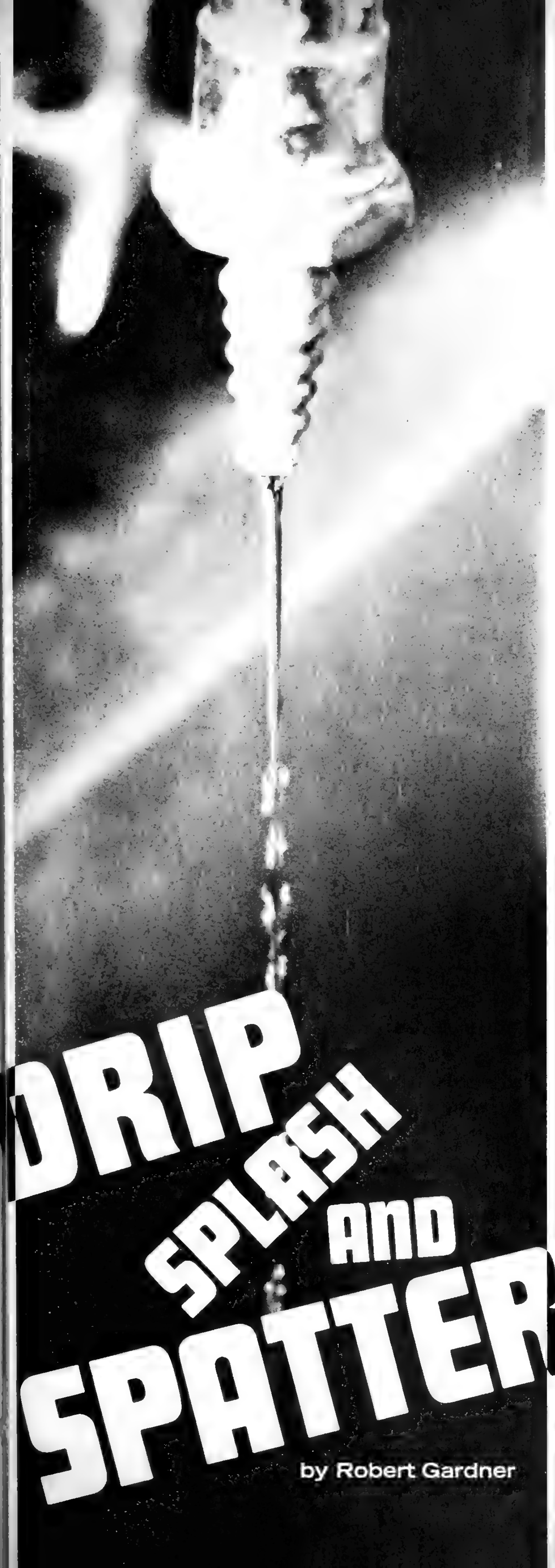


If possible, punch the holes from the inside out so the jagged edges will not block water from entering the holes.

stream and the wider stream bead at the same distance from the cup? Which stream has the longer unbeaded part?

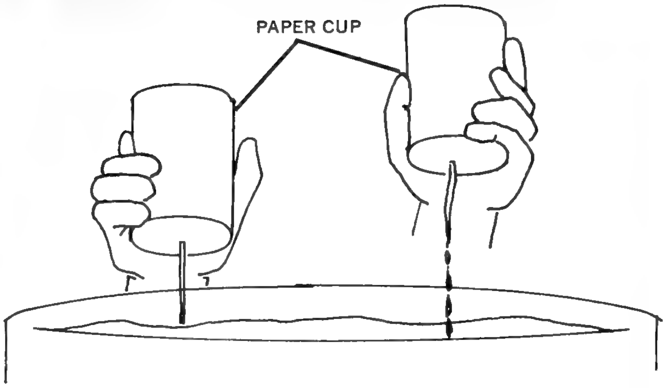
What happens to the beading point as the water level in the cup gets lower? Does one stream stop flowing before the other? If you punched a medium-sized hole in the cup, can you guess about how far from the cup the water coming out that hole would bead? Try it and check your prediction.

Punch a single hole in the bottom of a cup and let a stream of water fall into a bucket or glass of water *(see diagram)*. Listen to the sound when the unbeaded or "solid" part of the stream is entering the water. Now raise the cup and listen as the beaded portion of the stream strikes the water surface. How do the sounds compare? Can you explain why one part of the stream makes more noise than the other when it hits the water surface? Close



DRIP SPLASH AND SPATTER

by Robert Gardner



your eyes and raise the cup slowly from the surface of the water in the bucket. Can you tell by the sound when the stream of water from the cup begins to bead?

Spattering Streams

If you let the beaded part of a water stream fall straight down on the flat top of a tin can, can you guess in what directions the drops would go after they hit the can? Try it and see. Does the "spatter pattern" change when you lower the cup so that the unbeaded part of the stream is hitting the can? Lay the can on its side and see the drops spatter when the beaded stream falls on the curved side of the can. Where does most of the water go? Will the spatter pattern change if you use a drinking glass instead of a metal can?

What does the spatter pattern look like if you let the water fall on something that is curved in all directions, such as a ball, instead of on a flat or cylinder-shaped object?

From your findings in these investigations, can you think of at least two ways to quiet a dripping faucet when you can't stop the leak? ■

MORE INVESTIGATIONS

- Do all liquids bead the same way? To find out, punch holes of the same size in two cups, fill them with different liquids, and hold them side-by-side. How does the beading point of soapy water compare with that of plain water? How about alcohol? Salt water? Cooking oil? Syrup?
- Punch two holes in the bottom of a cup so that the centers of the holes are about 1/4 to 3/8 of an inch apart. When the cup is filled, and water is flowing out the holes, can you use your fingers to get the two streams to join? If you succeed, can you get them apart again? How far apart do the streams have to be before you cannot get them to unite? Is your ability to join the streams affected by the width (diameter) of the streams?
- Will a stream that is flowing upward bead also? Do the streams in fountains bead? Can you build a device that will enable you to try these "upside-down" beading experiments; that is, with streams that are flowing upward rather than downward?

MAN THE MEASURER

PART ONE

■ How long is an inch? If you didn't have a ruler and had to show someone how long an inch is, you could probably come pretty close by breaking a twig to about the right length. But you might think twice before using your twig-inch to measure a line in a math test.

Another way to show *about* how long an inch is would be to bend your thumb. The distance from the tip to the knuckle is very nearly an inch. The distance across the widest part of an adult's thumb is even closer to one inch.

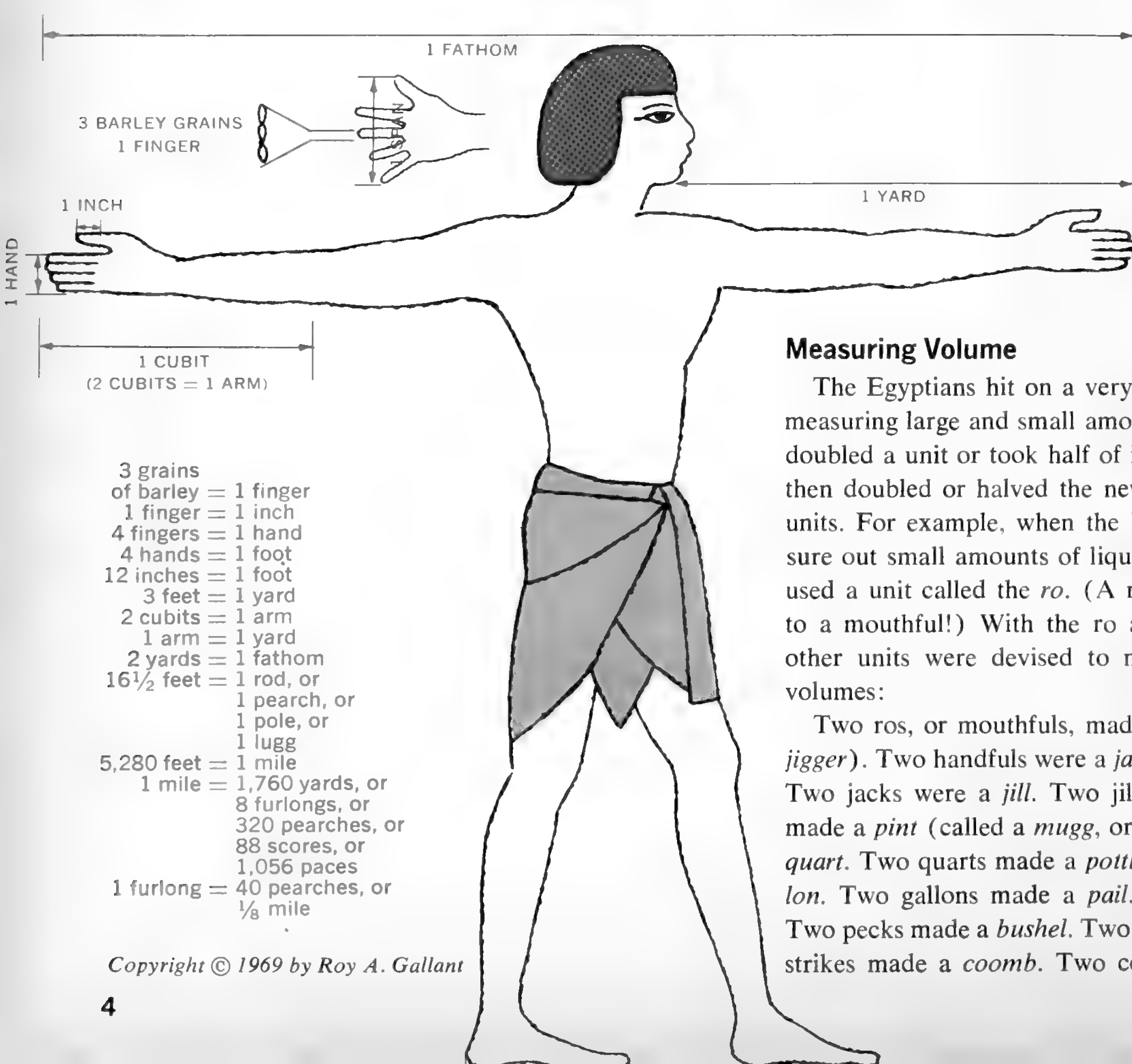
Measuring Distance

Many of our units of measure were invented by the Egyptians several thousands of years ago, and were based on different parts of the human body. As the diagram shows, the *foot* unit was the length of an adult human foot. Three grains of barley placed end-to-end made one *finger,* or digit. Four digits equalled one *hand*—the unit still used to measure the height of horses. We say that a horse is 17 hands high, for example.

The distance from the end of the middle fingertip to the elbow was one *cubit*. Two cubits equaled one *arm,* and one arm, measured from the fingertips to the chin, was one *yard.* And two arms (or yards) made one *fathom,* a unit still used by seamen to measure depths in the ocean.

Those units worked well enough for short distance, but not for longer ones, such as the length of a field or the distance between two villages. The ancient Egyptians used a larger unit called the *pace* for these measurements. It was equal to two regular steps, and was measured from the heel of one foot to the toe of the same foot on touching the ground again.

One hundred paces equaled 200 yards, which the Egyptians called a *stade.* Later, the Greeks used the stade as an official unit of distance for the Olympic foot races. That is why the place where the foot races were held came to be called a *stadium.* Still later, the Romans adopted the stade from the Greeks. Ten stadia in Roman times became one *mile.*



3 grains of barley = 1 finger
1 finger = 1 inch
4 fingers = 1 hand
4 hands = 1 foot
12 inches = 1 foot
3 feet = 1 yard
2 cubits = 1 arm
1 arm = 1 yard
2 yards = 1 fathom
$16\frac{1}{2}$ feet = 1 rod, or 1 pearch, or 1 pole, or 1 lugg
5,280 feet = 1 mile
1 mile = 1,760 yards, or 8 furlongs, or 320 pearches, or 88 scores, or 1,056 paces
1 furlong = 40 pearches, or $\frac{1}{8}$ mile

Measuring Volume

The Egyptians hit on a very simple and useful way of measuring large and small amounts of things. They either doubled a unit or took half of it to make a new unit, and then doubled or halved the new unit to make other new units. For example, when the Egyptians wanted to measure out small amounts of liquids, grain, and so on, they used a unit called the *ro.* (A ro of something was equal to a mouthful!) With the ro as a base unit of volume, other units were devised to measure larger and larger volumes:

Two ros, or mouthfuls, made a *handful* (also called a *jigger*). Two handfuls were a *jack* (also called a *jackpot*). Two jacks were a *jill.* Two jills made a *cup.* Two cups made a *pint* (called a *mugg*, or a *jug*). Two pints made a *quart.* Two quarts made a *pottle.* Two pottles were a *gallon.* Two gallons made a *pail.* Two pails made a *peck.* Two pecks made a *bushel.* Two bushels were a *strike.* Two strikes made a *coomb.* Two coombs made a *cask.* Two casks were a *barrel.* Two barrels made a *hogshead.* Two hogsheads made a *pipe,* and two pipes made a *tun.*

Need for a Standard ... *any* Standard

It's easy to see what's wrong with using feet, arms, hands, and fingers as units of measure. If my hand is wider than yours and each of us used his own hand to measure the height of a horse, then each of us would be right—but we would not agree on how high the horse is! Or if you wanted to buy a field that would be 200 paces long on

each side, you might get more or less land depending on whether a man with long legs or a man with short legs paced off the field.

If there are only a few people and lots of fields, the difference of a few feet or a few yards might not be very important. But in a town or city, where there are lots of people all wanting enough space to live in, a difference in a few feet or a few yards can become very important.

The ancient Egyptians knew the importance of agreeing on a *standard* length for a pace, or standard units of volume and weight. But whose arm or hand or foot would be the standard? It was simple. That of the king or queen then in power would become the official standard—but then they would have to change the standard when a new king or queen came to power! The next one surely would have a longer or shorter foot. And so it went, for centuries.

The ease with which standard measuring units could be changed caused many problems. Some may seem amusing to us now, but they were not very amusing to the poor. Here is one such instance.

Under King Charles I, poor people among the English had to pay a sales tax on every jackpot of food they bought. (The jackpot, remember, is two handfuls.) The king was a reckless spender, though, and to get more money without raising taxes, he simply made the size of

the jackpot smaller. This amounted to the same thing as raising taxes, of course, and the people were not fooled.

The poor people were angry over the trick tax move, and soon the jackpot—and the jill along with it—just about went out of use as units of measure. The people made up a rhyming joke about the king's attempt to trick them: *Jack and Jill went up the hill to fetch a pail of water; Jack fell down and broke his crown, and Jill came tumbling after.* (The "crown" in the rhyme refers to the king, and Jack and Jill are the "fallen" units of measure.)

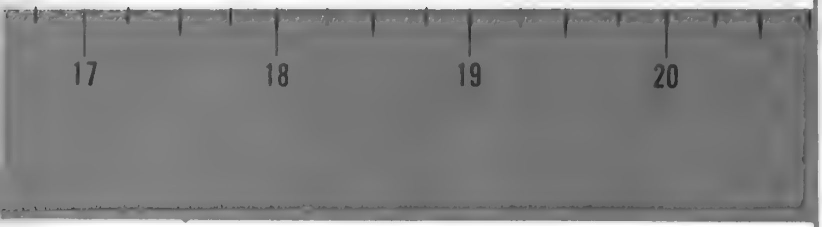
Before the English made their units standard, many of the units had been different from one place in England to another. This made it easy for a person to be cheated by a tradesman. When a housewife bought something, she wanted a "full measure." But a "full measure" in one shop might not be the same as the "full measure" in another.

The English finally agreed to a standard length for the yard unit by deciding to use the length of the arm of Queen Elizabeth I from her time on. By the year 1592, the English units of measure for length, volume, and weight had been made standard.

Enter, the Metric System

The French, too, were giving their units of measure a

(Continued on the next page)



standard, but in a much better way than the English were going about it. While the English clung to their old units based on parts of the body, the French invented new units. Their basic unit was a unit of length called the *meter*. The meter was also used as a base unit to work out units of volume and weight.

In the 1700s, the French measured the curvature of the earth's surface at different places and figured out the distance from the North Pole to the Equator. They agreed to call one ten-millionth of this distance one *meter* (which is equal to 39.37 inches). Later, they made a master meter-stick by marking this distance on a bar made of two metals—platinum and iridium. This bar is kept at the same temperature so it will not be likely to expand or shrink.

In the early 1900s, the distance from the Poles to the Equator was measured more accurately than it had been measured two centuries earlier. The new measurements showed that the distance marked on the master meter-stick was not exactly one ten-millionth of the Pole-Equator distance. There was no need to change the length of the meter unit, though, because it does not really matter whether it is exactly one ten-millionth of the Pole-Equator distance. What does matter is that everyone *agrees* that the length of a meter is exactly the same as the distance marked on the platinum-iridium bar. And that is what a *standard* is. It is something that everyone agrees to.

Once the length of the meter was agreed to, other units of length could be based on it. For measuring longer distances, for example, there are the *decameter* (10 meters long), the *hectometer* (100 meters), and the *kilometer* (1,000 meters). One kilometer (pronounced kil-LOM-et-er) is just over six-tenths of a mile.

For measuring shorter distances, there are the *decimeter* (1/10th of a meter), the *centimeter* (1/100th of a meter), and the *millimeter* (1/1,000th of a meter). One centimeter is just about four-tenths of an inch.

This system of measuring, called the *metric* system, is now used through most of the world. Once you are familiar with it, it is much easier to use than our clumsy English system. Britain and the United States are the only two major nations left that still use a system based on the length of the arm of Queen Elizabeth I! ■

The next article in this series of three will describe some of the many different kinds of things that man measures—from the sizes of atoms to the distances between galaxies.

The silhouette above represents one scientist's idea of what *Chirotherium* may have looked like.

■ For many years, people in Europe had been puzzled by hand-like tracks found imprinted in rocks that were removed from quarries. The tracks looked as if they had been made by giant hands—with four fingers, and a big "thumb" sticking off to one side. All five were tipped with large claws.

One strange thing about the prints was that the thumb-print was always on the *outside*. Handprints of a human or an ape would have the thumb on the inside. Also, the fossil prints were clear enough to show that the creatures that had made them had scaly skin on their feet.

After studying the prints for some time, *paleontologists* (scientists who study the ancient life of the earth) decided that the tracks had been left millions of years before by some kind of reptile whose feet were formed much like hands. They also decided that the "thumbs" had not been thumbs at all, but had been toe-like props for the feet. Scientists named the track-maker *Chirotherium,* which means "hand animal."

For a long time that was all anyone knew about *Chirotherium*—it was a reptile that had lived about 200 million years ago in Europe. Then, about 1935, a new *Chirotherium* clue was discovered in the United States.

Reptile Tracks on the Wall

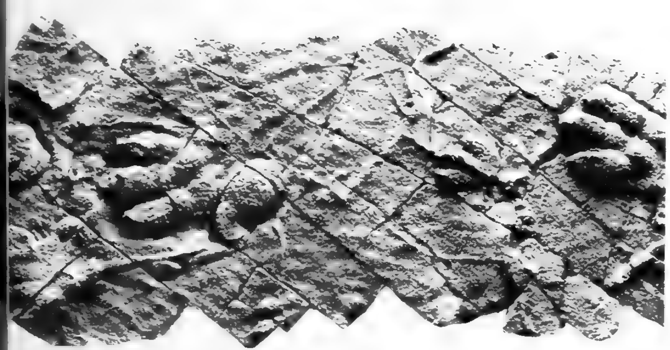
A man named Hubert Richardson of Cameron, Arizona, was building a hotel there as a stopping place for tourists on their way to the Grand Canyon. He used sandstone slabs in some of the construction.

The rock slabs had been formed from a layer of sand laid down millions of years earlier. As the sand had

The Mysterious "Hand Animals"

Scientists have studied fossils of hand-like tracks to learn something about the ancient reptiles that made them. But no fossil bones have been found, and the life of the "hand animals" remains a mystery.

by Iona Seibert Hiser



This fossil trackway, found in Arizona, shows prints left by *Chirotherium* as it moved from right to left.

:hanged into solid rock, some markings on the sand surface ıad been preserved as fossils.

While building his hotel, Mr. Richardson was surprised o find hand-like tracks on the underside of some of the andstone slabs. He thought the prints were so interesting hat he used them as decorations in the fireplace wall of he hotel.

Some time later, Major L. F. Brady of the Museum of Northern Arizona visited the hotel and saw the fireplace lecorations. He was surprised and excited because he new they were like the *Chirotherium* tracks found in Europe about a century before.

After close study by paleontologists, the tracks in Hubert Richardson's wall proved to be *Chirotherium* footprints. This discovery led to a search in northern Arizona for nore "hand animal" tracks. Major Brady and Dr. Edwin D. McKee—who was then Chief Naturalist at Grand Canyon National Park—discovered a fossil "trackway" showing three prints in a row left by a *Chirotherium (see photo)*. They also found many single footprints in the rocks.

Dr. Frank E. Peabody, a paleontologist at the University of California Museum, in Los Angeles, became interested in the *Chirotherium* footprints and made a study of them.

How Much Can You Learn from Tracks?

He found there had been at least eight kinds *(species)* of the "hand animals" in what is now the southwestern United States. Some that had left small prints probably had been only as large as a cat. Other tracks were quite big—over a foot long. But with no other remains, such as fossil bones, to judge by, Dr. Peabody and other paleontologists could not make any estimates of the actual size of the reptiles that made the biggest tracks.

Since many of the footprints plainly showed sharp claws, the scientists suspected that the reptiles had been meat-eaters. But the "fingers" on some of the mysterious tracks lacked claw marks and were blunt. This led Dr. Peabody to believe there may also have been some plant-eating species of *Chirotherium*. Dr. Peabody also found marks in the rocks that made it seem as if the animals had long tails that had dragged on the ground.

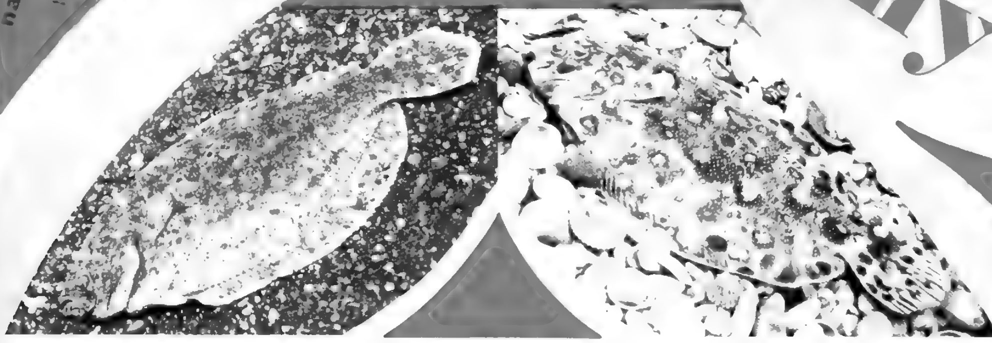
Since prints of both front and hind feet were preserved as fossils, scientists believe that *Chirotherium* walked on all fours. And the age of the rocks in which *Chirotherium* tracks are found tells us that these reptiles lived before the dinosaurs. In fact, the "hand animals" were probably part of a group of early reptiles from which dinosaurs evolved.

Beyond that, the many "hand animals" that lived 200 million years ago in Europe and North America remain a mystery. But the search for clues to ancient life goes on. Perhaps some fossil bones or a complete skeleton of *Chirotherium* will be found. Bit by bit, paleontologists may be able to picture the life of the mysterious "hand animals" ■

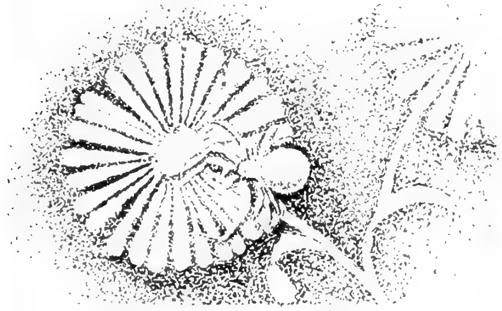
nature and science WALL CHART 1969

To Hide

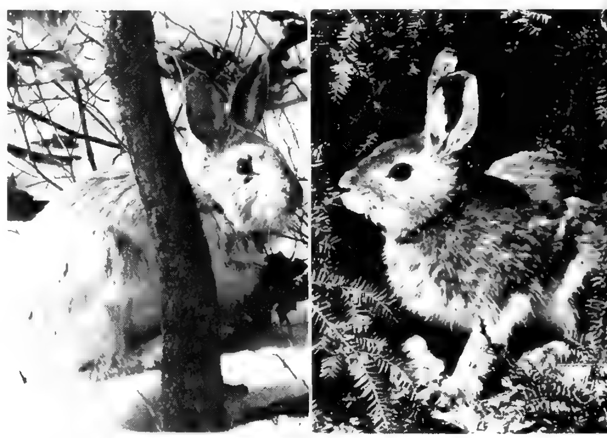
Why Animals



Many animals have colors that match their surroundings. But some, such as chameleons, can conceal themselves in *new* surroundings by *changing*—in a few minutes—to match the new background. These photos of models at The American Museum of Natural History, in New York City, show how a southern flounder changes to match different backgrounds on the ocean floor where it lives. The change takes a few seconds to a half-hour, depending on the background pattern.



Some insects, spiders, and other animals can slowly change their colors after their surroundings have changed. Crab spiders, for example, hide on flowers and catch insects that come to the flowers. In places where white flowers are common in early summer, the crab spiders on the flowers are white. Later, when yellow flowers are more common, cells in the spiders' bodies make a yellow substance and the animals turn yellow. The change takes from one to three weeks.



In places with cold, snowy winters, some birds and mammals, such as this snowshoe hare, are white in winter and dark during the rest of the year. Twice a year, a snowshoe hare grows a new coat of hair while shedding its old one. The colors help conceal the hare from animals that hunt it.

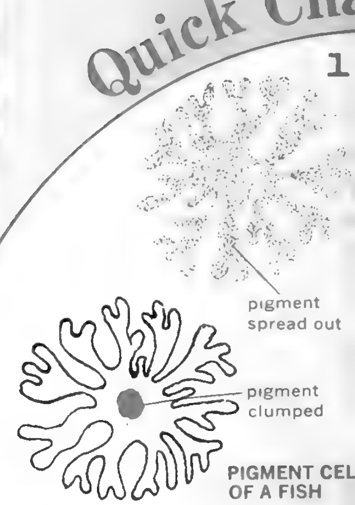
Young birds and mammals, such as this fawn of a white-tailed deer, are often spotted with white. When fawns lie on the forest floor in summer, their spots probably help conceal them from other animals. When they are older, their coats are mainly one color and help hide them as they stand or lie among bushes or trees, especially in fall and winter.

■ In less than a second,
black. In a day or so,
from green or violet to
reddish-brown weasel
then back again to br
cover show quick color
animals can change c
slowly.

Color changes help
produce. Many of the c
or keep them from bein
animals *more* easily see
nals or mating signals
some of the ways in w
and the captions tell h
to the animals. —SUSA

Quick Cha

1



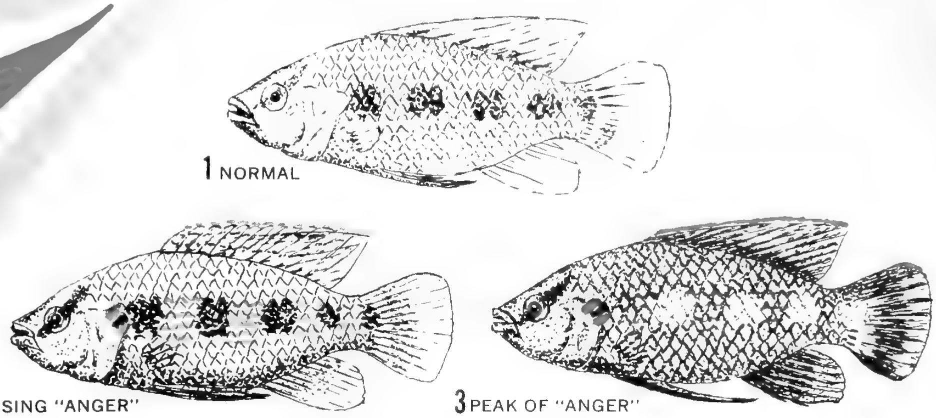
Quick changes of c
place in fishes, shri
due to special cells
bits of the color (*pig*
an entire cell (*see D*
ened with that color.
pigment are clumped
appears light-colore
change color quickly
muscles changing t
cells (*see Diagram 2*)

Change Color

To Be Seen

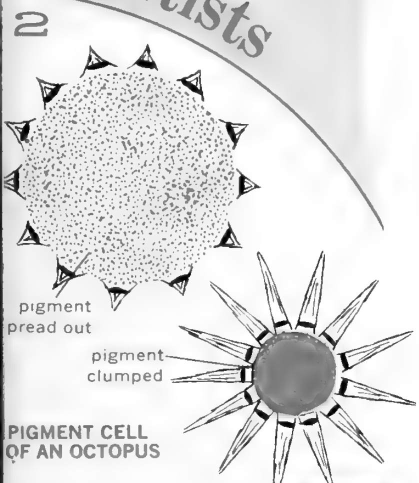
**ale fish may become jet
ung shrimp can change
nge. During one year, a
turn ermine-white, and
. The drawings on the
ges in an octopus. Many
—some quickly—some**

**mals to survive and re-
ges *camouflage* animals,
en. Other changes make
nd may be warning sig-
is WALL CHART shows
animals change color,
hese changes are useful
WERNERT**

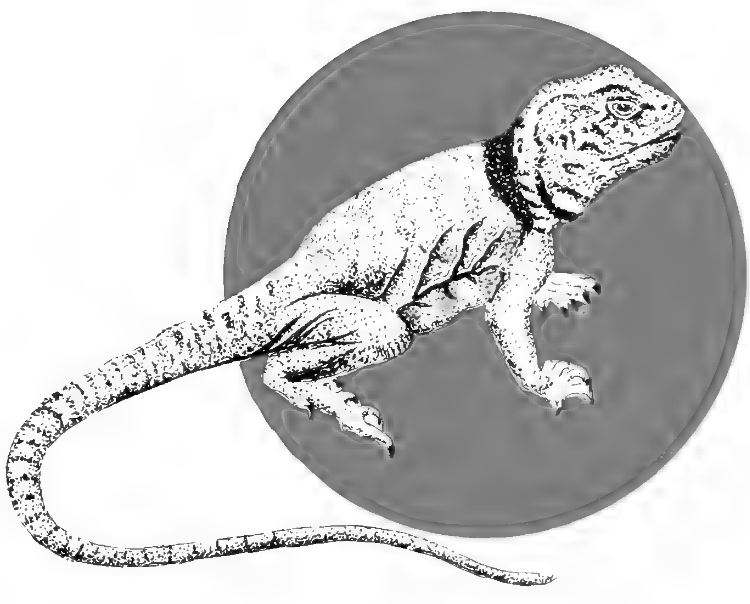


An animal ready to fight sometimes changes its color or pattern in seconds. Usually, the change makes the animal more easily seen. The new color may make the animal look more frightening, or it may warn another animal that it is ready to fight. The drawings show a small freshwater fish, a *cichlid*. The male is normally pale in color, with some spots of red and black (I). Its color changes quickly as the fish gets more and more excited (2 and 3).

ge Artists



and pattern that take
and chameleons are
eir skins. When tiny
t) are spread through
m 1), the cell is dark-
when the particles of
o a tiny spot, the cell
Octopus and squid
nother way, with tiny
hape of the pigment



Just before or during their mating season, many animals slowly change to a brighter color or pattern. Usually, it is the male that changes. The new color attracts a female to a male. It may also tell other males that he has chosen his breeding or nesting site and will fight to keep it. The drawing shows a *female* collared lizard. From the time she mates until she lays her eggs, she will not mate again. The bright red spots that develop during this time may be a signal to males that the female has already mated. Then males may look for females without red spots. This helps ensure that all females will mate and have young.

WHAT'S NEW

by
B. J. Menges

An old torn-down bridge has provided scientists with what may be parts of a dinosaur skeleton that they have been seeking for 85 years. In 1884, fossil bones of the rear half of a small dinosaur were discovered in some rocks in a quarry near Manchester, Connecticut. No remains of this kind of dinosaur had ever been found before. But by the time scientists realized the importance of the find and looked for the rest of the skeleton, nearby blocks of stone had been removed and used in one of 60 local bridges. No one knew which bridge.

Recently, Dr. John H. Ostrom of Yale University, in New Haven, Connecticut, followed up all possible clues and concluded that the bones were probably in the rock of one particular bridge. When he heard that the bridge was being torn down to make way for a new highway, he and fellow scientists arranged to beat the scene with hammers and chisels. Sure enough, they found some fossil bones, and are now checking to see whether the bones match those found 85 years ago.

Beach carpets may be used next summer to cover weedy bottoms of swimming areas in lakes and ponds. The "carpets" are made of plastic sheeting that is heavier than water and that blocks light. The sheeting lies on the lake floor and keeps sunlight from reaching the weeds. Like other green plants, the weeds need sunlight to make their food. Without sunlight, no food is made; and without food, the weeds wither and die.

Beach carpets have two advantages over chemical weed killers, according to Leroy A. Bushay, of Fridley, Minnesota, the scientist who developed them. The carpets can be put exactly where they are needed, and they will not harm fish or other water animals. What effects the weed-killing will have on animals that eat or live among the weeds remains to be seen, however.

Poisonous snakes are no match for some caterpillars. In New Jersey's Stokes State Forest last summer, caterpillars of the gypsy moth seemed to have forced deadly rattlesnakes and copperheads to leave their homes. Early in the summer, these brown, hairy caterpillars with red and blue dots hatched from eggs in record numbers. Munching on leaves, they soon stripped trees bare over a large area. The cool, moist woodlands where rattlers and copperheads had lived among rocky ledges were now exposed to direct sunlight, and became hot and dry. So the snakes moved to shady parts of the forest, apparently forced from their homes by the caterpillars.

Letting forest fires burn may help forests if the fires are small and are carefully controlled, say some forest experts. They believe it's a mistake to try to prevent *all* forest fires. Their theory can be summarized as follows:

Without fire prevention by man, small fires started by lightning sweep through forests regularly. These small blazes burn up underbrush and leaf litter without damaging large trees. But when foresters prevent or put out these small, regular fires, underbrush and leaf litter accumulate. In a forest loaded with this excess fuel, the fire hazard increases. And when a fire does start, it may burn so wildly that it destroys the whole forest.

Garbage power may help solve two problems of our modern age: 1) how to get rid of garbage and other rubbish; and 2) how to get enough fuel to meet our growing needs for heat and power. An incinerator plant now being built in London, England, will burn over 1,300 tons of rubbish a day, producing heat or electricity for part of the city. The plant will cost more to build than an ordinary incinerator plant, but it will be producing valuable heat or power. Such a plant might work even better in the United States. Our rubbish contains more highly-burnable materials, so a pound of our rubbish would produce more heat than a pound of British rubbish.

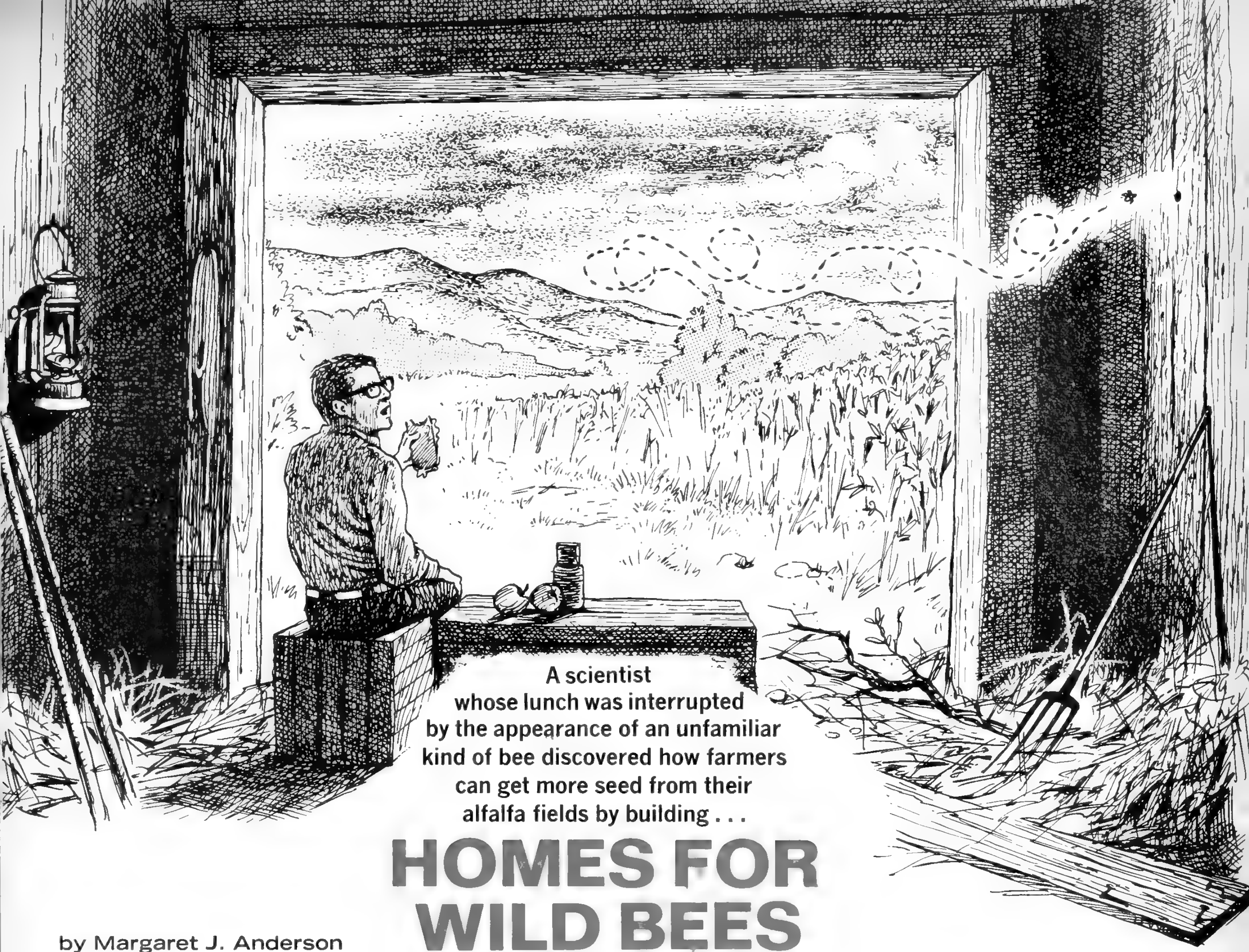
Swooping out of the night, the vampire bat sinks its teeth into a victim and laps up some blood. This is a nightly happening in many parts of Central and South America. The victims are usually cattle, but sometimes sleeping people.

The vampire's bite is harmless in itself, but some bats carry rabies and their bites spread the disease. Rabies can be prevented if the victim is given vaccine immediately. But if no vaccine is given and the disease takes hold, there is no cure,

and the victim dies. That's why an international team of scientists, working through the United Nations, is now studying vampire bats in an effort to find ways to control them and the disease they carry.

Outdoor air conditioners, known more familiarly as plants, should be enlisted in the fight against air pollution. So says G. O. Robinette, a landscape architect at the University of Wisconsin, in Madison. Plants filter and improve the air in somewhat the same way as man-made air conditioners, he claims in the University's *Science Report.* He suggests the use of more plantings in places where air pollution is worst.

Plants give off oxygen, thus diluting "poor" air with "good" air. They also remove dust and other particles from air by trapping them in the tiny hairs and moisture on the surfaces of leaves. Rain then washes the particles to the ground. Trees block air movement, and in wooded areas particles settle out of the still air by their own weight. Some plants even act as deodorants, filling the air with such pleasant fragrances as those of honeysuckle, jasmine, and lilac.



A scientist whose lunch was interrupted by the appearance of an unfamiliar kind of bee discovered how farmers can get more seed from their alfalfa fields by building . . .

HOMES FOR WILD BEES

by Margaret J. Anderson

■ Dr. William P. Stephen was eating his lunch in an abandoned barn near an alfalfa field when a small bee flew in. Before the bee disappeared into a nailhole in the wall, Dr. Stephen noticed that it was carrying a small, round piece of leaf.

Most of us would have gone on with our lunch, and the bee would have gone on with its business, and that would have been that. But Dr. Stephen is an *entomologist* (a scientist who studies insects) at Oregon State University, in Corvallis, and bees are his special interest.

This bee was of a kind *(species)* that he did not recognize. As he watched, another bee of the same species flew into the barn and went into another hole in the wood. Dr. Stephen wondered whether by drilling a few more holes he could attract more bees. By the end of the summer he had the wall riddled with holes and buzzing with bees.

Putting Wild Bees To Work

Dr. Stephen was concerned with something more than just providing a "housing development" for homeless bees. He is particularly interested in the part bees play in growing alfalfa—a kind of plant that cattle and horses eat all year around. As a bee collects nectar from an alfalfa flower, grains of *pollen* from the flower stick to the insect's hairy body. At the next alfalfa flower, some of the pollen rubs off the bee onto the *pistil* of the second flower, making it possible for the flower to produce seeds. (This process is called *pollination.*)

The pollen in the flowers of alfalfa is hard to reach, and only a few species of wild bees visit them. The farmers were getting poor seed crops because there weren't enough bees to do the job of pollinating. And things were getting worse because chemicals used to control pest insects were killing the wild bees.

Honey bees do not pollinate alfalfa, or the farmers could set beehives out in the fields. But Dr. Stephen hoped to find a wild bee that could be "domesticated" like the honey bee. He needed a species that didn't mind being crowded, that would live in an artificial home, and that preferred alfalfa to other flowers.

The scientist had already found a possible answer in the

(Continued on the next page)

Alkali bees follow a definite flight route between their nests and an alfalfa field. Where the route crosses a highway, a sign helps protect the bees from speeding cars.

Homes for Wild Bees (continued)

alkali bee. The females of this species burrow into the soil and lay each egg amid a mixture of nectar and pollen that serves as food for the *larva* when the egg hatches.

These bees are only found where the soil is just *alkaline*, or "salty," enough for them, and large numbers will crowd together in such areas. Each female, however, has her own burrow and is independent of the other bees in the area. (Bees that live this way are called *solitary* bees, while bees that live and work together in a nest, or *hive*, are called *social* bees.)

It seemed to Dr. Stephen that a good way to increase the populations of alkali bees would be to make artificial "bee beds" close to the alfalfa fields. By copying the soil conditions found in natural bee beds he was able to build up thriving colonies of alkali bees.

The alfalfa growers found that the artificial bee beds made their fields produce more seed, and the beds were soon in common use. But the beds couldn't be used everywhere, and Dr. Stephen kept on searching for other pollinators. He knew this could be a long search, because there are about 20,000 species of bees. The best place to start looking was in an alfalfa field. That is why Dr. Stephen forgot about his lunch when he saw a bee of an unfamiliar species.

Nests for Leafcutter Bees

He soon identified the insect as a *leafcutter* bee—a species that was fairly new to North America. It had been accidentally brought into the United States from Europe or Asia.

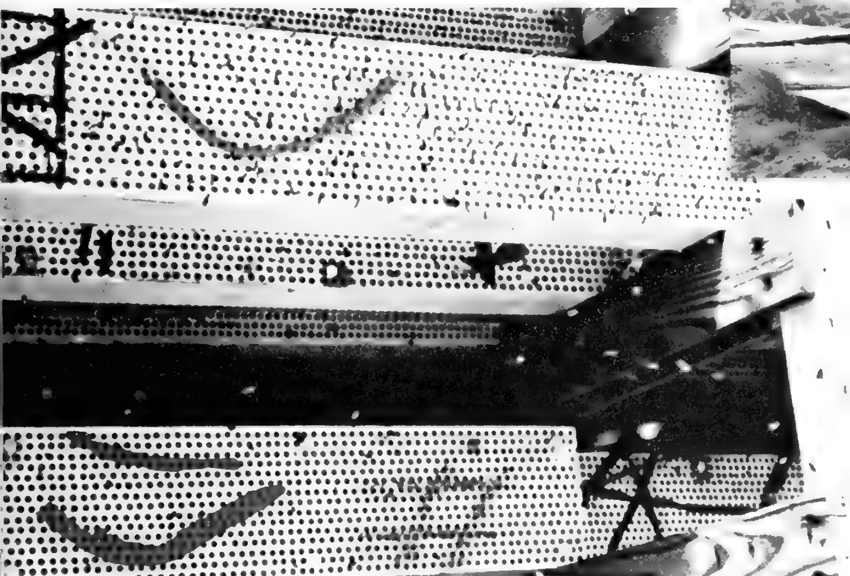
Like the female alkali bee, the female leafcutter nests in a burrow; but this bee chooses a ready-made hole, such as a nailhole or a hollow, dry, plant stem. When the female has found a suitable burrow, she forms a cell by lining the tube with overlapping pieces of leaf or petals cut from green plants. Then the cell is half filled with pollen and nectar, and a single egg is laid. The cell is capped with several round leaf cuttings (like the one carried by the first of these bees that Dr. Stephen saw). Another cell is started immediately on top of the first, until the burrow is full *(see photos)*.

Dr. Stephen was eager to see if he could get these bees to live in artificial nests. The holes the bees were using were about the size of drinking straws. Would they accept straws? He cut a carton of straws in half and glued the straws in place so they wouldn't fall out. The bees were quite happy with this arrangement. Each female bee had its own burrow and each was able to find her own entrance, even when faced with a choice of 250 straws.

Since the bees also nest in holes in wood, many farmers now nail drilled boards to posts around their alfalfa fields.

In these cut-open soda-straw nests you can see the larvae, one to a cell, hatched from eggs laid by leafcutter bees. The bee makes each cell of bits of leaf, and plugs the end of the straw with up to 130 circular cuttings.

This photo shows two adult leafcutter bees and the cells from which they came. Leafcutter bees will nest in both "school milk" straws and the larger "milkshake" straws, and the size of the straw determines the size of the bee.



This shelter at the edge of an alfalfa field contains many boards with holes drilled in them for leafcutter bees to nest in. The close-up view of these boards shows markings of different shapes and colors that guide a bee to the general area of its nest. Once the bee gets there, she can locate her own individual nesting hole.

The leafcutter bees do not fly very far from their nests, so distributing the nesting sites this way results in more uniform pollination.

Some farmers have made quite elaborate shelters. In high country, where the nights get cold, some put a heating coil in the roof of the shelter to keep the bees warm at night. The adult bees sleep in the burrows, and with "central heating" they get to work earlier in the morning!

Problems in Bee Apartments

Dr. Stephen discovered that if the nesting site is too big, a bee has trouble finding its own hole. On a fast trip, a bee can bring in a leaf cutting in 10 seconds or a load of pollen in less than five minutes. If there are too many holes,you'll see lots of activity around the nest, but these bees are just circling trying to find their own holes. Finally they get tired, settle on the boards, and drop their leaf cutting or load of pollen. Beneath such a nest you'll see a carpet of leaf cuttings.

The bee finds its own hole by recognizing "landmarks" around it. Since bees can see different colors, painting sections of the boards with contrasting colors helps the bees find their own holes *(see photo above)*.

So many bees crowded together make it easy for the bees' enemies to cause trouble. Fortunately this bee seems to have come into this country without any of its own parasites. But it is bothered by carpet beetles, earwigs, and ants. With good management, though, these pests don't become a serious problem.

The alfalfa growers are very happy to have become beekeepers. Their "domesticated" wild bees don't give them any honey, but they don't sting either! The most important thing is that by building homes for wild bees the farmers are getting six-to-10 times as much seed from their alfalfa crops ■

Dr. Stephen keeps milk cartons full of soda-straw bee nests in his laboratory refrigerator. You can see the plugged ends of the straw nests in the carton he holds.

HOW DOES YOUR BEANSTALK GROW?

You can find out quickly by marking the stems of some bean plants and watching to see what happens to the marks.

by Nancy M. Thornton

■ Your body grows taller as your legs, neck, and other parts become bigger and longer. Do you suppose that plants grow the same way? Or do certain parts of a plant's stem grow more than others?

You can easily investigate this question, and you don't have to wait long to discover an answer. You can find out in two weeks by using a fast-growing plant, like the bean.

Use any kind of bean that you can buy in a hardware or garden store. (The beans you buy won't grow as fast as the ones Jack got in trade for his cow.) You can also use a kind of baking bean, like the red kidney or pinto. You can buy these at a grocery store. Your mother may already have some. They must be uncooked though, not canned.

Getting Your Beanstalk Started

Soak the beans in water overnight. Plant about 10-12 in a pot or other container that is at least six inches deep. A cut-off half-gallon milk carton works very well. Fill the pot up to two inches from the top with soil. Spread the seeds over the soil, then cover them with about a half-inch of soil. Sprinkle the soil with water each day, keeping the top moist.

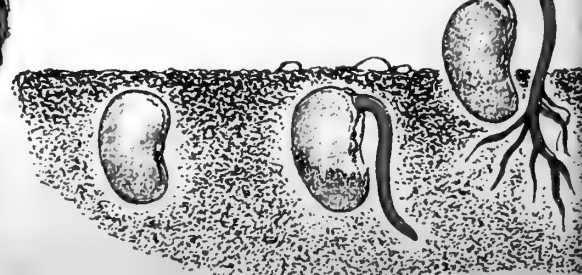
The beans are planted at a shallow depth so that they will come aboveground fast. They should show above the soil in less than a week if you keep the pot in a warm place.

For this investigation, you will get long growth fastest if you keep the plants away from windows and other sources of strong light. Can you suggest a reason for this?

Your plants will first appear as stem loops *(see diagram)*. The leaves are pulled out of the soil as the stem loop grows. The first leaves that you see are called *cotyledons*. Another name for them is *seed leaves*. They make up the two halves of the original bean seed. The cotyledons contain stored food—in the form of *starch*—that is used during the early growth of the young plant. Tucked between the cotyledons are the bean plant's first true leaves.

As soon as your bean plants have become straight, you can start your investigation. Use a waterproof marking

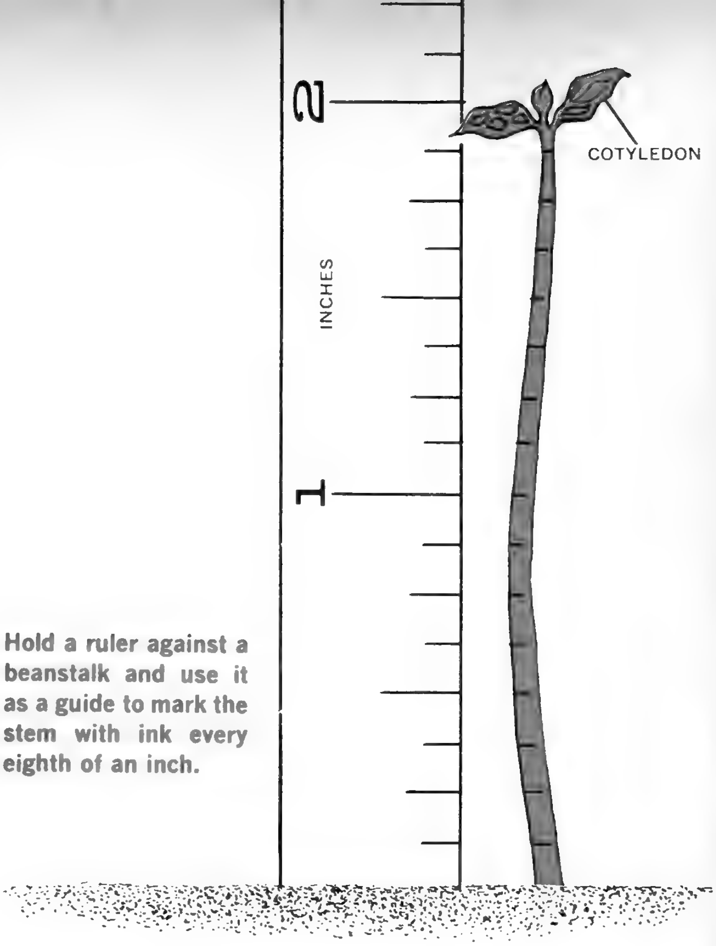
These drawings show several stages as a bean seed sprouts and grows into a young plant.



> **A PUZZLER**
>
> A farmer nails a wire fence to a row of young trees. Years pass and the trees grow several feet higher. Does the fence rise too?

pen (not a ballpoint). Have a friend hold a ruler against each bean stem, and use it as a guide to mark lines about every eighth of an inch along the stem *(see diagram)*. Start your marks at the soil level and go up to the cotyledons.

Another way to mark the stems is to touch the teeth of a comb to a stamp pad and then to the plant. This way you will be sure that the ink marks are evenly spaced.



Hold a ruler against a beanstalk and use it as a guide to mark the stem with ink every eighth of an inch.

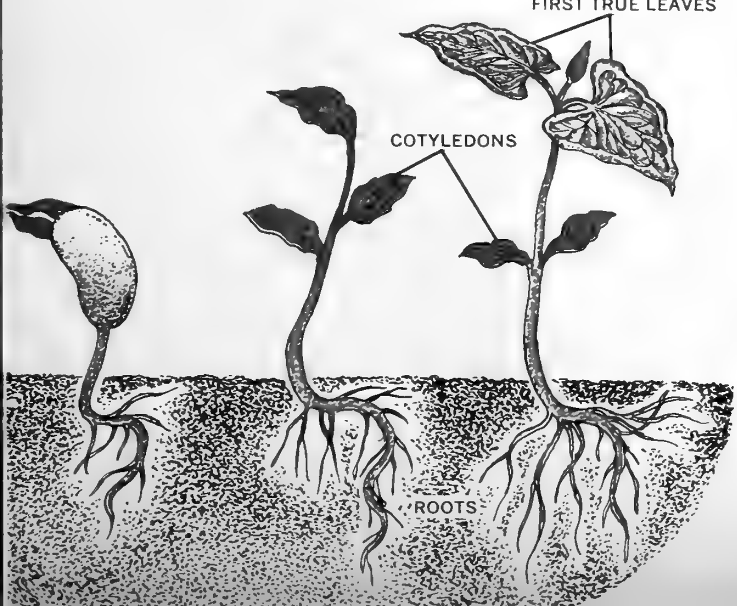
Check Your Marks

Check your marks on the stems after 12 to 24 hours. Compare them with the markings on the ruler (or with the teeth of the comb if you marked the stem that way). Have the stem marks spread apart? If they have, then growth has taken place. Keep records of your findings for each of the plants, so that you can compare them later.

Check again the next day. Are the marks spreading evenly? Is there any area where the marks are spreading farther apart than in other areas? If they are spreading more in one area than in others, then growth is more rapid there.

Check the stem marks for at least four more days. Do they continue to spread apart? If so, by how much? Measure the spaces between marks each time you check the beans. Is the growth speeding up, slowing down, or staying the same?

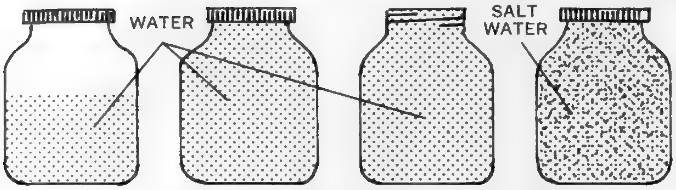
You may want to keep marking new parts of the stem as they appear above the cotyledons. Do they grow as rapidly as the parts below the cotyledons? ■



> **INVESTIGATIONS**
>
> • Do all plant parts grow in the same way? You can study root growth by presoaking bean seeds and then placing them between five or six layers of moist paper towels. Cover the towels with plastic wrap to keep them from drying out. Uncover the beans each day to check on their growth. As soon as roots appear, mark and check them daily, as you did the stems.
>
> • Do bean cotyledons change in size as growth takes place? Observe their appearance as the rest of the plant grows.
>
> • How does the amount of water affect the growth of young bean plants? This time plant two pots of seeds. Have the soil barely moist. As soon as stem loops appear, stop watering one pot. Continue watering the other. Mark the stems and check daily (for at least 10 days) for differences in growth between the plants in the two containers.
>
> You might do the same for warmth and coolness, light and shade. Start growth in pots under the same conditions. For warmth and coolness, put one pot outside if the weather is cool but not freezing. Place the other inside, next to a window. For light and shade, put one pot next to a window and the other nearby, but underneath a large cardboard box with a hole cut in the top of it. Give each pot the same amount of water. Compare the growth of the beans in the four different pots. Also, compare their growth with that of beans growing under "normal" conditions—midway between the conditions of warmth, coolness, light, and shade that you chose.

MYSTERY PHOTO

Why were the wires put through the tree?



WHAT WILL HAPPEN IF . . .

. . . you fill jars with water as shown and put them in a freezer? Which of the jars will be broken when the water freezes? *(If you try this, use small jars and set them in a baking pan to keep broken glass from falling in the freezer.)*

brain boosters

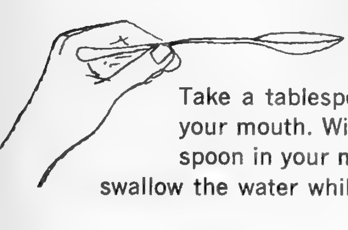
prepared by **DAVID WEBSTER**

FOR SCIENCE EXPERTS ONLY

Why are ice cubes sometimes made with a large hole through the center?

FUN WITH NUMBERS AND SHAPES

Suppose you have a lot of balls the same size. All of them are white except one, which is green. How many white balls can you make touch the green one at the same time?



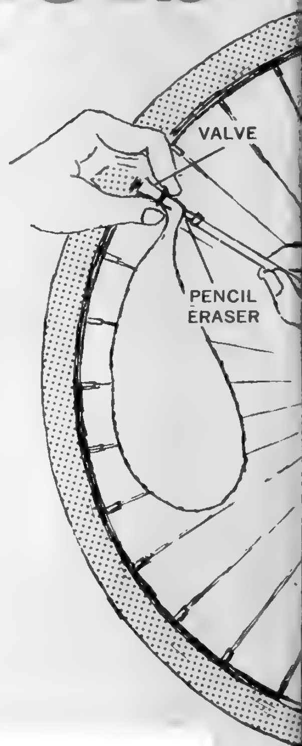
CAN YOU DO IT?

Take a tablespoon filled with water and put it into your mouth. Without swallowing the water, keep the spoon in your mouth on top of your tongue. Can you swallow the water while the spoon is still in your mouth?

Submitted by Pam Wilson, Ingleside, Illinois

JUST FOR FUN

How much air is there in a bike tire? Since the air in an inflated tire is squeezed together under pressure, it takes up a lot more space when released. You can use a balloon to measure the amount of space that the air in a bike tire would normally take up, since air in a balloon is not under much pressure. Hold the nozzle of the balloon tightly over the valve stem of a bike tire. Press the valve pin down by pushing on it through the balloon with the eraser end of a pencil. When the balloon gets big, tie off the nozzle. See how many balloons you can inflate with the air from a bicycle tire. How many balloons do you think could be filled from an automobile tire?



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The mystery tracks were made by a bicycle that was ridden through the puddle. Can you tell which track was made by the front tire?

What will happen if? If a glass of water at 100 degrees Fahrenheit is mixed with a glass of water at 40 degrees F., the temperature of the mixture will be about 70 degrees F. What temperature would you get by mixing a glass of water at 100 degrees F. with *two* glasses of water at 40 degrees F.?

Can you do it? One way to fill a glass with air while it is held under water is by using a straw. Turn the glass so it is upside down, and hold it just under the surface of the water. Place one end of the straw under the open end of the glass, and blow bubbles underwater so they rise inside the glass. The glass should soon become filled with "breath air." Can you figure out a way to fill the glass with plain "room air"?

Fun with numbers and shapes: A line of 1,000,000 nickels would be about 13 miles long.

For science experts only: To tell a hard-boiled egg from an uncooked egg, try to spin each egg on its narrow end. A hard-boiled egg will spin for a while like a top. What will an uncooked egg do?

nature and science
TEACHER'S EDITION

VOL. 7 NO. 6 / DECEMBER 1, 1969 / SECTION 1 OF TWO SECTIONS

THE IMPORTANCE OF MEASURING—Part 2

Our Quantified Views of the World

by Roy A. Gallant

■ Through our senses, we are continually "sizing up," or measuring, the objects and forces that make up our environment. Sometimes this is a conscious process; often it is an unconscious reaction to stimuli from outside or inside our bodies.

The amount of irritation a hay-fever victim feels is a measure of how much pollen there is in the air. Through our senses of taste and smell we measure certain qualities of the air and of things we put into our mouths. In both cases we assign the resulting sensation a place somewhere on a scale ranging from bitterness at one extreme to sweetness at the other.

How much we shiver on a winter day is a measure of our response to the temperature, motion, and water-vapor content of the air. Our responses to light vary with the length of its waves, which determines its color. One way we measure rate of change is by saying that such and such an amount of time has passed. You can probably think of many other ways in which we are continually responding to our immediate environment by quantifying it.

The Importance of Standard Units

Some of our measurement-responses are harder to evaluate than others. It is harder, for example, to describe to your doctor how much your bruised knee hurts than to describe to a carpenter the layout of a kitchen cabinet you want him to make; more difficult to evaluate your response to the "breath-taking" view of autumn leaf colors than to measure the height of the trees that are part of that view.

One of the reasons we formalize our sensory impressions by describing them in quantitative terms is to communicate those impressions in a meaningful way to other people. Once we all agree to certain standards of measure, we can describe certain things and events to other people with greater precision and objectivity, in terms that mean the same to them as to us. We can also record and store this information, knowing that it will still mean the same thing to us when we retrieve it for later use.

More "Mileage" from Measurements

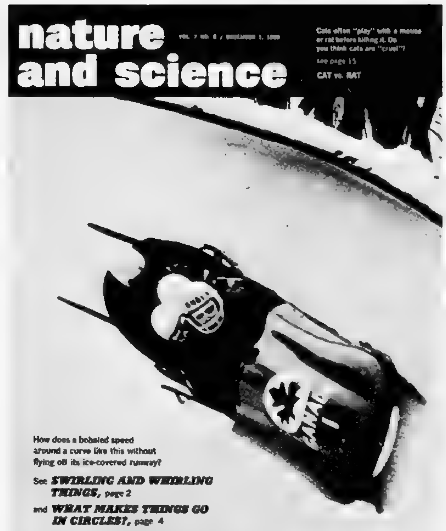
There are many ways we can manipulate, arrange, and record measurements to help us compare them, find "patterns" in them, and thus get more information from them.

Finding the ratio between two measurements is a handy way to compare their sizes. The ratio of the length of a ruler to the length of a yardstick is 12/36, or 1/3 (1:3 or 1 to 3; in decimal notation, .333 or 33-1/3 per cent).

The scale of 1:62,500 used on many government maps is the ratio of

(Continued on page 4T)

Roy A. Gallant is an editorial consultant to Nature and Science *and author of numerous science books and textbooks for children.*



IN THIS ISSUE

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

Swirling and Whirling Things
By swirling and whirling water, balls, buckets, and pennies, your pupils can get some clues to:

● **What Makes Things Go in Circles?**
They will discover that centrifugal "force" is merely a reaction to centripetal force—the force that moves things in curved paths.

● **Case of the Rampaging Reef-Wrecker**
Scientists are seeking ways to control coral-eating starfish, in order to preserve the Pacific's great coral . . .

Forests Beneath the Sea
This Wall Chart shows how coral animals produce reefs that grow, change, and provide a habitat for other animals and plants.

● **Man the Measurer—Part 2**
The second of three articles introduces a wide range of units for measuring length, and shows how to choose the best unit for each measuring job.

Cat vs. Rat
A scientist shows how a cat's seemingly "cruel" treatment of rats is simply an inherited behavior pattern that cannot be changed.

● **Brain-Boosters**

IN THE NEXT ISSUE

A biologist works harder than a beaver to find out how beavers work . . . Should we adopt the metric system of measurement? . . . Science Workshop investigations of growing plants in water and detecting when

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

What Makes Things Go in Circles?

After your pupils investigate "Swirling and Whirling Things" *(page 2)*, this article will help them distill from their findings these concepts: *1) To make a moving object follow a curved path, there must be a force pulling or pushing it toward the center of the curve. 2) The faster the object is moving, the more centripetal force is needed to keep it moving in a curved path. 3) Centrifugal "force" does not pull an object outward from the center of its curved path; it is merely a* reaction *to the centripetal force that is pulling the object toward the center.*

Your pupils may protest that they can *feel* their bodies being pulled against the outward side of a car when it rounds a curve. So they can. They can also feel a door knob "pulling back" when they pull on it, and a wall "pushing back" when they push on it. But the instant they stop pulling or pushing, the knob or wall stops "pulling" or "pushing" back. *(For investigations of action and reaction, see "The 'Law' of Pushing,"* N&S, *Feb. 5, 1968.)*

- *What supplies the centripetal force needed to make a car round a corner?* Friction between the tires and the road (unless the car is moving too fast or the road is ice-covered).
- *What supplies the centripetal force needed to make water or air swirl in a circular path?* Water in a spinning jar is pushed toward the center by the jar "wall"; the faster the water swirls, the farther it moves from the center of the jar. In the ocean, a stream, or a bathtub, moving water is pushed into a circular swirl by such things as rock formations, the end of the bathtub, or the side of the drainpipe. Fast-moving air is pushed into a circular swirl by friction between the air and the surface of the spinning earth *(see "How Do We Know the Earth Is Spinning?,"* N&S, *Oct. 13, 1969).*
- Things To Think About (page 6): The Equator is the part of the earth moving fastest in a circular path. Before the earth's crust hardened, this part pulled farther away from the earth's center than the slower-moving parts nearer the poles.

The gravitational pull between two objects decreases rapidly as the distance between them grows larger, so the centripetal pull of gravity is much less on a Telstar satellite than on a satellite orbiting only 100 miles from the earth. (The moon is more than 10 times as far from the earth as Telstar, so the pull between the earth and each pound of material in the moon is only about 1/100th as much as the pull between the earth and each pound of material in Telstar. But the moon is made up of so many pounds of material that the gravitational pull between them and the earth is enough to keep the moon circling the earth.)

The earth would have to spin much faster than it does for objects on its surface to overcome the centripetal force of gravity.

Rampaging Reef-Wrecker

It is unusual for a species of animal such as the crown-of-thorns starfish to increase in numbers as it has. In most communities of plants and animals, there are many natural controls that keep populations in check. When a species does "explode" in numbers, the cause can often be traced to some activity of man.

Topics for Class Discussion

- *Some scientists, tourist agents, and others are urging that the crown-of-thorns be wiped out. Do you think this is a good idea?*

This may be too drastic an action, and could lead to more trouble. The population explosion may ease of its own accord. A species doesn't normally wipe out its own food supply. Also, even if the population explosion continues for some time, corals may be able to rebuild the reefs. Reefs are normally in a continual state of repair, and some scientists believe that there are enough coral survivors to rebuild much of the damaged reefs.

A massive starfish-killing effort might have unexpected effects on life in and around the reefs. No one knows the cause of the increasing numbers of starfish. Perhaps there is some natural (non-human) cause or causes—a decrease in the numbers of some organism that competes with or consumes the starfish; or a change in the physical environment. Especially if there is a natural cause, tampering with nature might result in other changes in the interrelationships of life in the Pacific.

- *How would you go about solving this mystery?* The answers of your pupils will probably fall into three main categories: *experiments, observations,* and *comparisons.*

Experiments, for example, could test the idea that pesticides have a greater effect on starfish *enemies* than on the starfish themselves. By observation, biologists are trying to learn all they can about the starfish and its relationships to its physical and biological environment.

The article mentions a third approach to the problem—comparing the environment in a place where starfish are not "exploding" (in the Red Sea) with the environment where they are. Sometimes a "before and after" comparison is possible *(for example, see "Tale of the Torrey Canyon,"* N&S, *Feb. 3, 1969).* No such comparison is possible here, however, since very little is known about reef life before 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.

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

starfish population explosion began.

Man the Measurer—Part 2

The second article of this three-part series introduces your pupils to different units of length for measuring distances ranging from the microscopic to the astronomical. It gives them two important "rules" for measuring:

1. For convenience in measuring, use the unit of length closest in size to the distance to be measured.

2. The smaller the unit of length you use to measure a distance, the more precisely you can measure it.

Suggestions for Classroom Use

You might have your pupils test these two ideas by "inventing" three units of length and using them to measure distances of three different orders of size—say the distance around the school, the height of a pupil, and the width of a paper clip.

Have your pupils use a piece of rope or string *about* (but not exactly) three or four yards long, a stick *roughly* a foot-and-a-half long, and a strip of cardboard with a mark on the edge roughly an inch or so from one end. Each of these units (1 "rope," 1 "stick," 1 "mark") can then be marked off into smaller units. Let your pupils decide how many sub-units they need and how to make them. (Do they divide units in half to make sub-units? Or use some other way?)

Your pupils will find that measuring is easiest when they use the unit closest in size to the distance they are measuring. (The measurement will also be in numbers that are easier to remember and manipulate.)

In measuring the height of one pupil, or especially the width of a paper clip, they will see the need to use sub-units, such as "half-stick," "quarter-mark," and so on.

But how precise does a measurement need to be? This depends on what the measurement is to be used for. If you just want to know the distance around your school, a measurement precise to the nearest foot, or even yard, should satisfy your needs. However, to compare the heights of their classmates, your pupils will see the need for measuring more precisely, in inches and fractions of inches. (How precisely must you measure paper clips to see if all are the same size?)

- Have your pupils look up tables of units for measuring area, volume, weight (mass), and so on, in a dictionary or encyclopedia. Can they make up a similar table of units for measuring time? (Second, minute, hour, day, week, month, year, century, millennium.) Which unit of time would your pupils use to measure their own ages? Summer vacation? The time until recess? The time to run 50 yards?

They will probably select the unit closest to the amount of time being measured (for convenience), but will use smaller units where greater precision is desired (days to Christmas, etc.). These "rules" apply no matter what you are measuring.

For Your Reading

- How krypton light waves are used to measure distance is clearly explained in *For Good Measure: The Story of Modern Measurement,* by Melvin Berger, McGraw-Hill Book Company, New York, 1969, $4.85. This excellent book (for junior-high students and up) shows how to test the measuring capacity of your senses, summarizes the history of measuring, and explains in well-illustrated detail how length, mass, time, temperature, sound, light, and electricity are measured by modern methods.

Brain-Boosters

Mystery Photo. The tracks in the snow were made by an automobile that turned around by backing up, then going forward. The tracks that end and start at the top of the photo were made by the rear tires of the car. (The car backed in from lower right, and drove out toward lower left.)

Your class can have some fun trying to "decipher" auto tracks made in the snow in the school parking lot this winter. But before the snow comes, you can make some demonstrations with a toy car on the blackboard. Get a car that has front wheels that turn from side to side, and dip the four wheels in water before rolling the car across the board. You can go over the tracks with chalk so that they will be visible after they dry.

What will happen if? If you set up this demonstration in your classroom, your pupils will be able to see in a few days that the water has risen inside the jar. This is because the steel wool rusts by combining with some of the oxygen from the air in the jar, and the water rises to take the place of the "missing" oxygen. Since air is about 1/5 oxygen, the water will not rise more than 1/5 of the way up the unsubmerged part of the jar.

Be sure to use steel wool that does not contain soap. If the steel wool has been treated with a rust retardant, soak it in vinegar for a few hours to remove the chemical coating. Set up an empty jar in a pan of water also, as a control, so that your pupils can see whether water will rise in it the way it does in the jar containing steel wool.

Can you do it? Let the class try flipping books into the air and see whether anyone can keep the book from twisting over sideways. (Paperback books will be easiest to catch and will suffer less damage than hard-cover books if dropped.) After a few tries, some of your pupils will probably be able to make the book come down "right-side-up."

Fun with numbers and shapes. Here are two rows of figures that total 80,000 right-side up and upside down. Can your pupils figure out why these numbers "work"? What numbers could not be used in an "upside-down" problem like this?

```
0 0 0 0 8
6 8 1 8 9
---------
1 1 8 1 1
---------
8 0 0 0 0
```

For science experts only. When a washed glass is taken from the hot water in the kitchen sink, it becomes filled with cooler air from the room. The cool air is trapped inside the glass when it is turned upside down on the kitchen counter. As the air inside becomes heated by the warm glass and expands, some is forced out of the glass, making bubbles in the water around the rim.

The Importance of Measuring . . .
(continued from page 1T)

1 inch on the map to 62,500 inches (about one mile) of distance over the land represented on the map.

A map of the United States is based on measurements, but it shows us things that those measurements in tabular form alone cannot reveal. In the same way, a graph can give us insights into just about any kind of measurement—distance, area, volume, mass, temperature, population, and so on. By using appropriate scales of distance on the graph, we can record measurements in the form of dots and lines that reveal differences, similarities, changes, and relationships that we might never detect by simply studying tables of the measurements.

"Reading" the Population Curve

We can measure a sequence of events and then arrange those measurements on a graph. We can next interpret the graph by "reading between the lines," so to speak. In the world population graph shown below, let's assume that a human population sample was taken every 50 years from the year 1650 through 1900. If that were so, and even if we did not have measurements for the in-between years, we could *interpolate* for those quantities. And we could be reasonably confident that the values we interpreted were fairly accurate, if not precise.

Trying to forecast what will happen to the world population over the next 100 years or more, on the basis of the population curve we have to date, is pretty risky business. We do not dare to *extrapolate* to arrive at future quantities. We do not have a complete enough history of the curve to do so. The human population has not yet completed one cycle of growth and decline on a world-wide basis. Does that mean that our future as a species is utterly unforecastable? Not at all. Measurements of other animal populations suggest certain possibilities.

We have complete histories of population growth curves of many other animal populations. In not a single case does the growth curve continue upward for very long along the steep part of the slope. It either levels off, declines slowly, or drops off abruptly. By analyzing population measurements of other animal communities, we can come up with that generalization. Such generalizations—themselves measurements—can be constructed only after many other measurements have been made and analyzed.

The value of such generalizations is that they suggest what may happen in the future. As William D. McElroy, of Johns Hopkins University, has put it: "In nature no animal, plant, or bacterial population has ever maintained [itself on the steep part of the growth curve] for long. The major factors that slow this rate of growth are exhaustion of food supply, accumulation of toxic products, decimation through disease, or the effects of some outside lethal agent which kills a high proportion of the population. Any one or all of these factors will force the population back into a [slow growth] phase."

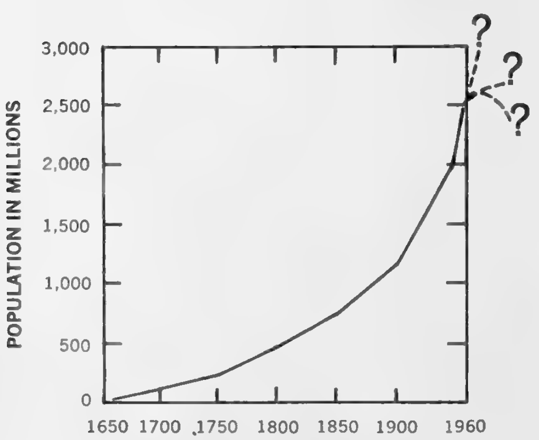
In this case, population experts have built a mathematical model of population growth based on measurements of many different kinds of organisms. The value of that model, like the value of all scientific models, lies in its reliability to forecast.

The Lynx and the Hare

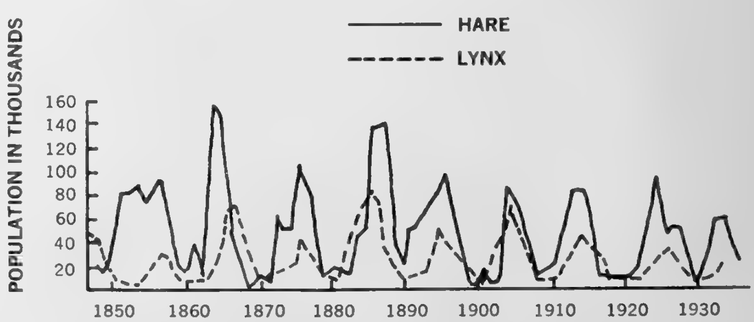
Here is an excellent example of how reliable this kind of statistical measurement can be sometimes. It is a graph of the oscillations in the populations of snowshoe hares and lynx between 1850 and 1935. Notice the ups and downs of the two lines, which represent the rise and fall of the lynx and hare populations. Soon after the hare population begins to rise, the lynx population also begins to go up. And soon after the hare population begins to fall, the lynx population also starts to decline.

If we relate these two independent sets of measurements, the predator-prey relationship between the two animals is dramatically shown during the eight cycles of population rise and fall. The pattern is repeated enough times so that we can interpolate with accuracy. We could even extrapolate with confidence, provided that conditions were pretty much the same after 1935 as they were between 1850 and 1935. But again, we have not yet had time to make enough measurements of the human population to be able to forecast what will happen when the curve tips over ■

The final article in this three-part series will appear in the next issue.



ESTIMATED GROWTH OF HUMAN POPULATION 1650-1960



CHANGES IN LYNX AND SNOWSHOE HARE POPULATIONS
(based on pelts received by the Hudson Bay Company)

nature and science

VOL. 7 NO. 6 / DECEMBER 1, 1969

Cats often "play" with a mouse or rat before killing it. Do you think cats are "cruel"?

see page 15

CAT vs. RAT

How does a bobsled speed around a curve like this without flying off its ice-covered runway?

See ***SWIRLING AND WHIRLING THINGS,*** page 2

and ***WHAT MAKES THINGS GO IN CIRCLES?,*** page 4

nature and science
VOL. 7 NO. 6 / DECEMBER 1, 1969

CONTENTS

PICTURE CREDITS: Cover, United Press International; pp. 2-7, 10-13, 16, drawings by Graphic Arts Department, The American Museum of Natural History, p. 5, photos by Robert Gardner; p. 7, top photo by Diane Dickerson, from Black Star, bottom photo from Australian Tourist Commission; pp. 8-9, Lloyd P. Birmingham; p. 10, top photo by Diane Dickerson, from Black Star, bottom photos from Australian News and Information Bureau; p. 11, photo by David Webster; p. 14, United States Bureau of Standards; p. 15, Anthony Mazzariello, p. 16, photos by Joseph F. Gennaro, Jr.

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

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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:

SCIENCE WORKSHOP

How does a hurricane or a whirlpool get a hole in its middle? You can find out by investigating—

Swirling and Whirling Things

by Robert Gardner

■ Have you ever seen a tornado, a whirlwind, or a whirlpool? At the center of these spinning masses of air or water is a funnel-shaped "empty space." You can take a closer look at a whirlpool if you make one yourself. Put some water in a clear jar or bottle, and swirl the liquid with a spoon. Or simply move the jar in small circles to get the water swirling. What do you see in the center of the jar? What happens if you make the water swirl faster?

PROJECT

Does water empty faster from a jar if you make a whirlpool while it is emptying? How about a bottle of water? A sinkful of water? Does it matter how big the jar or bottle is?

You have probably felt yourself being pushed against the side of an automobile, or other moving vehicle, as it went around a curve. Do you think this happens for the same reason that swirling water in the jar tends to "pile up" on the outside, leaving a "hole" at the center? Here are some investigations to help you find out.

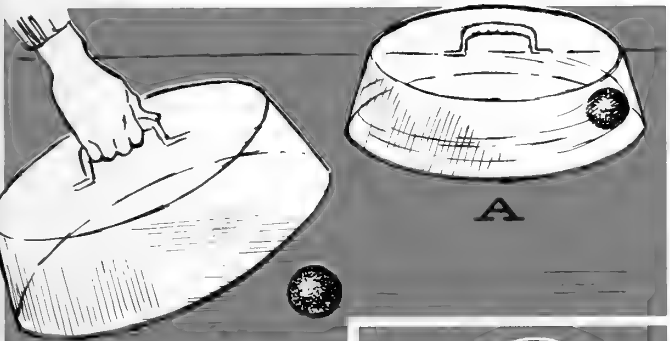
Making Things Go in Circles

If something is at rest or moving along in a straight line, it will stay at rest or continue along the same straight path at the same speed unless someone or something pushes or pulls on it. The pushing or pulling force may make the

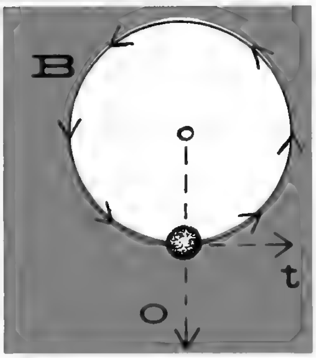
STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Act of October 23, 1962, Section 4369, Title 39, United States Code) 1 Date of filing October 1, 1969 2 Title of publication NATURE AND SCIENCE 3 Frequency of issue Fortnightly September, October, December through March, monthly November, April, May and July (special issue) 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, Nassau, New York 11530 6 Names and addresses of publisher, editor, and managing editor Publisher David R Replogle, Doubleday & Company, Inc., 277 Park Ave., 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. Box 2781, Grand Central Station, New York, N.Y. 10017, Ellen Doubleday, Nelson Doubleday, Neltje Kings, Madeleine V Martin, Lawrence McNaughton, Robert McNaughton, and Ellen Violett (all c/o Doubleday & Company, Inc., 277 Park Avenue, New York, New York 10017) 8. The known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities are: NONE. 9. NON-APPLICABLE. 10 Extent and Nature of Circulation: The average number of copies each issue during the preceding 12 months are: (A) Total number of copies printed (net press run) 225,093; (B) Paid circulation (1) Sales through dealers and carriers, street vendors and counter sales. 360, (2) Mail subscriptions 193,134; (C) Total paid circulation 193,494; (D) Free distribution. (including samples) by mail, carrier or other means: 2,348, (E) Total distribution (Sum of C and D) 195,842, (F) Office use, left-over, unaccounted, spoiled after printing 29,251, (G) Total (Sum of E and F—should equal net press run shown in A): 225,093. The number of copies single issue nearest to filing date are: (A) Total number of copies printed (net press run) 242,648; (B) Paid circulation: (1) Sales through dealers and carriers, street vendors and counter sales: 360; (2) Mail subscriptions 191,183; (C) Total paid circulation: 191,543; (D) Free distribution (including samples) by mail, carrier or other means: 1,967, (E) Total distribution (Sum of C and D): 193,510; (F) Office use, left-over, unaccounted, spoiled after printing: 49,148, (G) Total (Sum of E and F——should equal net press run shown in A) 242,658.
I certify that the statements made by me above are correct and complete.
David R. Replogle
Publisher

object start moving, slow down, speed up, or move off its straight-line path. But suppose a ball is moving in a circle. What will happen if you remove the force that pushes or pulls the ball inward and keeps it moving in a circular path?

To find out, get a ball moving in a circle. You can do this by rolling a small ball—a golf ball or a marble—toward a clear cake cover or round baking dish, one side of which is raised *(see Diagram A)*. As the ball moves under the

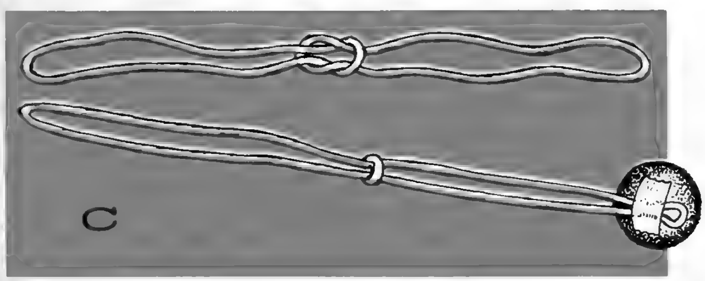


cover, you can "capture" it so that it moves around the circumference of the cover.



If you raise the cover so that the circling ball can escape, where will it go? Will it move outward along the path marked "O" or along path "T" in Diagram B?

To find out how the speed and weight of an object affect the force needed to keep the object moving in a circle, connect a "chain" of long, thin, flexible rubber bands to a golf ball or a small rubber ball *(see Diagram C)*. Attach an



identical chain to a ping-pong ball or a cork. Wrap tape all the way around each ball when you attach the rubber-band chain to the balls. Take the balls outdoors, or to a large room where there is plenty of space (and nothing to break) before doing your experiments.

Swing the golf ball in a circle *(see Diagram D)*. Then swing the ping-pong ball at about the same speed. Which ball do you have to pull harder to keep it moving in a circular path? (You can get a good idea by comparing how far the rubber-band chains stretch when the balls are mov-

ing at about the same speed.) Do you think the weight of a ball determines how much force it takes to keep the ball moving in a circle?

If you release the chain while the golf ball is circling, can you predict where the ball will go?

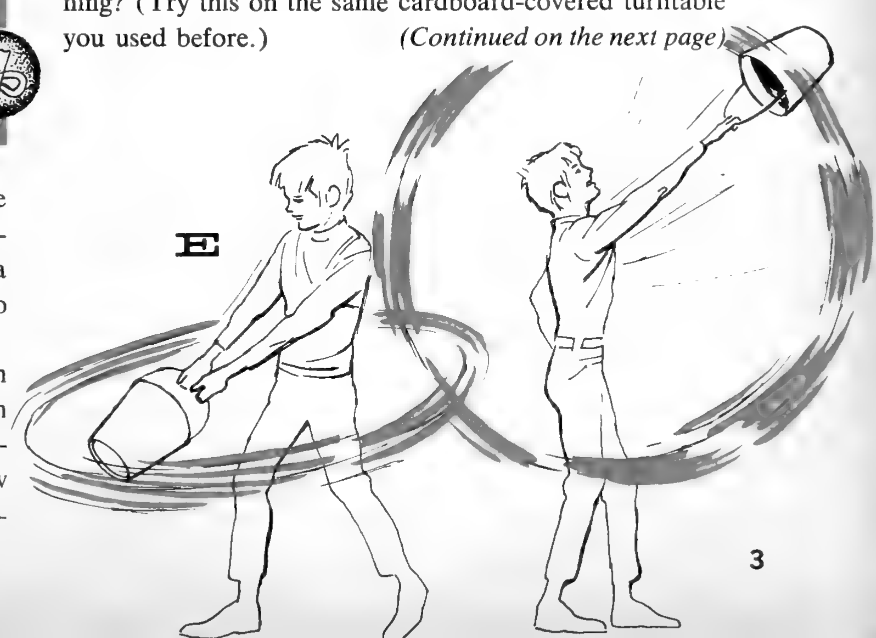
Swing the golf ball around faster and faster and see what happens to the size of the circular path it follows. Does speeding up the ball change the amount of force it takes to keep it moving in a circle? How can you tell?

You can check your findings by pouring some water into a plastic pail outdoors and swinging the pail in a "go-around" circle *(see Diagram E)*. If this makes you feel dizzy, just stand still and swing the pail in an "up-and-over" circle as shown in the diagram. As you swing the pail faster, do you have to pull it toward the center of the circle with more force, or less force?

What do you think keeps the water in the pail when you swing it in an "up-and-over" circle? What happens if you swing the pail slower and slower? *(Watch out! You may get wet.)*

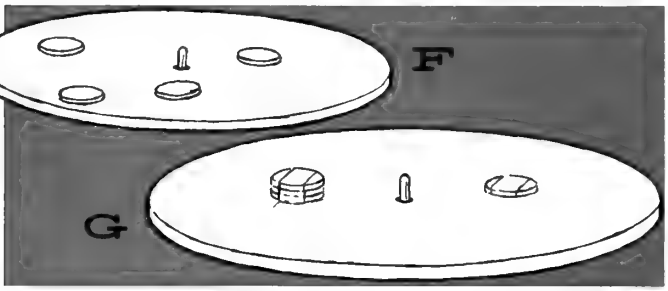
Whirling on a Turntable

If you used a spinning turntable to find out how we know the earth is spinning (N&S, *October 13, 1969*), you may have had trouble keeping your pendulum on the platform while it was rotating. From what you have learned about the force needed to keep an object moving in a circle, can you figure out where to place a coin on a turntable so it will be sure not to slide off when the turntable is spinning? (Try this on the same cardboard-covered turntable you used before.) *(Continued on the next page)*



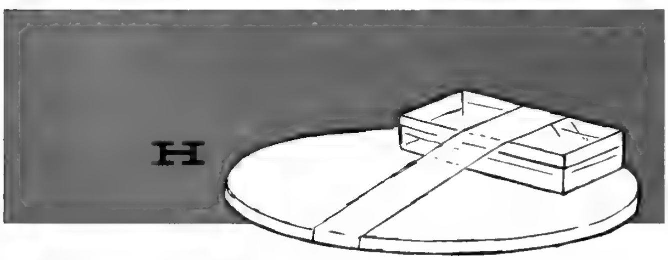
Place several pennies on the turntable at different distances from the center *(see Diagram F).* Can you predict which one will start to slide first after you begin rotating the turntable? (Can you explain why?) After testing your prediction, place a penny near the edge of the turntable, start the turntable spinning very slowly, and gradually increase the speed of rotation. How does the speed of the turntable affect the motion of the penny?

Wrap a strip of sticky tape around a stack of several pennies, and another strip around a single penny. Place these two "packages" on the turntable at equal distances from the center *(see Diagram G).* Which package is likely to slide off first when you rotate the turntable—the lighter one or the heavier one? (If neither package slides off, what can you do to get them to slide?)



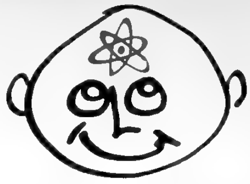
Repeat the investigation several times. Does the heavier or lighter package slide off easier—or do they both slide off at about the same time?

If you place a jar, or better, a rectangular container of water on the turntable *(see Diagram H),* what will the water's surface look like when the turntable is rotating?



Will the speed of rotation affect the shape of the water's surface? Will the distance of the container from the center of the turntable affect the water's surface?

From your findings in these investigations, you can probably explain why a funnel-shaped airspace forms in a jar of swirling water. What would the water's surface look like if you whirled the whole jar in a big circle? ■



What

From your investigations of whirling golf balls and swirling water, you can find out what keeps the moon circling the earth and the planets circling the sun.

by Robert Gardner

■ Did you get wet when you were swinging a bucket of water in a circle, as suggested in the article on page 2? If so, it was probably because you didn't swing it fast enough —not because the bucket handle slipped out of your hand while it was swinging. If the handle slipped, you would no longer be pulling the bucket of water toward you, so it would fly off in the direction it was moving the instant it was no longer being pulled toward you *(see path "T" in Diagram B on page 3).*

The force with which you pulled the bucket toward you to keep it moving in a circle is called a *centripetal,* or center-seeking, force. To make any object move in a curved path, there must be a centripetal force either pulling or pushing the object toward the inside of the curve. (What pushed the water in the bucket toward you so it would move in a circle?)

The Outward Pull on Your Hand

While your hand was pulling the bucket toward you to keep it moving in a circle, you could feel the bucket pulling outward on your hand. This outward pull on your hand is called *centrifugal,* or center-escaping,"force." But the bucket handle is pulling on your hand simply because your hand is pulling on it! (Pull on the knob of a closed door and see if it "pulls" back. Or push a wall and see if it "pushes" back.)

Some books say that centrifugal "force" pulls the bucket outward from the center of its circular path, but this is not correct. If centrifugal "force" were pulling outward on the bucket and you let go of the handle, the bucket would fly straight out from the center of its circular path.

When you whirled the bucket around at a faster speed, you probably found that you had to pull harder to keep it moving in the same circular path. If the bucket handle had been made of rubber, what would have happened to it as the bucket speeded up? (What happened to the rubber-band chain when you whirled the ball around faster and faster?)

You might sum up your findings from these investigations in this way: 1. To make an object move faster in a circular path without changing the size of the circle, a

Makes Things Go in Circles?

stronger centripetal force is needed. 2. When an object moving in a circle speeds up, it tends to move in a bigger circle if it can.

Pennies on a Spinning Turntable

Did you find that a golf ball needed a larger centripetal force than a lighter-weight ball to make it move along a circular path? This makes sense; but when you placed piles of pennies with different weights on the turntable at equal distances from the center, both piles seemed to slide off at the same time. Seems strange!

The only thing that can give the pennies enough centripetal force to keep them moving in a circle is the *friction* between the pennies and the turntable. Heavier things, as you have found, need a bigger centripetal force to keep them moving in a circle. But the frictional force on a heavier object is larger too. (Did you ever try to slide a heavy box along the floor?)

When you rotate the turntable, a pile of three pennies requires three times as much centripetal force as one penny needs to make it go in the same circle. But the frictional force on three pennies is three times the frictional force on one penny, so all is well. As long as the frictional force can give the pennies enough centripetal force, the pennies go round and round. The faster the pennies move, the more centripetal force is needed to keep them moving in a circle. When friction can no longer supply enough centripetal force, the pennies slide off the turntable.

What can you do to increase the friction? How will this change the speed needed to make the pennies slide off the turntable?

Now that you know something about centripetal forces, and the centrifugal effects that go with them, you will probably notice them pulling or pushing on you in your daily life. Look for them whenever you are moving in a curved path—rounding a corner on your bike, in a car, or while running; riding on a merry-go-round; swinging; playing crack-the-whip. You can also find them at work in machines with spinning parts, such as a kitchen mixer, a

(Continued on the next page)

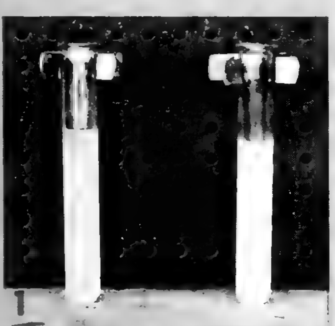
A SWINGING SEPARATOR

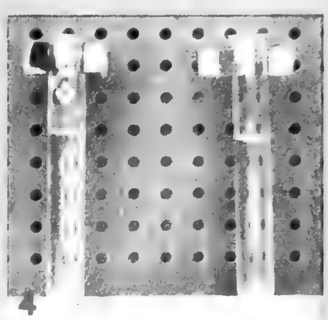
If you mix some sand or fine soil with water in a small bottle and let it stand for a while, the sand will eventually settle to the bottom of the bottle. (Can you explain why?) From your experience in whirling balls of different weights, can you think of a faster way to make the sand separate from the water?

Some substances have such tiny particles that they stay suspended, or "hanging," in a liquid such as water, instead of settling to the bottom of the container. The cells in your blood, for example, tend to remain suspended in the *plasma*, or liquid part of the blood. (Stir some water into a spoonful of cornstarch from your kitchen and see whether the starch settles out of the water after a while.)

To quickly separate a solid substance from a liquid, or even one liquid from another, scientists use a machine called a centrifuge. The photos below show how a centrifuge works by whirling containers of the mixture at high speed.

- **A blood cell is heavier than an equal volume of plasma. As blood is being whirled in a centrifuge, which will be farther from the center—the cells, or the plasma?**
- **Farmers use a larger centrifuge to separate cream from milk. While the centrifuge is rotating, which will be farther from the center of the machine—the milk or the cream?**
- **Do you think that it might make more sense to call a machine that works like this a "centripete" instead of a "centrifuge"? Can you explain why?**



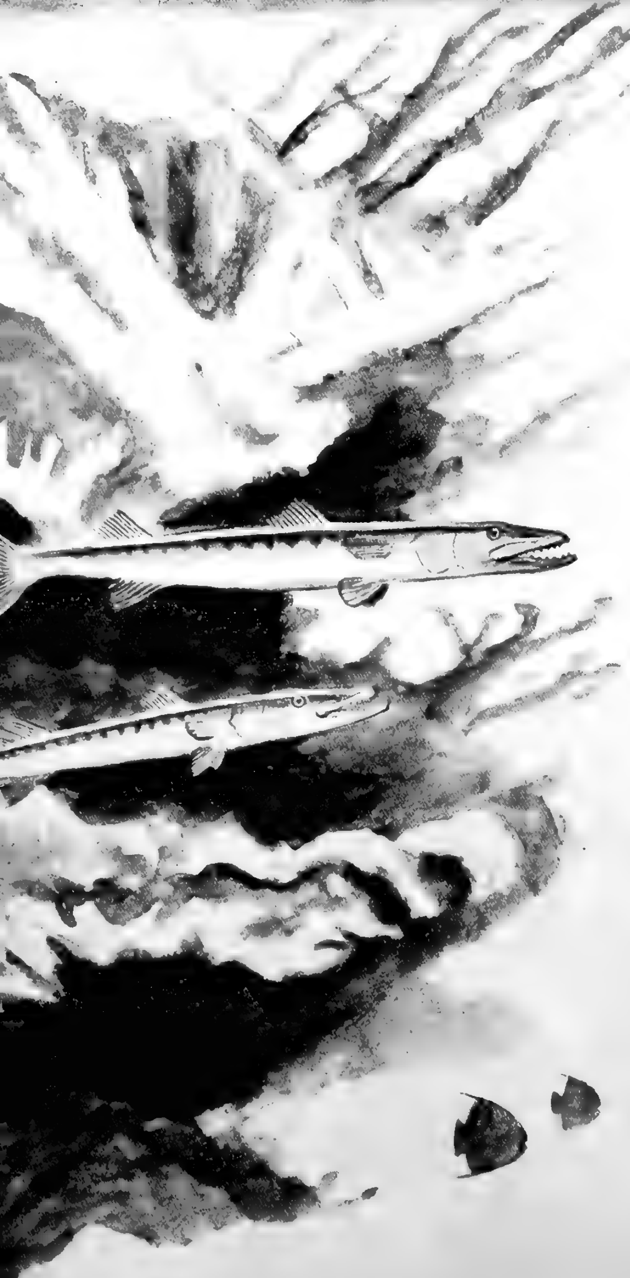


Two test tubes of water mixed with starch *(Photo 1)* were placed in holes slanting out from the center of a centrifuge *(Photo 2)* and whirled around at high speed *(Photo 3)*. The starch, which is heavier than an equal volume of water, separated from the water and sank to the bottom of the test tubes, as you can see in Photo 4.

OIL FROM TANKER

Forests Beneath the Sea

Man sometimes threatens coral reefs. The corals may be killed by oil dumped into the water by ocean tankers, by pesticides carried from farmlands into the ocean by rain and rivers, or by sewage and detergents that are dumped into the sea. In some places the reefs are mined for their limestone.



■ Some of the most beautiful "forests" in the world are under the sea. These forests are coral reefs, which rise from the ocean floor like walls and may be hundreds of miles long. They are made of the limestone skeletons of generations of coral and other sea animals, topped by a living layer of coral animals.

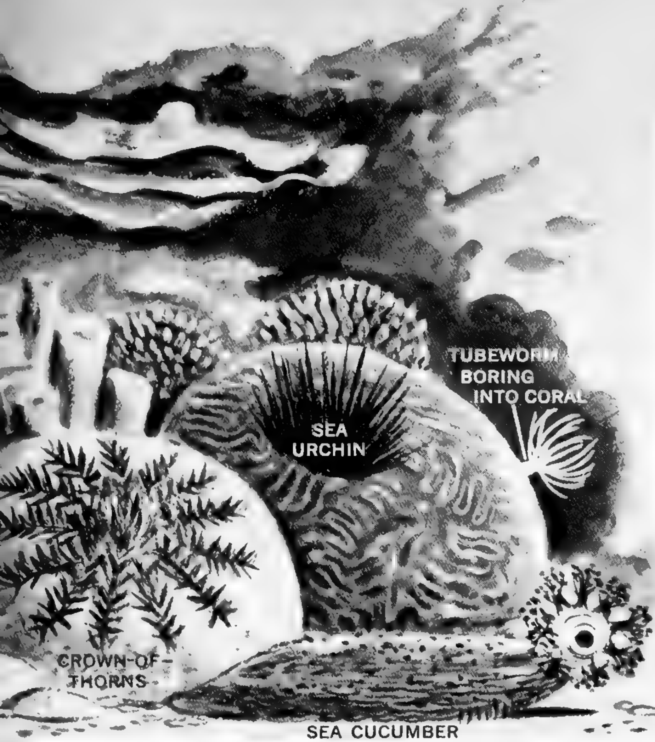
Each coral animal takes calcium oxide from the sea water, combines it with carbon dioxide that the coral gives off, and forms an outer skeleton of calcium carbonate, or limestone. These skeletons of living and dead corals make up the stony part of the reef.

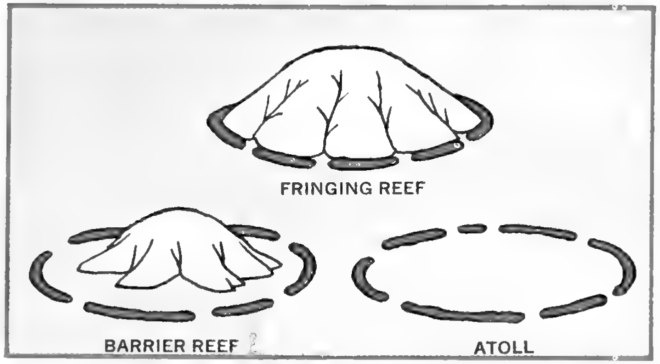
Coral reefs are found in tropical parts of the Pacific and Indian Oceans, the Caribbean Sea, and along the eastern coasts of Africa, Australia, and South America. These places have ideal living conditions for coral animals. The animals need salt water that is always warm (at least 70 degrees Fahrenheit) and nearly free from mud and sand. They also need a good surf to bring in fresh supplies of food.

Reef-building coral animals do not usually grow in water deeper than 150 feet. Yet some reefs extend down into the ocean for thousands of feet. The corals whose remains form these reefs must once have lived near the surface, and then sunk. Scientists think this might have happened when reefs formed on coasts or undersea mountains that gradually sank. Other reefs might have formed on platforms of coral that

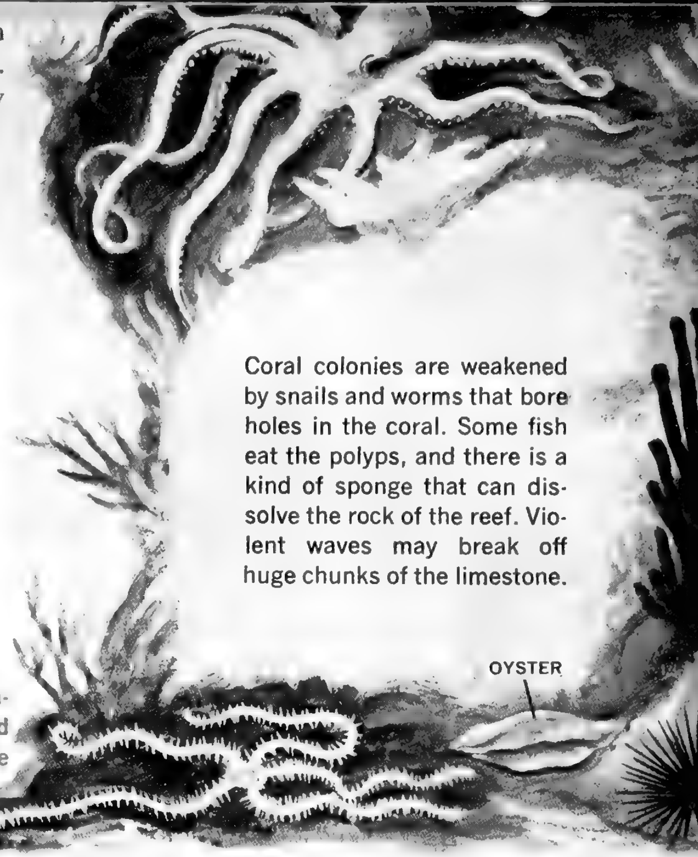
A reef provides a solid place for plants and some animals to attach themselves. The many plants attract great numbers of hungry animals to the reef. The small for fish. The caves and many holes in a reef allow small fish to hide from their enemies—and larger fish to wait in ambush for the small fish.

A coral reef and the animals and plants that live on it form a community in which each living thing has its part to play. On this WALL CHART you will see how a reef community begins, functions, and changes.—MARGARET E. BAILEY



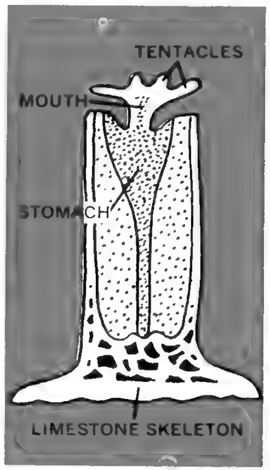


There are three main types of coral reef. *Fringing* reefs are connected to the shore around them. *Barrier* reefs are separated from land by shallow bodies of water called lagoons. *Atolls* are ring-shaped reefs that have no center islands.

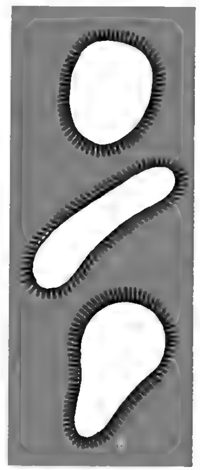


Coral colonies are weakened by snails and worms that bore holes in the coral. Some fish eat the polyps, and there is a kind of sponge that can dissolve the rock of the reef. Violent waves may break off huge chunks of the limestone.

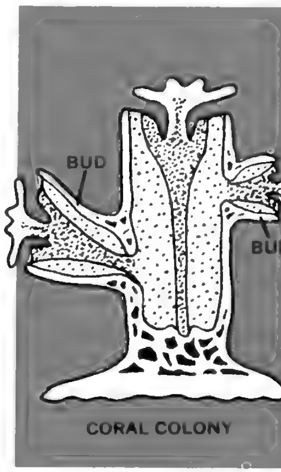
A coral reef begins with a single coral animal, only a fraction of an inch long, called a *polyp.* The polyp has a mouth ringed with tentacles that can sting and capture tiny animals called *zooplankton* for food. Some corals are colorless, but others are yellow, green, pink, orange, or brown. Coral reefs have other colors, too, which come from tiny plants called *algae* that live within the polyps.



Each coral polyp can produce egg and sperm cells that join to form young polyps, called *planulae.* The planulae grow inside the parent polyp for a while; then the polyp squeezes its walls together and spurts them into the water. The planulae have tiny hairs that help propel them through the water until they find a suitable place to settle down and grow into adult corals.



Adult reef-building corals can reproduce another way also, by *budding.* New polyps, exactly like the parent, grow from its sides. The corals keep budding until a whole group of connected animals, called a *coral colony,* has formed.



Marine biologists search for crown-of-thorns starfish. The man in the center is holding equipment for injecting a quick-killing chemical into the starfish.

Reef-Wrecker (continued from page 7)

man the blame. People may have caused the deaths of too many starfish *predators* (animals that kill the starfish).

One predator of the crown-of-thorns is a snail-like animal called the *giant triton (see photos, right)*. People collect the giant triton because it has a pretty, cone-shaped shell that is sometimes more than a foot long. Perhaps so many tritons have been collected that few starfish are being killed by them.

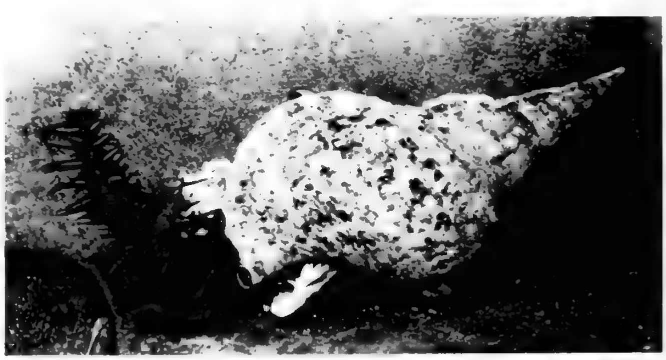
Coral animals also prey on the starfish when the starfish are in their young, or *larval,* form. Men have blasted away coral reefs to clear passages for ships, and to get limestone from the reefs. Removing coral reefs has made coral-free places where large numbers of young starfish might survive and grow, then move onto living coral.

Chemicals used by man to kill insect or plant pests on land might have drifted into the sea near reefs. These chemicals might have killed some of the starfish predators. With fewer predators, more starfish would survive and reproduce.

An Unknown Difference

No one knows whether any of these explanations, or any of the others that have been suggested, is the right one. Last summer, nearly 50 skin-diving marine biologists, from the United States, Australia, and the West Indies, began observing starfish near Guam and other Pacific islands. Their first goal is to find out how much of the reefs has been destroyed. But they also hope to learn why starfish numbers have increased so rapidly, and what can be done about it.

Also last summer, a group of British biologists began to observe the crown-of-thorns in another place—the Red Sea, near the African country of Sudan. There, the numbers of starfish have *not* increased. Perhaps scientists can find out what is different between the surroundings of the starfish in the Red Sea and the surroundings of the starfish in the Pacific Ocean. Then the mystery of the rampaging reef-wrecker will be closer to being solved ■

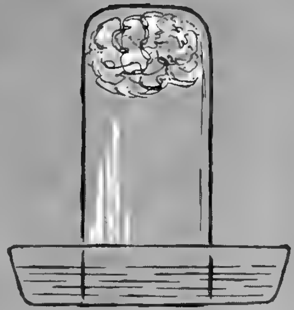


Giant tritons prey on the crown-of-thorns *(bottom photo)*. The top photo shows a triton shell, prized by collectors.

brain boosters

prepared by **DAVID WEBSTER**

What will happen if?



Stuff some wet steel wool into the bottom of a narrow jar, then place the jar upside down in a shallow pan of water. What will happen inside the jar after a few days? Try it to find out.

Fun with numbers and shapes

Write two rows of figures that total 80,000 right-side up and upside down, too.

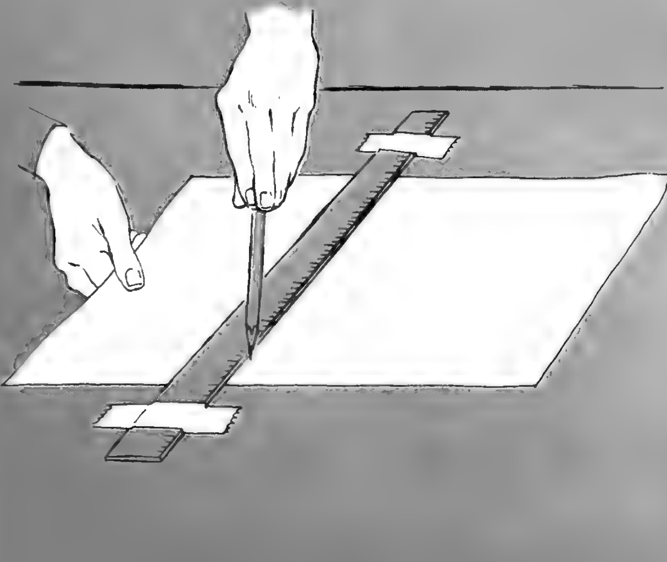
Submitted by Peter Nemarick, Plainview, New York

For science experts only

A girl is washing a drinking glass in the sink. When it is clean, she turns the glass upside down on the counter. Then she notices that bubbles are forming in the water around the rim of the glass. What causes the bubbles?

Just for fun

Set up the device shown. If the pencil is held steady while the paper is pulled to the right, what will the pencil line look like? If the pencil is moved up the ruler while the paper is pulled to the right, what will the pencil line look like? Try moving the pencil up the ruler and then down. Try slanting the ruler and moving the pencil up and down. Move two pencils along the ruler while the paper is moving. What can you do to make other kinds of lines?



Mystery Photo: How were these tracks made?

Can you do it?

Hold a paperback book in front of you by the bottom two corners with the cover up. Now throw the book up in the air so it does one complete flip, and catch it again. The cover of the book should be facing up; but you may find that it is facing down because the book twisted over sideways as it flew through the air. Can you throw a book into the air so that it tumbles end-over-end without twisting?

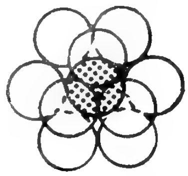
ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The wires through the tree trunk were nailed to it a long time ago for a fence. Then, as the tree grew larger, it grew over the wires. Do the fence wires also get carried higher above the ground as the tree gets bigger?

What will happen if? The jar that is filled with water and capped will probably be the only one to break when the water freezes. If the salt water has a lot of salt, it will only freeze into soft slush.

Can you do it? It is almost impossible to swallow when the tongue is blocked with a spoon. Food in the mouth is normally squeezed backwards by the tongue pressing against the roof of the mouth.

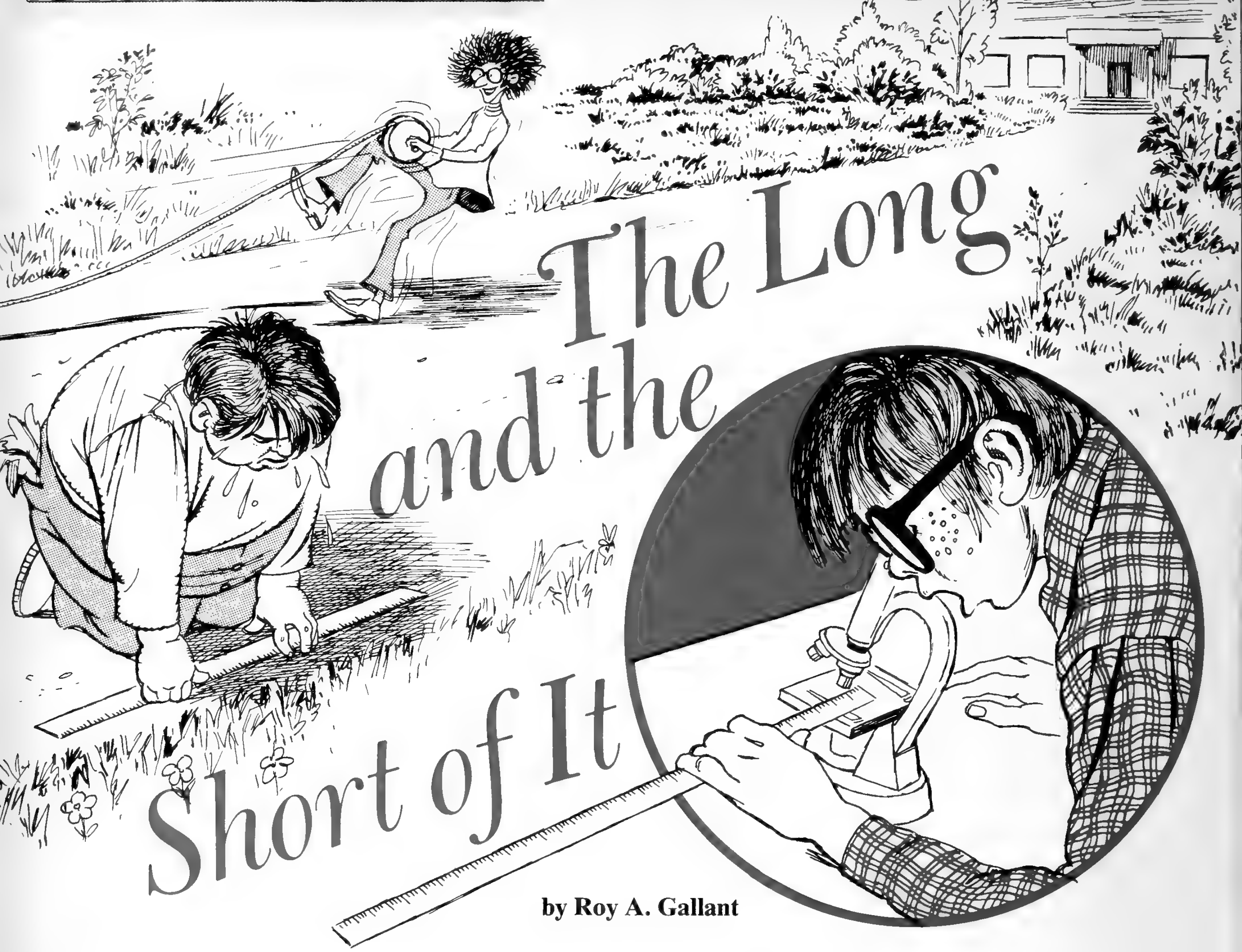
Fun with numbers and shapes: 12 white balls can be made to touch the colored one. How many cubes can be made to touch a single cube?



For science experts only: Ice cubes with holes are used because they melt faster, making a drink get colder more quickly. Would two holes make an ice cube melt even faster?

MAN THE MEASURER—Part 2

The Long and the Short of It



by Roy A. Gallant

■ Do you know how far you walk or ride each day from your home to your school? If your path follows roads all the way, you can get a good idea of the distance by measuring it with the *odometer,* or mileage measurer, of an automobile. An odometer measures distances in miles and tenths of miles. If it showed the distance to be a little more than 1.2 miles, that would probably be close enough to the exact measurement to satisfy you.

But the difference between 1.2 miles and 1.3 miles is 528 feet, so you can see that "a little more than 1.2 miles" is not a very exact, or *precise,* measurement. To find the distance more precisely, you would have to measure it in units smaller than tenths of a mile. Using a yardstick or a long tape measure, for example, you might find the distance to be 6,442 feet 8-3/16 inches (106 feet 8-3/16 inches longer than 1.2 miles).

For thousands of years, men have invented various units of measure to do certain jobs. A mile or kilometer does well enough for measuring the distance between two cities, for example, but it is not a very good unit for measuring a bee's wing that is only 1/126,720th of a mile, or 1/2 inch, long. And inch units, divided into fractions, work well enough for a carpenter making a cabinet, but they do not work so well for a scientist measuring a blood cell or a molecule, for example.

Measuring Tiny Things

Measurements in inches and fractions of an inch from 1/2 to 1/4 to 1/8 to 1/16 to 1/32 to 1/64 are fairly easy to work with. But as the fractions get smaller—from 1/64 to 1/128 to 1/256 to 1/512 to 1/1,024, and so on—the numbers get larger and clumsier to work with. This happens in the metric system, too, when you divide one millimeter (1mm=1/1,000th of a meter) into smaller parts: 0.1 mm to 0.01 mm to 0.001 mm, and so on.

A biologist measuring one of your red blood cells in these units would find that it is about 276/1,000,000ths of an inch, or 0.007 millimeter, across. But it is clumsy to work with such "big" small numbers. To make it easier to talk about the size of objects as small as cells and their parts, we use a unit called the *micron.*

Since there are 1,000 microns to a millimeter, the biologist could say that your red blood cell is 7 microns wide—a much easier number to work with. The new unit also enables the biologist to measure tiny things more precisely than he could using inches or millimeters. This is because the micron unit is closer to the size of the object he is measuring.

If the biologist next looked at different parts of your red blood cell, he would find a certain kind of molecule that is 0.007 micron long. Again, a "big" number. To make things easier, he could say that the molecule is 7 *millimicrons* long, since there are 1,000 millimicrons in one micron. (A millimicron is 39/1,000,000,000ths of an inch.)

PROJECT

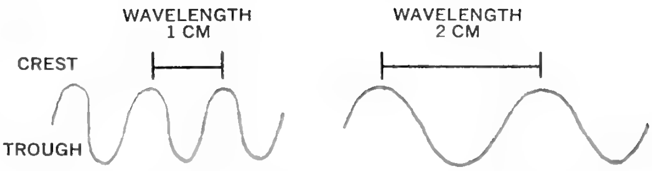
Place a single strand of hair on a sheet of white paper and lay across the hair a ruler divided into millimeters or into tiny fractions of an inch (64ths, if possible). Use a magnifying lens to try to measure the width of the hair. Do you think you could measure it more precisely with a ruler divided into millimeters, microns, or millimicrons? Why?

You can see that the smaller the unit you use to measure an object, the closer you can get to its exact measurement. But that doesn't mean that your measurement will be *accurate*, or "correct." You might make a mistake, for example, in counting the yardstick-lengths from your home to your school. Or you might not start each yardstick measurement from exactly the end of the one before it. Or if your yardstick is worn at the ends, it might be a little shorter than the standard 1-yard unit.

As scientists began to explore the nature of molecules, then of atoms, and then of the bits and pieces that make up atoms, they needed a way to measure smaller and smaller things with great precision. And just as important, they needed a convenient way to make sure that their measuring instruments were accurate.

A New Standard for the Standard Unit

In 1960, the nations attending the Eleventh General (International) Conference on Weights and Measures agreed on a new definition for the meter. When they did, they did two important things. First, they made it possible for scientists to measure very tiny things more precisely than ever before. And at the same time, they made it possible for nearly every laboratory to have its own "master"



The length of a wave can be measured from, say, the *crest*, or top, of one wave to the crest of the next wave. Visible light travels in waves from about 400 millimicrons long (violet light) to about 700 millimicrons long (red light). (One millimicron is about 1/25,000,000th of an inch.)

standard of length that would never have to be checked for accuracy. The new unit that made all this possible was a certain wavelength of light.

You probably know that light is a kind of energy that travels in waves, and that different colors of light have waves of different lengths (*see diagram*). Under certain

(Continued on the next page)

For Expert Measurers Only

The units of measurement mentioned in this article—inches, feet, meters, centimeters, and so on—are all used to measure distance. You can also use them to measure area. For example, a room 10 feet long by 10 feet wide has a floor area of 10 x 10, or 100 square feet. If the room is also 10 feet high, its volume—the amount of space inside the room—is 10 x 10 x 10, or 1,000 cubic feet. So you might say these units are all used to measure *size.*

- We measure many things other than size, however —such things as weight, temperature, and time, for example. Can you think of some units that are used to measure very heavy objects? Lightweight objects? Can you think of at least two different units for measuring temperature? How about units for measuring short, medium, and very long periods of time?

- By using distance units together with time units, we can measure speed. When a car is moving so that it will travel 30 miles in one hour, for example, we say it is moving at a speed of 30 *miles per hour.* What units would you use to measure the speed of the tip of the big hand of a clock as it moves from 12 around to 12 again on the clock dial?

- Do you know what these units are used to measure: foot-pound? calorie? pounds per square inch? volt? decibel? candlepower? (A dictionary or encyclopedia will help you find out.)

conditions, each element, such as hydrogen, oxygen, and the more than 100 others, gives off light of its own particular wavelength. And light of that wavelength identifies a particular element as surely as your fingerprints identify you, and only you. The wavelength of the red-orange light given off by the atoms of the element krypton was chosen at the international conference as the new basis for the meter. All nations that use the metric system have agreed to the idea that one meter equals 1,650,763.73 wavelengths of krypton light. So that number of krypton wavelengths has become the new official meter "stick."

Since every well-equipped laboratory can produce krypton light, it has *the* master standard (*see photo*). No longer does a scientist have to have his instruments checked against the official meter stick of his country. Nor does his government have to check its meter stick against the international standard meter stick in Paris.

But this does not mean that the meter is no longer the standard. It is. What has changed is the way we say what a meter is. When the meter was introduced about 200 years ago, it was defined as one ten-millionth of the distance from the Equator to the North Pole (through Paris). We now agree to say that it is so many wavelengths of krypton light. What we have done is to chop the meter up into smaller units, which makes it possible to measure with greater precision than ever before.

The wavelength of the orange-red light from lamps like this one has replaced the standard metal meter bar as the international standard of length. The light comes from a tube filled with krypton when an electric current is sent through this gas. Liquid nitrogen keeps the lamp at a temperature of —346°F. so it produces light waves exactly 605.78 millimicrons long. With this lamp, scientists can measure lengths to 1/100,000,000th of an inch.

Measuring Big Distances

What about big distances? Centimeters and inches become more and more clumsy to use as distances become greater and greater. So do miles and kilometers.

You probably know that the distance from earth to the sun is about 93,000,000 miles. Astronomers use that distance as a kind of "meter stick" to express distances within our solar system. They call that 93-million-mile distance 1 *astronomical unit*. Our planet, then, is 1 astronomical unit from the sun; Mars is 1.5 a.u. from the sun; Jupiter, 5.2; Pluto 39.4.

But as large as the astronomical unit is, it is too small to be a convenient unit for measuring distances to the other stars. To use it would be like using the millimeter to measure the height of a skyscraper. Astronomers use a unit called the *light-year* to measure distances to neighboring stars and to the more distant stars.

One light-year is the distance that light travels in one year, at a speed of 186,300 miles per second. If you did all the multiplying, it would come out to nearly 6,000,000,000,000 miles. Our nearest neighboring star beyond the sun is the star Alpha Centauri, which is 4.3 light-years away.

Our closest neighboring galaxies are about 2,000,000 light-years away. Others are billions of light-years away. To express the vast distances between galaxies, astronomers use two additional units. One is the *parsec*, which is equal to 3.26 light-years, or 206,000 astronomical units. The other is the *megaparsec*, which equals 1,000,000 parsecs.

Again, we invent new units of measure whenever we have a need for them. And we can use the length of a certain dog's tail, the distance to a certain star, or the distance across the universe as standards. But the units we choose must be the right size to do the measuring job that needs to be done. For example, the astronomer does not need or want to know the distance from earth to the sun in centimeters any more than you need to know the length of your bedroom in microns. The physicist would also find it very clumsy to use astronomical units to describe distances within the atom.

Each special job of measuring may be more easily done with one unit than with another. But remember, no matter what the unit's name might be, the measurement it expresses is based on the agreed-on length of the meter in wavelength units of the light of krypton ■

cat vs. rat

■ "Cats are cruel."

People often say that when they see a cat "playing" with a rat or mouse before finally killing it.

But when we say that a cat is "cruel"—or "mean" or "hateful"—we are using words that describe human feelings. We do not know whether cats have these feelings. Scientists who study the behavior of animals are very careful to avoid using such human terms. They try to see the world from the animal's point of view.

Why, then, do cats "play" with their prey? Recent studies by a German scientist, Dr. Paul Leyhausen, may have revealed some answers.

Dr. Leyhausen studied the killing behavior of several kinds (*species*) of cats. Besides domestic "house" cats, he observed wild species such as servals, margays, and European wild cats. He took motion pictures of cats in their cages as they were fed live hamsters, rats, or mice.

Born Killers?

One question Dr. Leyhausen wanted to answer was whether cats were born with the ability to kill their prey, or had to learn the ability. He watched both young and old cats attack the small animals placed in their cages. The cats clearly aimed their bites at the neck of their prey. (A strong bite in the neck usually causes a quick death as the cat's teeth tear into the spinal cord.) Even very young cats bit the necks of mice. So Dr. Leyhausen decided that this is an *inherited* characteristic, passed from one generation of cats to the next generation when the cats reproduce.

Knowing *where* to bite is inherited, but apparently knowing *how* to bite is not. Dr. Leyhausen discovered that an inexperienced cat is unable to kill its prey because it doesn't bite hard enough. As the cat becomes more excited, it bites harder. Normally, a young cat learns to bite hard as it fights over a mouse with other young cats, or with its mother.

Search, Seize, Kill, Eat

A cat doesn't get its food in a single act, but in a series of acts—searching, seizing, killing, and eating. Dr. Leyhausen discovered something important about this pattern when he gave some cats an unlimited supply of live mice and watched to see what would happen. At first the cats went through all four steps of food-getting. When they were no longer hungry, they stopped eating but went on killing. After a while they stopped killing but went on stalking and catching mice—the acts that look "cruel" to us. Later the cats only stalked the mice, and still later they stopped doing that and ignored the live mice around them.

This pattern is inherited, and it may help cats to survive in the wild. A cat would die if it "gave up" after missing the first few mice it tried for. Instead it keeps on hunting. Only after it has eaten enough food does the cat begin to break its food-getting pattern. The pattern is broken in reverse order, with searching and seizing given up last, not first.

The next time you see a cat "teasing" a mouse, don't think of it as cruel. The cat is simply following a way of food-getting that may have helped its ancestors to survive in the wild, millions of years ago.—LAURENCE PRINGLE

Why Raccoons "Wash" Their Food

The food-getting pattern of "search, seize, kill, eat" is found in many meat eating animals, not just cats. According to Joseph A. Davis, a mammalogist at the New York Zoological Park, this pattern may explain why raccoons and some kinds of otters "wash" their food before eating it. Writing in the December 1968 issue of *Animal Kingdom* magazine, Mr. Davis said, "The reason for 'washing' in raccoons, a behavior pattern that seems never to have been reported in wild raccoons, applies to clawless otters as well.

"Their first act of food-getting is searching in shallow water. In zoos they are fed on dry land, and have no chances to search and seize food in the water. But searching and seizing are still part of their food-getting pattern. So the raccoons and clawless otters take their 'prey' to water, 'lose' it by letting go of it, and then search for it again. They do this even after their actual hunger has been satisfied. If the 'prey' is ground meat, as it often is in zoos, the otter or raccoon may lose it permanently as it breaks apart in the water. But the animal keeps searching until its urge is satisfied."

WHAT'S NEW

by
B. J. Menges

Moon rocks brought back by the Apollo 11 astronauts last summer are unlike any known earth rocks. The moon rocks contain unusually large amounts of such rare elements as chromium, titanium, zirconium, and yttrium. Their makeup seems to rule out the theory that the moon was torn from the earth. For if it had been, moon rocks and earth rocks would be similar.

That leaves two other theories about the moon's origin: (1) The moon and the earth were formed about the same time from space dust. (2) The moon was formed earlier than the earth, outside the solar system, and was later "captured" by the earth's gravity. Tests show that some of the Apollo 11 moon rocks are about 3.5 billion years old. Rocks from other parts of the moon are expected to be older, perhaps dating from the moon's origin. The age of such rocks may reveal whether the moon was formed when the earth was—about 4.6 billion years ago — or whether it is an older visitor from elsewhere in space.

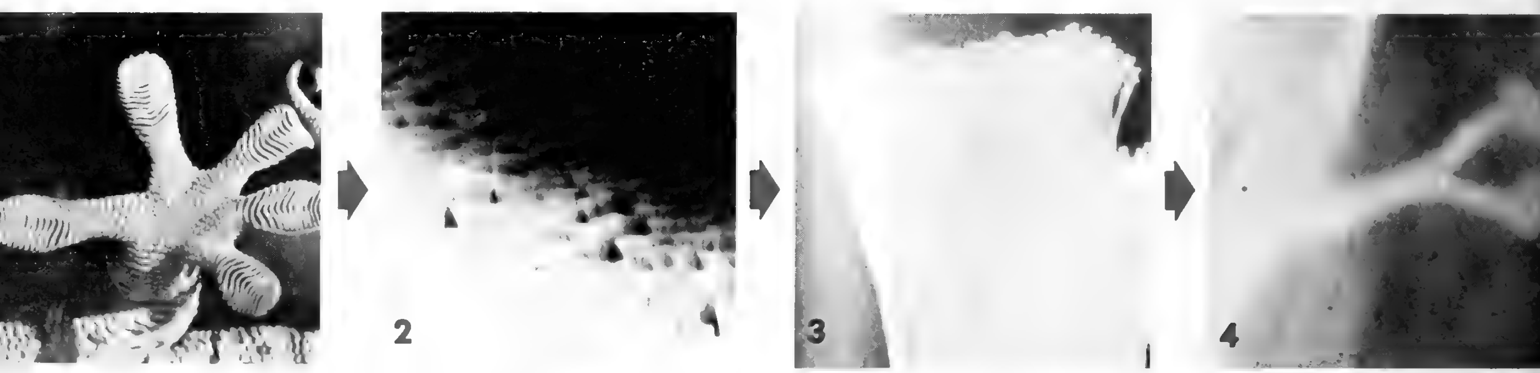
Sponges can't fly, but some birds are able to use their feathers for bringing water to their thirsty young. Two ornithologists from Cornell University, in Ithaca, New York, watched sandgrouse soak themselves at a waterhole in the Kalahari Desert in South Africa, and then fly back to their nests, where their young stripped the water from the adults' feathers with their beaks.

This method of water-carrying had been reported over 70 years ago, but had been labeled a myth by scientists. Now the Cornell University scientists are able to describe just how the process works. When the male sandgrouse reaches a waterhole, it wades in up to its stomach, then fluffs out its feathers and squats down in the water. The feathers on the bird's stomach are especially good water-holders, and the bird may spend 15 minutes rocking back and forth and soaking the feathers. When the bird gets back to its nest, it stands up and fluffs out its feathers so that the young can strip the water from them. The closer the nest is to the waterhole, the more water the male bird can bring, since water evaporates quickly in the hot, dry desert air.

Crime-busting chemists are using the latest laboratory techniques to track down lawbreakers. In a recent case, reported in the journal *Chemistry,* firemen were suspicious of a blaze that destroyed a building. So they called in a special team of chemists. Using sensitive instruments, the chemists found faint traces of gasoline fumes in the air around the charred ruins. They concluded that the gasoline could have been used to set the fire.

Not just any gasoline, however. After careful sleuthing, the chemists identified impurities in the gasoline. This enabled police to locate the station that sold the gasoline. The station attendant identified the man who had bought it, and the man was arrested, tried, and convicted of deliberately starting the fire.

A robot sailboat is being built. Its maker, the RCA Corporation, expects the boat to be able to sail itself to any point at sea by radio, stay there up to a year, and then return when it receives the proper radio signal. The boat could be used as a floating platform to chart ocean currents, report the weather, relay radio messages, and aid navigation. The only "crew" aboard will be a computer that will act as navigator and pilot. Receiving radio signals from an orbiting navigation satellite, the computer will determine the boat's position. It can then change the boat's course by turning the sail and rudders.



Walking upside down on a smooth ceiling *(see top of page)* is easy for the gecko lizards of the tropics. But how do they do it? Their toes aren't sticky, so they obviously don't use an adhesive, as flies do. Nor do they seem to have suction cups on their toes, as some frogs do. Instead, the toes of geckos are ridged *(Photo 1)*. And the ridges, as seen through an ordinary microscope, consist of thousands of tiny bristles *(Photo 2)*. Looking at these bristles recently through a new kind of high-powered microscope, scientists discovered the gecko's secret. One of the scientists, Dr. Joseph F. Gennaro, Jr., describes it in *Natural History* magazine. Each bristle divides several times into smaller and smaller fibers *(Photo 3)*, and the last fiber ends in two suction cups *(Photo 4)*, about 8 millionths of an inch in diameter. With millions of these tiny suction cups on its toes, the gecko has no trouble walking upside down—even on glass, or other very smooth or slippery surfaces.

nature and science
TEACHER'S EDITION

VOL. 7 NO. 7 / DECEMBER 15, 1969 / SECTION 1 OF TWO SECTIONS

THE IMPORTANCE OF MEASURING—PART 3

Culture, Science, and Measuring

by Roy A. Gallant

■ People of primitive cultures seem to get on perfectly well without standards of measurement and devices for measuring things precisely. But a technological culture can not develop without the sophisticated methods of measuring that make such processes as mass production and scientific research possible.

In such a culture, the ability of many people to measure precisely in accordance with a given standard is valuable to the individual, and perhaps vital to the survival of the culture itself.

We can suppose that precision in measuring evolved erratically as men first began mixing vegetable dyes, then making glass, then alloys of metals. Discovery through trial and error might have spurred them to devise a more precise way to measure materials. For example, by patient trial-and-error experimentation, men of prehistoric times learned that a bronze cutting tool with a certain ratio of tin to copper would hold its cutting edge better than another cutting tool made of an alloy with a different ratio of tin to copper.

Over the ages, we have refined not only our systems of measurement, but our measuring tools as well. Nearly always the refinements have been in response to a need to find out more precisely what something is, or how something works. The design of a better tool often serves science by refining our knowledge of a thing or a process. Science may then turn around and advance the technology that gave science the push in the first place. The process is circular and, therefore, never-ending.

Quantifying Is Not a Panacea

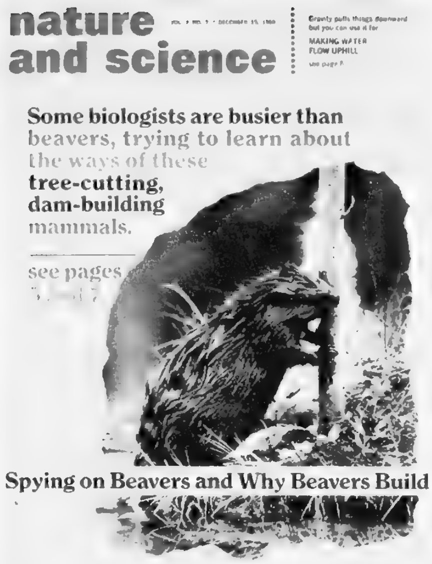
Each decade, it seems, quantitative science comes up with new ways of showing us the world. The electron microscope and radio telescope are two examples. But there are many aspects of our lives that quantitative science alone cannot tell us about, at least not directly.

Although we can measure performance, intelligence, and perception to some extent, we cannot pin them down with the sureness of *pi*.

The psychologist is asked to measure human phenomena even more nebulous—anxiety, hate, love, hope, despair. These emotions cannot be measured directly. They are far too complex to be explained by simple quantitative measurement. But often they produce physiological effects that a biochemist or neurophysiologist can measure directly. However, the sum total of such measurements does not add up to a definition of love or despair, nor does it do very much to improve our understanding of them.

Although man is a measurer, his quantitative approach to an understanding of the world, and of himself, is not a panacea. It is only one of several useful ways of looking at the world, and at our responses to it ■

Roy A. Gallant is an editorial consultant to Nature and Science *and author of numerous science books and textbooks for children.*



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T-4T.)

● **Speed-Ups, Slow-Downs and Other Changes in Motion**
Simple investigations show your pupils how to detect acceleration and the forces causing it.

● **Spying on Beavers Why Beavers Build**
How biologists are studying the behavior of this little-understood mammal, in the wild and the lab.

● **Making Water Flow Uphill**
Your pupils can make and investigate a siphon, then test their learning with siphon puzzles.

A Garden without Soil
By growing plants in water or gravel, your pupils can find out how the absence of certain minerals affects plant growth.

● **Man the Measurer—Part 3**
The series ends with a discussion of the metric system's advantages and the arguments for and against adopting it in the United States.

● **Brain-Boosters**

IN THE NEXT ISSUE

Beginning a series on atoms and nuclear energy . . . How anthropologists learn about dead humans from their bones . . . Is Traill's flycatcher one species of bird, or two? . . . The forms of frozen water that fall in winter . . . Is your body temperature normal?

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Speed-Ups, Slow-Downs

This SCIENCE WORKSHOP article explains the scientific concept of *acceleration* (any change in speed or direction of motion), and shows your pupils how to detect acceleration and the forces that cause it. After your pupils have completed their investigations, have them compare their findings.

Topics for Class Discussion

- *Why do you think most people use the word "accelerate" only to mean "speed up"?* Perhaps because the gas pedal of an automobile is called the "accelerator." We tend to think it is just for pushing, to make the car go faster, but what happens to the speed of the car when the driver "eases up" on the accelerator? (The motor slows down, giving the car some backward acceleration that slows it down.)
- *Can you think of two other ways a driver accelerates a moving car?* Pushing the brake pedal accelerates it backwards. Turning the steering wheel accelerates it sideways.
- *How does an artificial satellite accelerate when it is launched, while in orbit, and when it returns to the earth?* Thrust from rockets accelerates the satellite forward to lift it into space, then sideways to push it into orbit. Gravity provides the centripetal force that keeps accelerating the satellite sideways so it moves in a curved path around the earth *(see "What Makes Things Go in Circles?",* N&S, *Dec. 1, 1969).* A rocket fired forward accelerates the satellite backward to slow it down so gravity can pull it to the earth.
- *What makes the bubble in a hand-held bubble accelerometer move in the same direction you move when you take a step?* For a fraction of a second after the tube is accelerated forward, the water in it piles up against the "back" end of the tube, pushing the bubble forward. Then, as the water accelerates forward, the bubble returns to the higher end of the tube.

Beavers

Probably beavers are second only to humans in their ability to change the environment to suit their needs. They create and maintain their own environment much as humans do. Beaver behavior and survival are strongly linked, and knowledge about beavers may give clues to a better understanding of how mammals in general respond to their environment.

The quest for beaver skins was the motivating force behind much of the exploration of North America. Beau Brummel in England established the vogue for beaver hats. The demand for beaver fur was so great that the species was practically wiped out east of the Mississippi River. Then, early in the 19th century, silk replaced beaver fur in the making of men's hats and the beaver boom was over. Protective laws and transplanting of beavers by state conservation departments have helped restore these mammals in many states. Limited trapping is now permitted. Beavers sometimes become a nuisance, flooding orchards and roads, or conflicting with man's interests in other ways. In such cases, the beavers often are trapped alive and moved to areas where they may do less damage.

Both sexes of beavers have a single opening (the *cloaca*) for excreting wastes and for reproduction. It is impossible to tell the sex of a beaver externally unless the animal is a nursing female. This is why the discovery of a sex-determination method based on a blood sample was such a breakthrough in behavioral studies of wild beavers.

Your pupils might be interested in some further studies of Dr. Lars Wilsson ("Why Beavers Build"). He raised one European beaver for a year and a half, all the time making sure that the animal never saw or heard running water. In the beaver's cage was a large tub of standing water.

Dr. Wilsson put a loudspeaker at one side of the tub above the water level and "played" the sound of running water. The beaver started building a dam at that side of the tub, and built every night Dr. Wilsson "played" to it. This is strong evidence that the beaver's dam-building response to the sound of running water was an inborn characteristic.

Making Water Flow Uphill

By investigating siphons as suggested on page 8, your pupils can find out enough about siphon action to solve the "puzzles" on page 9.

A few simple demonstrations will help your pupils understand how a siphon works. Point out first that if you have a clean piece of tubing, and if you don't mind getting some of the liquid in your mouth, you can "fill" the tube to start the siphon action by using it as a "straw."

Your pupils probably know that when they suck the air out of a straw in a glass of liquid, the liquid is pushed up through the straw by the weight of atmospheric air pressing down on the surface of the liquid. Not *all* of the air that is pressing on that surface, but just a "column" of air the same diameter as the inside of the straw, extending from the surface of the liquid up to the top of the atmosphere *(see "Discovering an 'Ocean' from the Bottom" and Teacher's Edition,* N&S, *Nov. 11, 1968).*

To start the siphon action by "sucking" water through the tube, make

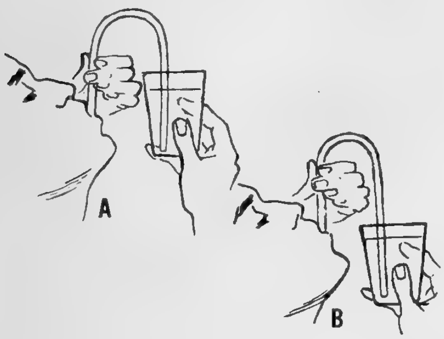
(Continued on page 3T)

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.

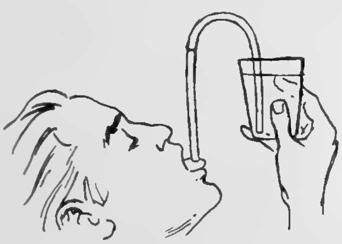
Using This Issue . . .
(continued from page 2T)

sure that the "output" end of the tube is below the level of the water in the glass when you remove the end of the tube from your mouth *(Diagram A)*.



Now, try to start the siphon action as before, but this time with the output end of the tube *above* the level of the water in the glass *(see Diagram B)*. When you remove the tube from your mouth, water in it will flow back uphill and into the glass.

Now, with the output end lower than the water level in the glass, suck water through the tube until it reaches a point in the output side between the top of the tube and the level of the water in the glass *(see diagram)*. At



that point, seal the end of the tube with your tongue. The water will stay there, supported by the air in the end of the tube. Remove your tongue from the end of the tube and open your mouth at the same time. Again the water will flow back into the glass. Can your pupils figure out why the water does not fall down the output side in these two cases?

An astute pupil might suggest that when the output end of the tube is lower than the surface of the water in the glass, the column of air pushing air up into the output end is a tiny bit taller than the column of air pushing water up into the input end of the tube. This is so, but the same condition exists when the water flows out of the output end of a filled tube and starts the siphon working. So the slightly greater air pressure at the output end can't be what makes water flow back into the glass.

By now, your pupils probably see that for siphon action to start, there must be more water in the output side of the tube than there is in the input side (between the top of the tube and the surface of the water supply). The reason is that the pull of gravity is greater on the larger mass of water, so whichever side contains the most water is the side the water will fall out of. As soon as the water begins to fall out of one side, atmospheric pressure pushes water or air up into the other side.

If the water from the output side rises up to the level of the water in the supply glass, both sides of the siphon will contain the same amount of water. The pull of gravity will be equal on the water in both sides, and so will the atmospheric pressure, so the siphon action will cease, leaving the tube full of water.

Man the Measurer

The final article in this series tells your pupils some advantages of the metric system of measurement over the English system, and reviews some of the arguments for and against adopting the metric system in the United States.

If this article does not persuade your pupils that the metric system is easier to use, then actually measuring with metric units — and especially manipulating (adding, subtracting, multiplying, dividing) such measurements—should do the trick.

Since scientists the world over already use the metric system, adopting it for all of our measuring is mainly a question of technology and economics.

- Have your pupils think of some of the things we would have to change in shifting to the metric system: new measuring tools, from rulers to car odometers and speedometers; new sized containers, and adjustments in machinery to fill and handle them; new scales for weighing things; new standard sizes for nuts and bolts, screws, pipe, and replaceable parts for automobiles and other machinery. Your pupils can probably think of many more.

If this seems a hopelessly big job to do, point out that many of the necessary changes can be made gradually, over a period of years. A 1970 auto, for example, has few if any parts exactly like those in a 1958 model; as parts are redesigned, they can be made to metric system measurements. In a screw-making machine, the die that cuts the screws wears out after cutting 200,000 screws; it can be replaced at no extra cost with a die that makes screws to a metric measure.

Changing a single milk packaging machine to fill 2-liter cartons instead of 2-quart cartons would cost about $6,000. But such a machine fills about 45 million cartons a year, so the change would be paid for in one year at a cost of less than 2/100ths (0.0133) of a cent per carton.

While England is a smaller country than ours, changing to the metric system there poses the same kinds of problems it would here. Yet England expects to complete the change by 1975. That will leave the U.S. and Canada the only two major countries doing most of their measuring in the archaic English units.

Brain-Boosters

Mystery Photo. Tiny pieces of dirt caught under the blades of windshield wipers scratch the windshield in curved lines when the wipers are in use. Dust then collects in the scratches while the wipers are at rest. In cold weather, frost tends to form first around the dust particles in the scratches.

You can demonstrate this effect to your class on a day when the air temperature is 32°F. or lower. Simply pour a little hot water on a car windshield (one that is old enough to be sure to be scratched), and let the class watch as the ice crystals form almost immediately.

What would happen if? Of course, there will be no change in weight as an ice cube changes to water. One of your pupils may point out that some of
(Continued on the next page)

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

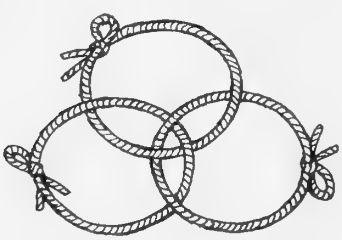
the water formed from the melting ice will evaporate, but this change in weight will be too small to affect an ordinary scale immediately.

You can make a simple balance quickly by suspending a thin strip of wood by a string at the center. Hang a small can with an ice cube in it at one end of the stick, and a small weight at the other end. Move the weight back and forth along the stick until it balances.

What happens if you leave the melt-water uncovered for a long time? What if you cover the can containing the water (and adjust the weight on the other side to balance the scale again)?

Can you do it? Your pupils will probably find that the hardest combination of fingers to move together is that of the middle and little fingers. If any member of the class is skilled at playing any stringed instrument, perhaps he could bring it to class to show his classmates how he must move his fingers while playing. Are his finger movements more "flexible" than those of most of his classmates?

Fun with numbers and shapes. The diagram shows one way to link three loops of string so that they all come apart if any one is cut. Can your pupils find another way?



For science experts only. Many of your pupils may guess that the compass directions were meant to be seen from behind, or in a mirror. But if they try looking at them in these ways, they will see that the directions are still incorrect. The compass directions were printed on a light fixture for the ceiling. If your pupils hold the magazine page over their heads, with the arrow for "north" pointing behind them, they will see that the directions look quite normal.

nature and science

VOL. 7 NO. 7 / DECEMBER 15, 1969

Gravity pulls things *downward*, but you can use it for . . .

MAKING WATER FLOW UPHILL

see page 8

Some biologists are busier than beavers, trying to learn about the ways of these tree-cutting, dam-building mammals.

see pages 5 and 7

Spying on Beavers and Why Beavers Build

nature and science

VOL. 7 NO. 7 / DECEMBER 15, 1969

CONTENTS

PICTURE CREDITS: Cover, p. 7, Leonard L. Rue III; pp. 2-4, 6, 8-11, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 4, photo by David Webster; pp. 5, 6, 14, photos by Laurence Pringle; p. 10, photo courtesy of United States Department of Agriculture; p. 12, left, courtesy of Israel Information Service, right, United Press International; p. 13, top, Wide World Photos, bottom, courtesy of Space Craft, Inc.; p. 16, courtesy of National Bureau of Standards.

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

CIRCULATION DIRECTOR J. D. Broderick; PROMOTION DIRECTOR Elizabeth Connor; SUBSCRIPTION SERVICE Frank Burkholder

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a divison 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.

SCIENCE WORKSHOP

Do you think an automobile can accelerate and slow down at the same time? You can find out by investigating...

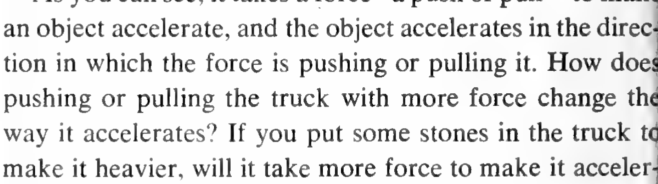
SPEED-UPS, AND OTHER CHANGES

■ The name of the game is *Acceleration,* and the goal is to find out when and how you and other objects are accelerating. Most dictionaries say that the word "accelerate" means "to speed up," or "to increase speed of motion." But scientists use the word to mean more than that, and since this is a scientific game, you must play it by the scientists' rules.

To a scientist, an object accelerates when it starts moving, speeds up, slows down, stops moving, or even when it moves in a different direction without changing its speed. Whenever an object *changes speed or direction,* it is accelerating.

Place a toy truck on the floor and give it a push. This changes its speed from no miles an hour to some miles an hour, so your push accelerated the truck. Since the truck moved in the direction in which you pushed it, you might say that you gave it *forward* acceleration. Friction between the wheels and the floor slows the truck down, so you can say that the force of friction is giving the truck *backward* acceleration.

Push the truck so that it bumps head-on into a wall. Can you explain how the wall gives it backward acceleration? Now push the truck so that it meets the wall at a narrow



angle *(see diagram).* Does the wall give it *sideways* acceleration as well as backward acceleration?

As you can see, it takes a force—a push or pull—to make an object accelerate, and the object accelerates in the direction in which the force is pushing or pulling it. How does pushing or pulling the truck with more force change the way it accelerates? If you put some stones in the truck to make it heavier, will it take more force to make it accelerate the same amount as before?

When a moving object is changing its speed or direction very slowly, you may need an *accelerometer* to help you

SLOW-DOWNS

N MOTION

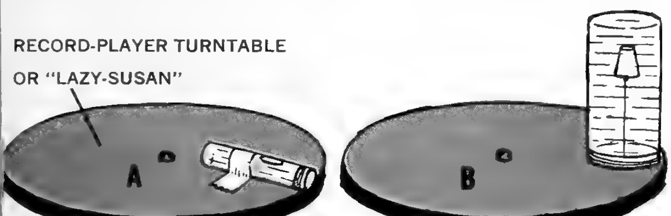
by Robert Gardner

find out how it is accelerating. You can use a carpenter's level as an accelerometer, or you can easily make one *(see "How To Make Two Kinds of Accelerometers").*

Tilt your bubble accelerometer so that the bubble is near the end of the tube that is toward you, then take a step. Which way does the bubble move as you start to walk (accelerate forward)? Which way does it move as you stop walking (accelerate backward)? How does the direction in which the bubble moves compare with the direction in which you accelerate?

Tape the bubble accelerometer to your truck and push the truck around as you did before. Can you tell by the motion of the bubble when the truck is speeding up or slowing down?

Tape your bubble accelerometer to a turntable as shown



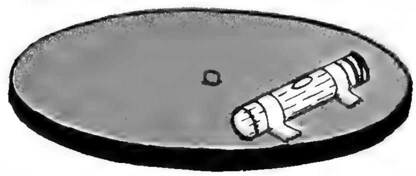
in Diagram A. Try to predict which way the bubble will move when you start rotating the turntable and when you stop it. Can you explain why the bubble moves the way it does? *(See "What Makes Things Move in Circles?",* N&S, *December 1, 1969.)*

If you place a cork accelerometer on the turntable as shown in Diagram B, which way will the cork move when you spin the turntable? What does this tell you about the acceleration of the water in the jar? About the force that causes that acceleration? Which way will the cork point if you hold the jar at arm's-length as you spin around?

Take your cork accelerometer with you the next time you go for a car ride. See if you can predict which way the cork will move when the car speeds up, slows down, or goes around a curve ■

THINGS TO TRY OR THINK ABOUT

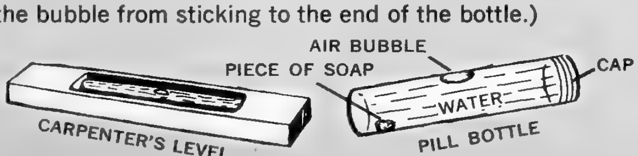
- A helium balloon on a string makes a good accelerometer in still air. Take one with you on an automobile ride. Does it behave like your other accelerometers?
- The cork and the air bubble in your accelerometers are lighter (less *dense*) than water. The helium in the balloon accelerometer is less dense than air. Try making an accelerometer using an object that is *more* dense than water. Use a stone or a metal washer in a jar instead of a cork. Test this device the same way you tested your cork accelerometer. Can you tell when you are accelerating? In what ways is this accelerometer different from the cork-in-jar device?
- Could you use a metal washer on a string to detect accelerations in a car?



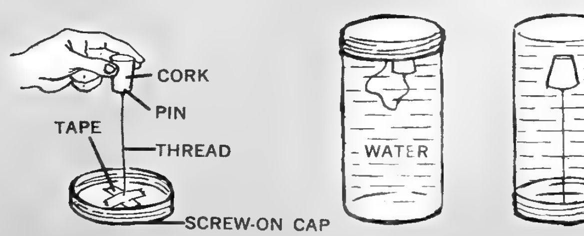
- Tape your bubble accelerometer to a turntable as shown. How will the bubble move when you start the turntable spinning? Where can you place the accelerometer so that the bubble will not move at all?

HOW TO MAKE TWO KINDS OF ACCELEROMETERS

BUBBLE ACCELEROMETERS: You can use a carpenter's level as an accelerometer, or make one by nearly filling a narrow pill bottle with water. Leave a little space at the top so that when you seal the bottle there will be a bubble inside. (Place a small piece of soap in the water to keep the bubble from sticking to the end of the bottle.)



CORK ACCELEROMETER: Stick a pin into a small piece of cork (or styrofoam) and tie a piece of thread to the pin. Tape the end of the thread to the center of the cover. Fill the jar with water, screw on the cap, and turn the jar upside down.



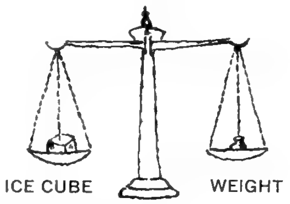
BRAIN BOOSTERS

prepared by
DAVID WEBSTER

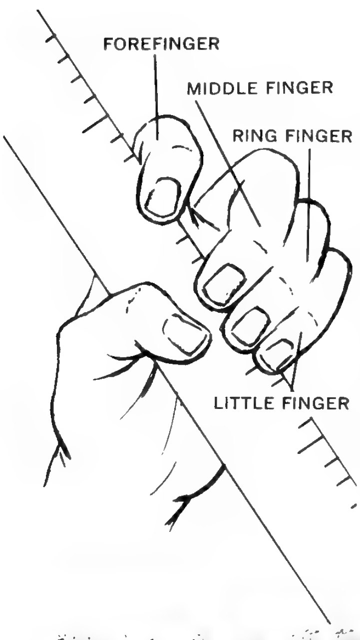
MYSTERY PHOTO What causes frost to form in this curved pattern on a car's windshield?

WHAT WOULD HAPPEN IF?

An ice cube is placed in a cup and balanced with a weight on a balance scale. What will happen to the scale as the ice melts?



CAN YOU DO IT?

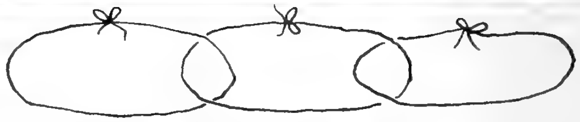


In playing the guitar, it is necessary to raise several fingers at a time and place them on different strings. Hold a ruler in your left hand as shown in the diagram, and see if you can quickly lift these pairs of fingers up and down:

Fore and middle
Middle and ring
Ring and little

Fore and little
Fore and ring
Middle and little

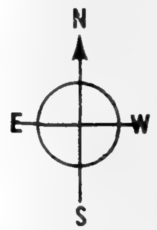
Were you able to do all of them? Which pair was the hardest? Try it with your right hand, too.



FUN WITH NUMBERS AND SHAPES

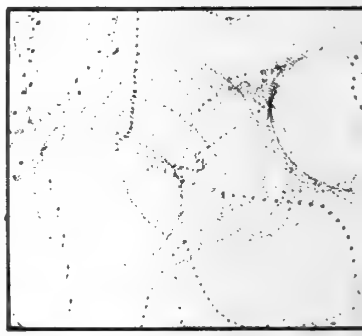
If the middle loop of string is cut, all three pieces of string will come apart. But if the loop on either side is cut, two loops will still be together. Can you connect three loops of string so that all three will come apart if any one of the three is cut?

FOR SCIENCE EXPERTS ONLY



Compass directions like these were printed on something. You can see that east and west are reversed from their normal positions. But when the thing was used, the compass directions were correct. What were the directions printed on ?

JUST FOR FUN



Here is how you can make interesting patterns with a toy top. Place a piece of carbon paper on a table with the carbon side up, and put a piece of white paper on top of it. Then spin the top so it moves around on the paper. After doing this several times, look at the underside of the paper.

Submitted by Richard Pusateri, Westchester, Illinois

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

For science experts only: When a washed glass is taken from the hot water in the kitchen sink, it becomes filled with cooler air from the room. The cool air is trapped inside the glass when it is turned upside down on the kitchen counter. As the air inside becomes heated by the warm glass and expands, some of it is forced out of the glass, making bubbles in the water around the rim of the glass.

Mystery Photo: The tracks in the snow were made by an automobile turning around. The car backed up and then went forward. Can you tell which tracks were made by the front tires and which were made by the rear tires?

What will happen if? Some water will rise up inside the jar containing the wet steel wool. As the steel wool rusts, it takes some oxygen out of the air. Water takes the place of the oxygen that is removed. Would anything happen if there were no steel wool in the jar?

Can you do it? It is difficult to throw a book into the air so that it doesn't twist sideways. Can you figure out why?

Fun with numbers and shapes: Here are two rows of figures that total 80,000 right-side up and upside down.

```
 00008
 68189
 11811
 80000
```

■ Harry Hodgdon lurked in the shadowy forest, peering through binoculars. Occasionally he spoke quietly into a small tape recorder. Then, as darkness fell, he stole quietly away, got into a car hidden nearby, and drove off.

Harry Hodgdon is a spy, but don't call the F.B.I. He spies on beavers and the "secrets" he steals are glimpses of the lives of these mammals, the largest rodents in North America.

You might think that beavers would have no secrets. For centuries they have been trapped in North America for their fur, first by Indians, then by European settlers. Many books and articles have been written about beavers. Yet there are still mysteries about their lives.

Some things that we "know" about beavers may not be true. To learn more about the lives of these mammals, biologists are keeping busy...

by Laurence Pringle

Spying on Beavers

Beavers were wiped out in many areas of North America by trappers, but are now becoming more common. At the University of Massachusetts, in Amherst, Dr. Joseph Larson decided to begin some studies of beavers in that state. Dr. Larson is now Associate Professor of Wildlife Biology at the university. He chose Harry Hodgdon, a graduate student, to "spy" on some of the beaver colonies near the university.

Red, White, and Blue Beavers

One of the biologists' first jobs was to read most of what has ever been written about beavers. But, says Dr. Larson, "Despite the bulk of material written about beavers, there is little precise information on their natural behavior.

"For example, it is reported that the male beavers start the repairs on broken dams, with females helping only if needed. Also, adults are said to force the two-year-old beavers away from the colony just before the birth of a new generation of young. But it is very difficult to tell the age and sex of a live beaver, so much of this kind of information is open to question."

In 1968, Dr. Larson and an assistant found that they could tell the sex of live beavers by taking a blood sample, then looking at parts of the white blood cells under a microscope. Then, in 1969, Dr. Larson and Harry Hodgdon picked a beaver colony near Amherst for special study.

The first step was to catch every beaver in the colony alive. For this job, Harry used big traps made of heavy wire mesh. The traps were set along the water's edge, and snapped shut when a beaver touched a trigger.

Within a week, Harry had caught eight beavers—and himself. One trap sprung as he was putting it in place, bruising his shoulder and gashing his forehead. (Ordinarily, the traps do not harm beavers.)

The captured beavers were measured and weighed, and a blood sample was taken so their sex could be determined later. Harry put a different-colored plastic marker on one ear of each beaver. Then the animals were let go.

From the size and weight of the beavers, Harry decided that the colony was made up of two adults, three yearlings, and three *kits*—young born that spring. The kits weighed only six pounds each.

Once the beavers were marked, the "spying" began in earnest. Harry has spent more than a hundred hours, mostly in the evening, watching the beavers in and around their pond. As soon as he sees a beaver appear above water near the lodge, he looks through binoculars to identify it (by its colored marker), then describes its behavior by

(Continued on the next page)

Each beaver in the colony was marked by attaching a colored plastic tag to one ear. Then Harry Hodgdon could identify the beavers as he watched them with binoculars *(see photo on page 5)*.

Spying on Beavers (continued)

speaking into a tape recorder. Later, these observations are written down in a notebook.

In the summer, Harry found that the members of the colony were definitely not "as busy as beavers." They cut down few trees, feeding mostly on small shrubs and on green algae that grew in the pond water. The adult female did what little work was needed to repair the dam.

During his visits to the beaver pond, Harry Hodgdon saw many wild animals besides beavers. "The pond is a home for fish, frogs, and many water insects," he said. "These creatures attract other animals that feed on them—raccoons, fish-eating birds, insect-eating birds. Deer feed on plants along the pond edge. A beaver pond is like a magnet for wildlife."

In the autumn, the beavers were much busier—felling trees and carrying branches into the pond, storing them for winter food. From his observations during the fall, Harry hopes to discover which beaver is "boss" of the colony, and whether certain beavers fell trees while others have different "jobs."

The Beavers' Hidden Lives

Right now, the secrets of the beavers are sealed beneath the ice and snow that cover the pond. Beavers usually spend most of the winter in their lodge, leaving it only to get food from the pile of branches stored underwater. When the ice melts from the pond this coming spring, Harry will again be watching. He will pay special attention to the three beavers that were born two springs before. Will the adults force them to leave the colony?

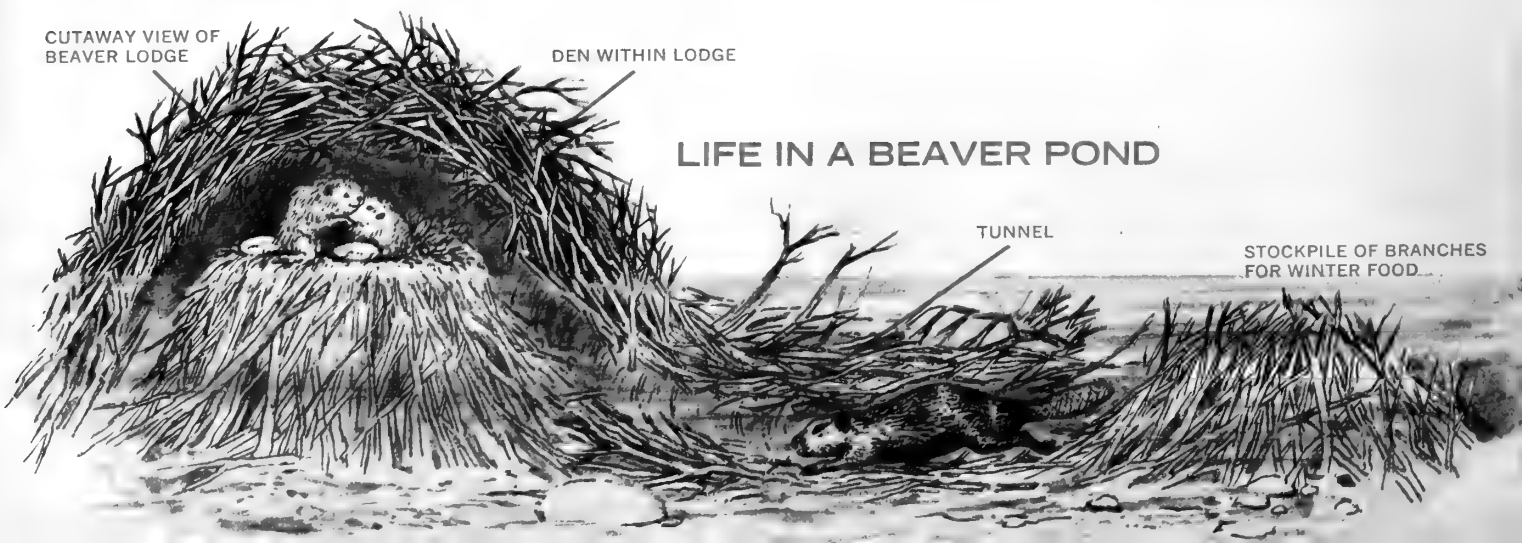
As he watches the beavers during the coming year, Harry will also try to figure out why these mammals sometimes slap the water with their big flattened tails. Most books about beavers say that the loud tail-splash is a warning of danger. Sometimes that seems to be true—a tail slap causes all of the beavers to dive underwater. At other times, however, beavers seem to pay no attention to the sound.

Much of a beaver's life is hidden from human view—outdoors at night; inside the lodge or underwater during the day. The kits don't leave the lodge until they are about two months old. Dr. Larson and Harry Hodgdon are planning other studies to learn more about the behavior of beavers—especially of the kits.

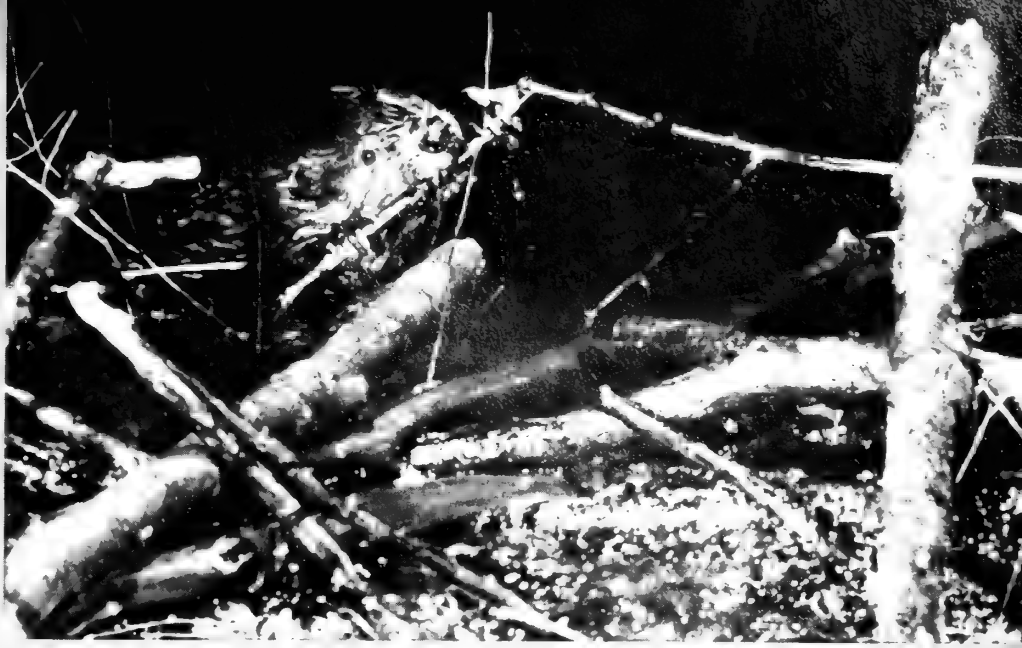
Next summer, the biologists plan to capture several kits and raise them in captivity. They also hope to mate captive beavers and then study the kits from the moment of their birth. If they can raise beavers successfully, they may be able to find out whether beavers are born with the ability to build dams and lodges, or whether this behavior is learned from other beavers. They can then compare their results with those of a biologist who is studying a different species of beaver in Sweden *(see the next page)*.

There are enough mysteries about beaver life to keep biologists *busier* than beavers for many years ■

■ Look in your library or bookstore for these books, illustrated with many photographs: **The World of the Beaver,** by Leonard L. Rue III, J. B. Lippincott Company, Philadelphia and New York, 1964, $4.95; **My Beaver Colony,** by Lars Wilsson, Doubleday & Company, Inc., Garden City, New York, 1968, $4.95.



WHY BEAVERS BUILD



■ For the past 10 years, Swedish biologist Lars Wilsson and his family have lived with beavers. He has caught baby beavers and fed them milk from bottles, raising them on his farm and later at a school. The animals he studies are European beavers, closely related to those that live in North America.

From his years of raising and observing beavers, Dr. Wilsson probably knows more about these mammals than any other human does. Some of his most fascinating studies began when he got permission to keep beavers in a huge aquarium, and began studying their dam-building behavior.

A Dammed Aquarium

The aquarium was 33 feet long and 6½ feet wide, with a glass wall on one side. Water flowed through it like a stream. The water was about 8 inches deep and flowed over a thick layer of earth, gravel, and stones. Also, after a pair of beavers had lived in the aquarium for a year, the bottom was littered with "leftovers"–uneaten sticks and branches.

One day Dr. Wilsson piled some stones in a ridge across the "stream," a few yards from the outlet. Soon the beavers built a dam, using the ridge of stones as the base. They pushed pebbles, gravel, and small sticks against the upstream side of the dam until it was smooth. The downstream side was made of a fencework of longer sticks and branches, most of them lying in line with the direction of the current. The dam was watertight, except for an overflow on one end.

The beavers now had themselves a "pond" 27 inches deep. And these beavers were only a year old and had never seen a real stream or dam before.

A Quiet Leak Is No Leak at All

From time to time, Dr. Wilsson broke holes in the dam to see how the beavers went about repairing the damage *(see photo)*. After watching the beavers for some time, he suspected that it was the sound of running water that made the beavers start their repairs.

To check this idea further, Dr. Wilsson tried increasing the flow of water so that it overflowed the dam. The beavers built the dam higher at any point where the water flowed with much force. The more the water rushed, the harder the beavers worked.

Once Dr. Wilsson made a deep furrow in the top of the dam so that water poured through it. Then he put a clear plastic hood over the furrow and stuffed bits of wood around it so he couldn't hear the sound of water rushing underneath. He could see the escaping water, though. A short distance from the plastic hood he made another furrow in the top of the dam. This furrow was above the water level.

When the beavers came to the dam they quickly filled the dry furrow with sticks and mud. This didn't stop the leak, of course, but it seemed to satisfy the beavers.

Then Dr. Wilsson made another dry furrow and replaced the plastic hood with a fine net through which the rushing water could be heard but not seen. The beavers covered the net with shredded wood. Then, having cut off the sound of rushing water, they filled the dry furrow once more.

Once again the beavers' work had failed to stop the leak but seemed to satisfy them. From his studies, Dr. Wilsson has concluded that beavers make dam repairs wherever they hear water rushing or where they see an unevenness in the top of the dam.

Later he found that he could make beavers begin work on a dam by simply playing a recording of running water. Even though there was no leak, the beavers added material to the dam at the source of the sound. Dr. Wilsson hopes to analyze and test the different sounds made by running water to find out whether the building material picked by beavers depends on the different sounds they hear.

—LAURENCE PRINGLE

MAKING WATER FLOW UPHILL

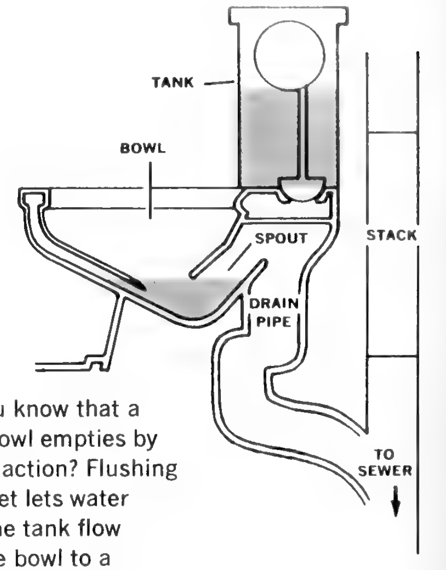
The pull of gravity usually makes water flow downhill, but the ancient Greeks found a way to use gravity to make water flow uphill. They did it with a simple bent tube, called a siphon, which we still use to move liquids from one container to another without pouring, pumping, dipping, or sipping.

You can easily make a siphon and find out how it works. Get a piece of flexible tubing at least a foot long. The rubber hose from a "bathtub shower" device will work. Clear plastic tubing (from a store that sells aquarium supplies) is better, because you can see air bubbles inside it.

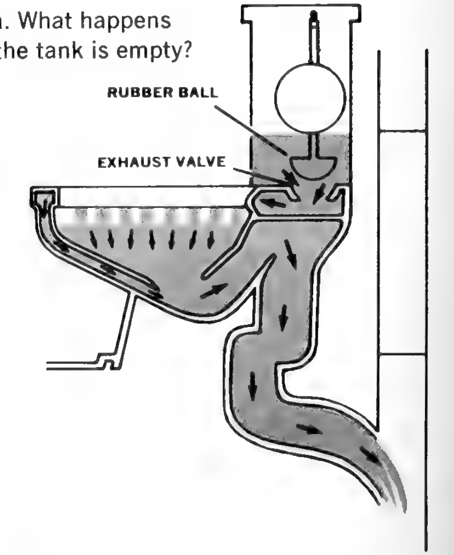
Bend the tube in a U-shape and fill it with water. Seal one end with your finger, and hold the tube straight up to let air bubbles escape from the open end. Add water to fill the tube, then seal the top end with another finger. Place one end of the tube into a glass full of water and the other end into an empty glass, then open both ends at once. Unless the tube contains some air bubbles, water will flow up through the siphon, and down into the empty glass.

Gravity pulls water out of the tube into the "empty" glass, letting the weight of the air pressing down on the water in the full glass push the water up into the siphon. Why won't this work if there is air in the tube? Can you explain why the siphon stops working when the water reaches the same level in both glasses? Will the siphon work if the full glass is higher than the other glass? Lower? Can you explain why?

The weight of the air pressing down on the water in the full glass will push water up through a siphon to a height of about 25 feet above the surface of the water. Do you think it would push cooking oil higher than water, or not as high? How about mercury?— FRANKLYN K. LAUDEN

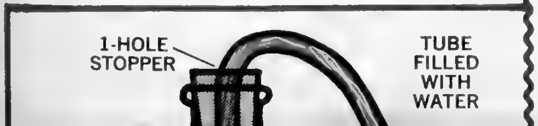


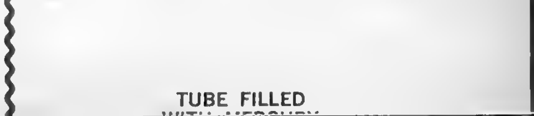
Did you know that a toilet bowl empties by siphon action? Flushing the toilet lets water from the tank flow into the bowl to a level higher than the top of the "hidden" siphon. What happens when the tank is empty?

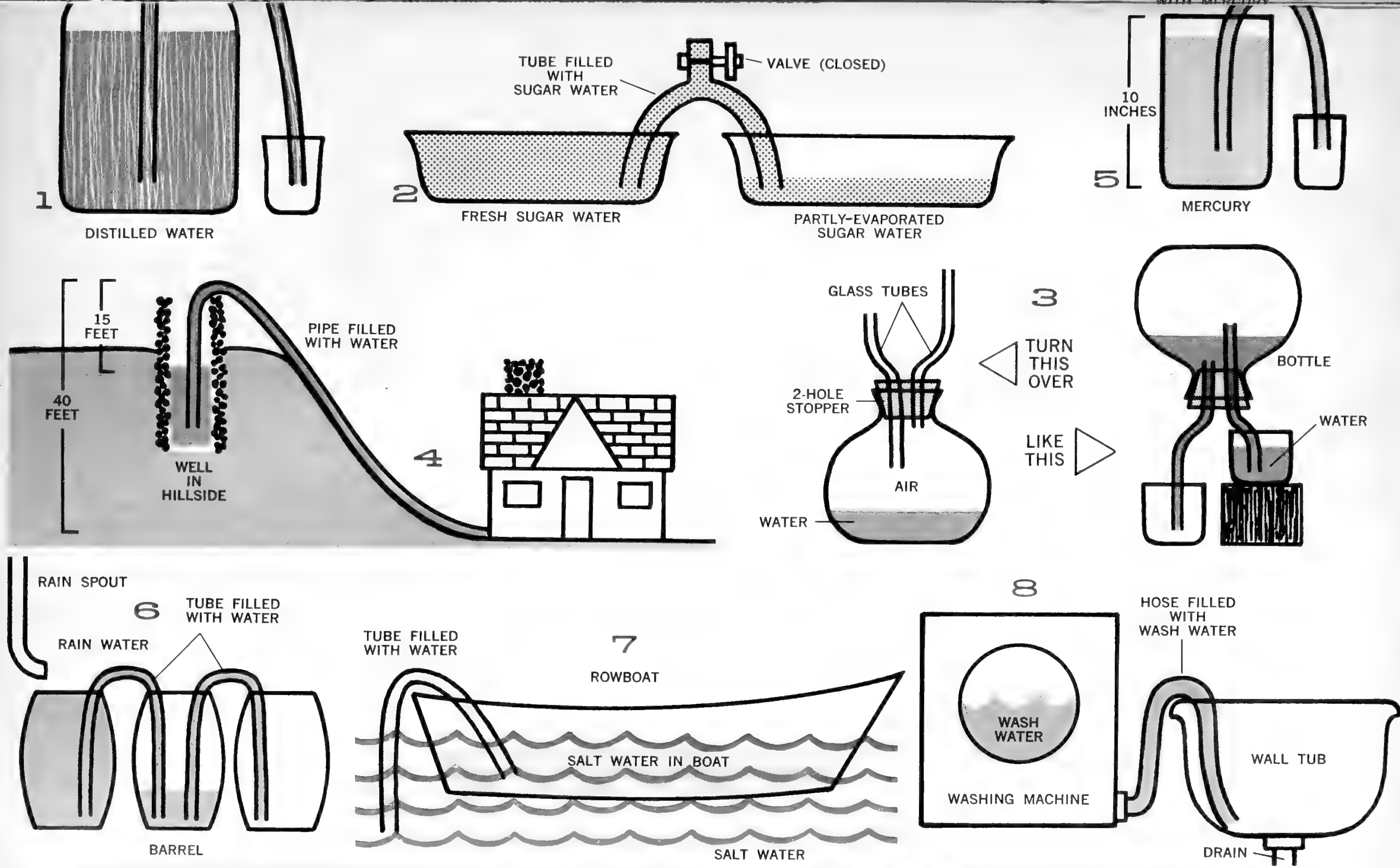


WHICH OF THESE SIPHONS WOULD WORK?

Each of these diagrams shows an attempt to use a siphon to do a particular job. Which ones will work, and where will the liquid be when it stops flowing?







ANSWERS TO SIPHON PUZZLES

1. Only a little water will run into the glass. The atmosphere is pressing down on the bottle and its stopper instead of on the water inside. **2.** Fresh sugar-water will flow until it reaches the same level in both pans. **3.** This is a self-starting siphon. The water in the bottle will start flowing down into the lower glass. This lets the air in the bottle *expand*, or spread out, so it is not pushing downward as hard as the air in the atmosphere is pushing down on the water in the upper glass. The water pushed up into the bottle will make a tiny fountain, which will run as long as there is water in the upper glass. **4.** The water (down to the end of the siphon) will flow into the house. **5.** Mercury is heavier (more *dense*) than water, but it will fill and overflow the smaller glass. **6.** The water will flow from one barrel into the next one until it reaches the same level in all three barrels. **7.** The sea-water will flow into the boat until it reaches the same level as the water around the boat. **8.** All of the wash-water will flow down the drain.

Seeds from your kitchen will grow well in . . .

A Garden without Soil

by Ed Ledford, Jr.

These potatoes have been grown without soil, in a container with water and minerals. A nylon screen holds up the plants.

■ Living things need certain minerals in order to stay alive and to grow. Plants usually get these minerals from the soil, but they can be grown without soil—as long as you give them the minerals they need.

Growing plants with water and minerals is called *hydroponics.* (*Hydro* means water, and *ponics,* cultivation.) You can grow plants hydroponically in just water with minerals, or in gravel that is watered with the mineral solution. This SCIENCE WORKSHOP tells how to grow plants hydroponically, and suggests some investigations you can try. The box on this page lists the materials you will need.

Wash the gallon jug thoroughly with soap and water, then carefully rinse all of the soap out. Put some tapwater in the jug, and add the mineral ingredients: 1 level teaspoonful Epsom salts, 1 level teaspoonful baking powder, ½ teaspoonful ammonia, 1 level tablespoonful saltpeter. Shake the jug thoroughly, fill it with water, and shake again. Your mineral solution is ready for use.

Your home probably has several kinds of seeds that will grow well hydroponically. Take some seeds from a tomato. After they dry, they will be ready for planting. Dried (not canned) white or brown beans are also good. Use the seeds of watermelon, or cantaloupe. Try the seeds of other plants you eat, such as lettuce, or the seeds of petunias or marigolds. Plant popcorn seeds. (Some of the seeds—but not many—will sprout.) You can also grow potatoes hydroponically. Cut out an "eye," attached to a part of the potato, and plant it. Potatoes grow better in a mineral solution than in gravel.

Growing in Gravel

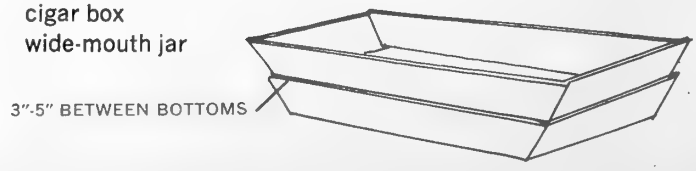
To grow plants in gravel, line the inside of a cigar box with plastic wrap so that water will not leak through, except through a small drainage hole you cut in the bottom. (You can also use a clear plastic shoe box, instead of the cigar box and plastic wrap. Drill a hole for drainage.) Fill the box with gravel, sand, or Vermiculite to an inch from

Materials You Will Need

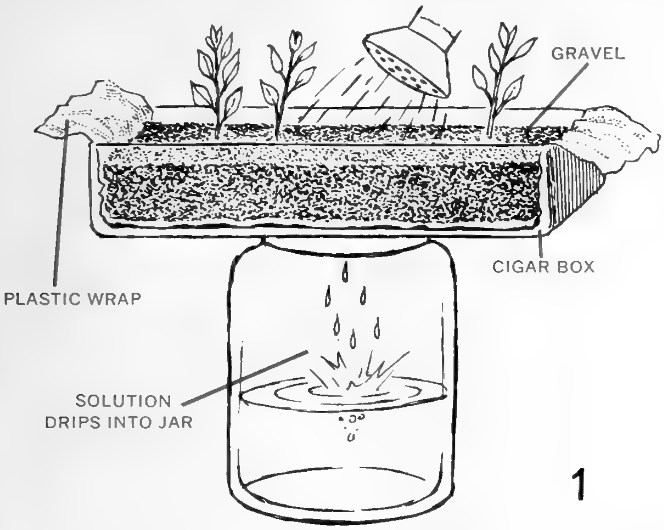
seeds
gallon jug (such as Clorox jug)
Epsom salts (from a drugstore)
saltpeter (from a drugstore)
clear household ammonia (from a supermarket)
baking powder (with *calcium phosphate*)

Also needed for growing plants in gravel:
fine gravel, sand, or Vermiculite (from a garden supply store)
plastic wrap
cigar box
wide-mouth jar

Also needed for growing plants in mineral solution:
sawdust
wide-mesh cotton gauze
2 aluminum pans *(see diagram)*



the top. Place about two dozen seeds on the surface, and cover them with another inch of gravel. (*See Diagram 1.*)

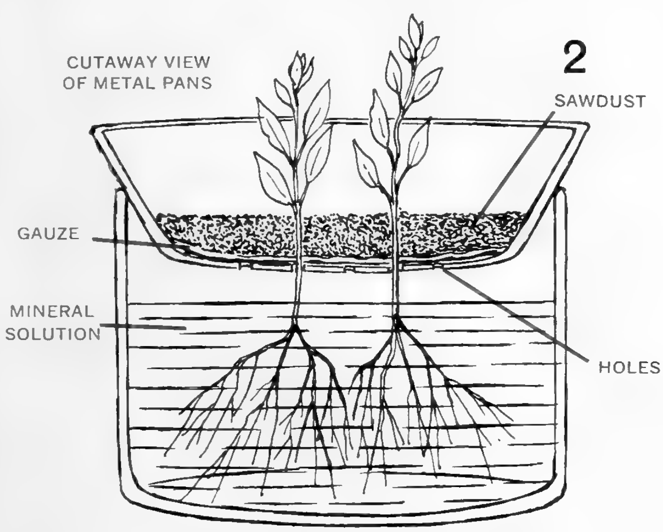


The gravel doesn't provide any minerals, but helps hold up the plants.

No more than three times a day, flood the box with mineral solution. (Let the solution drain through the hole into a jar so that it can be used again.) After your plants have sprouted, be sure to keep them in a well-lighted place.

Growing in Mineral Solution

For growing plants in a mineral solution, punch small holes in the bottom of the upper pan, every quarter-inch or so (*see Diagram 2*). The roots will grow through the



holes. Spread gauze over the bottom of the pan, and about two inches of sawdust over the gauze. The sawdust helps support the plants.

Scatter at least a dozen seeds on the sawdust. Put enough mineral solution in the bottom pan so that the liquid almost touches the bottom of the upper pan. Sprinkle mineral solution on the sawdust after planting, and whenever the surface feels dry.

After roots have grown through the holes, take away some of the liquid, to make an air space around the top of the roots. Another way of giving the roots air is to put air bubbles in the solution, by pouring the solution out of the pan and then pouring it back from a height, six or seven times. Do this every day.

Do not water the sawdust after the roots have grown through the holes. Instead, change the solution in the bottom pan every five days.

How Does Your Garden Grow?

After several weeks, you may find it necessary to make a new mineral solution. Perhaps your supply is just about used up, or your plants seem to have trouble growing. (If the leaves begin to turn yellow, your plants may also need iron, which you can buy at a garden supply shop. Ask for "chelated iron.")

On the other hand, your plants may grow so well that some block light from the others. If the plants are too close together, try to separate them by tying them to stakes, so that sunlight can reach all the leaves.

(Continued on the next page)

INVESTIGATIONS

- Does changing what is in the mineral solution affect plant growth? Grow plants from seeds, using a mineral solution made *without* one of the ingredients. At the same time, grow some plants of the same kind in the *complete* mineral solution. After several weeks, look at the average height in each group, the number and color of leaves, the color and hardness of stems, and the roots. Which group seems healthier? What happens if you double the amount of one ingredient, instead of leaving it out?

- If plants grown without one of the ingredients seem unhealthy, can you "cure" them by changing back to the complete mineral solution?

- Does "plant food" provide the minerals needed for plant growth? Add one teaspoonful of a powdered plant food, such as Hyponex, to one quart of water. Use this in place of the other mineral solution. Compare plants grown in this solution with plants of the same kind grown in the other mineral solution.

- Use tapwater instead of mineral solution for growing plants. Are young plants grown in water different from those grown in mineral solution? Find out whether plants with large seeds (such as dried beans) grow better in water than plants with small seeds (such as tomatoes). Do seedlings grown in water get any minerals?

MINERALS AND GREEN PLANTS

Some growers of tomatoes, potatoes, and other crops raise their plants hydroponically, instead of in soil. One advantage is that plants growing hydroponically can get all the air they need. Air can be pumped easily through mineral solution—but not through soil. Hydroponics is also used to grow plants in places where there is no soil at all such as on top of a coral reef.

But the main reason for growing plants hydroponically is that plants can be given just the right amounts of the minerals that they need in the mineral solution. Soil often does not have all the necessary minerals in the amounts best for growth.

Plants do not need Epsom salts, saltpeter, baking powder, or household ammonia. What most plants *do* need are some of the minerals contained in these substances. Epsom salts provide the plants with magnesium and sulfur; saltpeter, with potassium and nitrogen; baking powder, with calcium and phosphorus; household ammonia, with nitrogen.

Plants use some of these minerals to make *proteins,* substances that help living things to function and grow. Other minerals are needed to make *chlorophyll,* the green substance that the plant needs to make food.

Green plants require more than these mineral elements in order to grow. They must get oxygen and carbon dioxide from the air, and hydrogen from water. They also need other minerals, such as iron, but in very small amounts.

In this greenhouse in the Negev region of Israel, plants such as onions are grown hydroponically.

WHAT'S NEW

by
B. J. Menges

Snails as big as a man's fist are making pests of themselves in Florida. Not natives of the state, these are giant African snails *(see photo).* How did the snails get to Florida? It all started with a shell collector who took some of the snails to India in 1847. With no enemies and plenty of food, the snails multiplied rapidly in their new home. By 1900 they had spread to other parts of Asia, and travelers soon introduced the snails to Indonesia. During the 1930s and 1940s, the snails were brought to Hawaii and other parts of the South Pacific by travelers from Japan, where the snail had also become numerous. The snails quickly became a pest in Hawaii. Then about three years ago, a few of the snails were brought to Florida by a boy returning from a Hawaiian vacation. Today there are thousands in North Miami.

The giant snails, whose soft bodies may be almost a foot long, are eating the leaves off trees and the paint off houses. They seem to thrive on the calcium in paint. Ordinary pesticides have no effect on them. How can the snail population be reduced? A Florida Agriculture De-

partment official suggests that "one solution could be to eat them." That is one way in which they are controlled in Africa.

Frozen beetles have come "back to life" when thawed. Found in a decaying tree in Alaska during winter, the beetles were brought indoors by a scientist. When warmed to room temperature, the beetles moved around, apparently unharmed. The scientist, Dr. L. Keith Miller, of the University of Alaska, in College, later tested similar beetles and found that many could survive temperatures as low as 125 degrees below zero Fahrenheit.

Dr. Miller doesn't know how the beetles do it. He does know, however, that the body fluids of these beetles contain an "antifreeze" whose amount increases from zero in summer to 25 per cent of the total body fluid in winter. The antifreeze, called glycerol, seems to lower the freezing point of the beetles' body fluids by 10 degrees. Dr. Miller suspects that after most of the body fluids freeze, glycerol helps keep the fluids inside the cells from freezing. This may be the beetles' key to survival.

Will Mount Rainier erupt in the near future? A dormant volcano, Washington's highest peak apparently produced its last major eruption about 550 years ago. But now the 14,410-foot mountain is showing signs of what may be renewed volcanic activity. One sign is an increasing number of slight earthquake tremors. These could be caused by molten rock pressing upward from deep within the earth. The buildup of pressure from molten rock can cause a volcano to erupt.

A second warning sign comes from recent *infrared* (heat) photographs of the mountaintop. These appear to show a hotspot that wasn't present in earlier pictures. Neither sign is definitive evidence that Mount Rainier is likely to erupt soon. But scientists of the United States Geological Survey say that a close watch should be kept on the mountain.

Invisible shields for aircraft might prevent many mid-air collisions. The "shield" consists of radio signals sent out at frequent intervals in all directions from the plane. When two planes come too close to one another in the sky, their radio shields brush, and a warning alarm

sounds in each cockpit. If the planes are on a collision course, a red light flashes in each cockpit, and a computer in each plane operates a warning dial *(see photo)* that directs the pilot to climb, fly level, or dive. For instance, one pilot may be ordered to climb, while the other is told to dive.

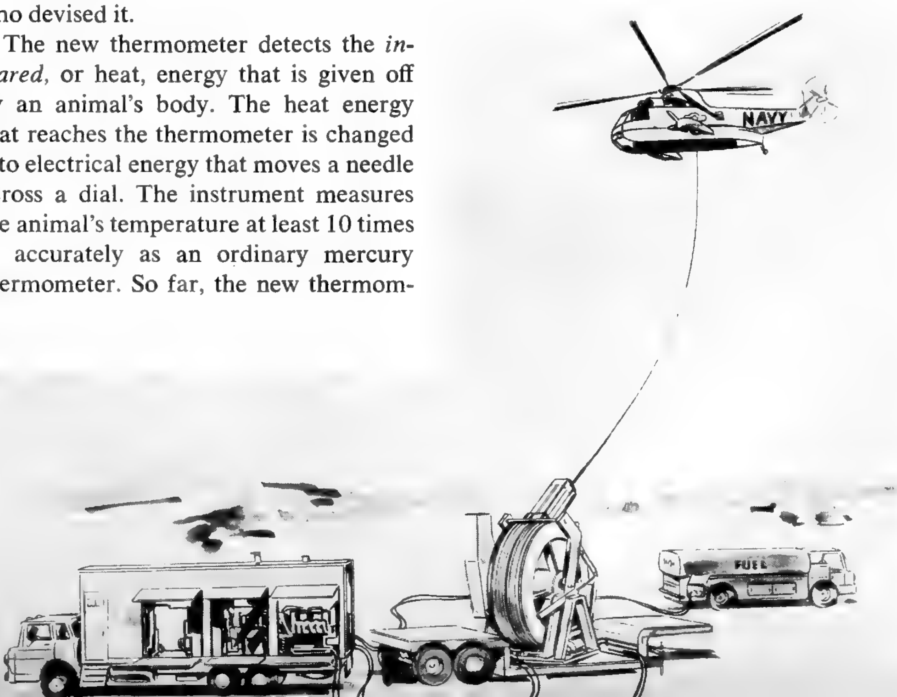
In recent tests, the new system has worked well. But it's expensive to install in a plane, and many airplane owners probably couldn't afford to do it, or wouldn't want to. Other means of avoiding collisions will also be needed. The United States had 38 mid-air collisions in 1968. Unless preventive measures are taken, the number is bound to increase as the skies become more crowded in the years ahead.

Taking an animal's temperature may be easier now with a new kind of thermometer devised by a scientist at the Michigan State University Center for Laboratory Animal Research, in East Lansing. Previously, an animal had to be caught and held for at least three minutes while its temperature was being taken. By just pointing the new thermometer at an animal, you can take its temperature in just a fraction of a second, according to Dr. Lawrence A. Julius, the scientist who devised it.

The new thermometer detects the *infrared*, or heat, energy that is given off by an animal's body. The heat energy that reaches the thermometer is changed into electrical energy that moves a needle across a dial. The instrument measures the animal's temperature at least 10 times as accurately as an ordinary mercury thermometer. So far, the new thermometer has been used only on dogs and cats. But Dr. Julius hopes soon to be able to use it for many other kinds of animals as well.

A helicopter on a string is what the Navy's new experimental project looks like *(see photo)*. The "string," however, is an aluminum refueling tube that makes it possible for the helicopter to remain aloft almost indefinitely, without running out of fuel. Only ⅝ of an inch thick, the tube is flexible enough to stand repeated winding and unwinding from a 10-foot drum, yet strong enough to withstand 60-mile-an-hour winds while the helicopter hovers as high as 10,000 feet above the ground. With a constant supply of fuel coming from the tube, an automatically-controlled, unmanned helicopter would never have to come down until it needed repairs or servicing.

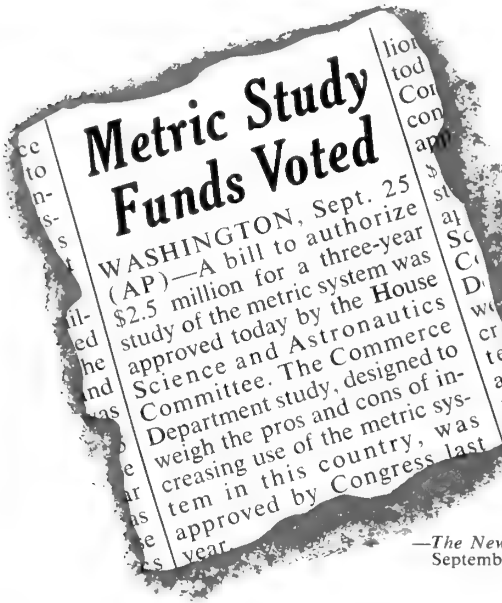
The new system can use any standard helicopter, with or without a human pilot. One truck carries the aluminum tube on its reel, another truck carries equipment to power the reel and pump the fuel through the tube, and an ordinary fuel truck carries the fuel. Aside from having military uses, the new system may be used wherever a "stationary platform" in the air is needed. For example, television signals sent out from such a platform 10,000 feet above the ground could be received over a much wider area than signals sent from a transmitter tower on the ground. Can you think of other ways a system like this might be used?



What's Wrong with an Inch?

Should we give up our English system of measuring and change over to the metric system? Some say "yes," others say "no."

by Roy A. Gallant



Metric Study Funds Voted

WASHINGTON, Sept. 25 (AP)—A bill to authorize $2.5 million for a three-year study of the metric system was approved today by the House Science and Astronautics Committee. The Commerce Department study, designed to weigh the pros and cons of increasing use of the metric system in this country, was approved by Congress last year.

—*The New York Times*, September 26, 1969

■ The newspaper story above might also have added this: In 1866 Congress passed an act making it legal to use the metric system in the United States. But the system was never adopted as the official system of measurement here.

Some people say it should be. Others say no. The fact is that we and Canada are the only two major countries in the world that have not adopted the metric system as our official system. England plans to switch from the English system to the metric system by 1975.

Is there something "wrong" with our English units of inches, feet, pounds, tons, pints, gallons, bushels, and so on?

Harder To Learn, Harder To Use

There's nothing *wrong* with them at all. But when you compare our measuring system with the metric system, you find that the English system is harder to learn and harder to use. Also, as the United States trades more and more with other nations, it will be much easier and less costly to use the same measuring system that nearly all of the rest of the world uses.

You may think that the metric system is harder than the English system. That is only because you learned the English system first and now feel comfortable with it. Look at it this way:

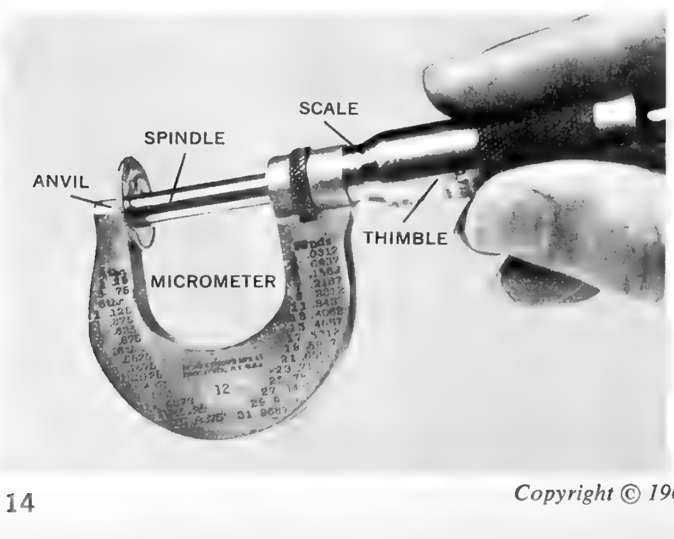
With the English system we measure short distances in inches and fractions of inches. We get smaller and smaller fractional units (½ inch, ¼ inch, ⅛ inch, ¹⁄₁₆ inch, and so on) by *halving* the inch, than halving the half-inch, and so on. But we do *not* get units larger than the inch (1 foot, 1 yard, and so on) by *doubling* the inch, then doubling the new unit. For someone just learning the English units, it is hard to remember that 1 foot is 12 inches, 1 yard is 3 feet, and 1 mile is 5,280 feet (or 1,760 yards).

Now look at the metric system. Each unit smaller than the meter is 1/10th of the next larger unit, and each unit larger than the meter is 10 times the next smaller unit *(see table)*. Such a system is called a *decimal* system. Not only is it easier to memorize the values of the units in the metric than in the English system, but the metric system units are much easier to use when we try to make fine measurements, as we pointed out in Part 2 of this series.

Converting from one metric unit to another metric unit is simpler than converting from one English unit to another English unit. (How many yards make 3 miles? What part of a yard is 4 inches? How many meters make 3 kilometers? What part of a meter is 4 centimeters?)

Again, what makes it easier to convert from one unit to another in the metric system is that the metric system is a decimal system.

Machinists and other craftsmen in the United States who make very fine measurements use a decimal inch—



A *micrometer* measures the thickness of a dime. Each complete turn of the *thimble* moves the *spindle* 25/1,000ths (0.025) of an inch away from the *anvil*. The *scale* shows that the thimble was turned through 1-20/25ths turns, so the dime is 0.025 plus 0.020, or 0.045 inch thick.

an inch divided into tenths. A machinist's rule is nearly always marked in tenths of inches along one edge, and in 64th-inch units along the other edge. The tenths, hundredths, and thousandths units in the decimal inch are much easier to work with than the fractions of an inch most of us use. But measurements as fine as hundredths and thousandths of an inch are not made with a simple ruler, of course. Special instruments are used.

Measuring Weight and Volume

There is another important difference between the metric system and the English system. In the metric system the meter is the basic unit of measure. All other units in the system are related to the meter. That includes not only units for measuring length, but also units for measuring *mass* and *volume*. (The mass of an object or substance is the amount of matter that makes it up.We usually measure the mass of an object or substance by weighing it. The volume of an object or substance is the amount of space it takes up.)

When the metric system was first set up, the basic unit of mass was called the *gram*. One gram is the mass of the water that would fill a cube that is one centimeter along each edge. One thousand grams is equal to one kilogram (about two pounds).

The amount of space that one kilogram of water takes up—1,000 cubic centimeters—is called one *liter*. (A liter is equal to about one quart.) So, units for measuring mass and volume are based on the basic standard of length, the meter.

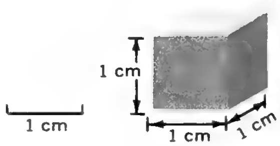
PROJECT

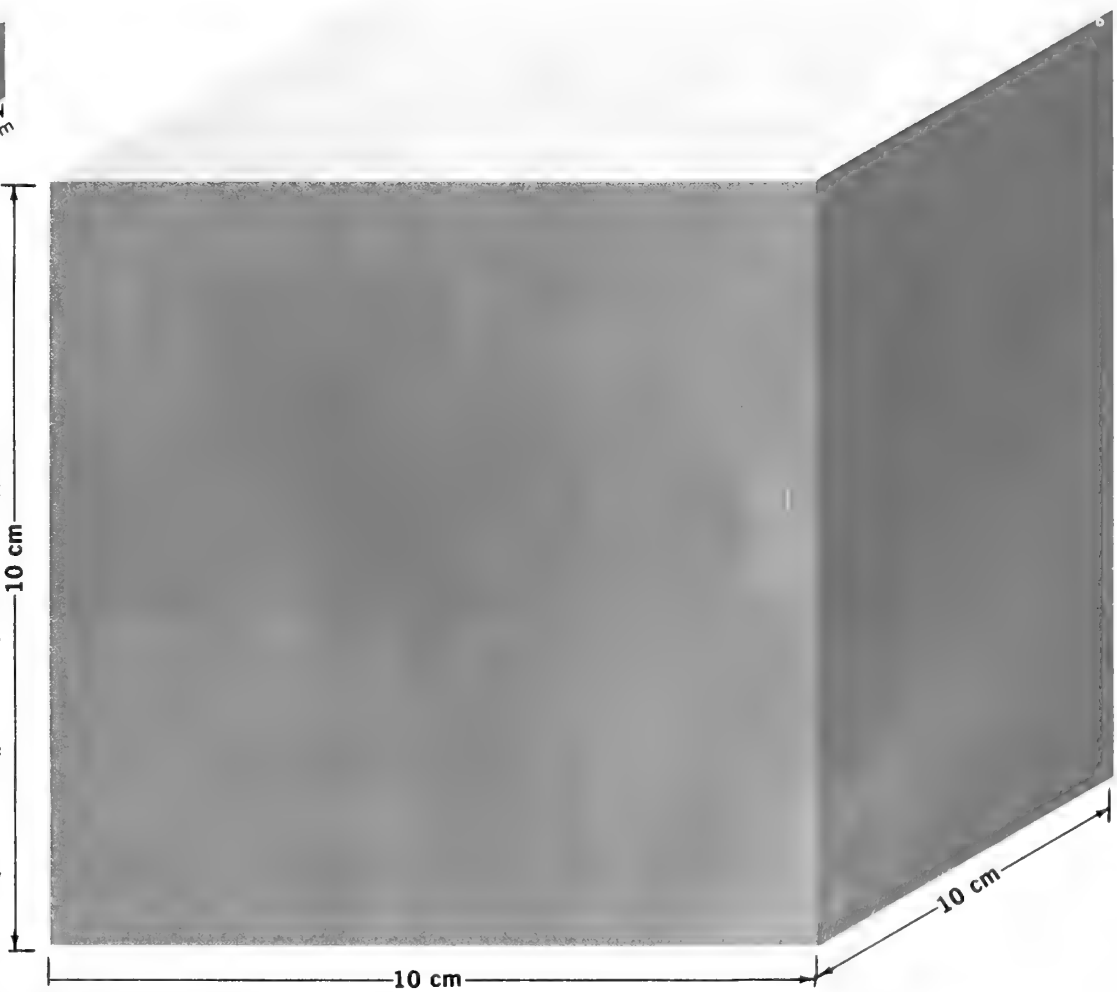
Look for a table of the units of mass (weight) in the English system. (You can probably find one in a dictionary, under "measure" or "weight.") How many tables of units of weight are there? Can you arrange *all* of those units in a single table of mass units like the metric system table on page 16? How about the English units of volume (capacity)?

Units of mass and volume in the English system grew up in a helter-skelter way. They were not all based on any *one* standard, as are mass and volume units in the metric system.

Our English system of weights is dreadfully mixed-up. We have a long ton, which equals 2,240 pounds, and a

(Continued on the next page)





The metric unit for measuring volume is based on the length of 1 centimeter. A cube measuring 1 cm along each edge fills 1 cubic centimeter of space, and 1 *liter* is equal to 1,000 cubic centimeters. (A liter is about the same volume as 1 quart. Do you know how many cubic inches equal 1 quart?) The metric unit for measuring mass (weight) was originally based on the centimeter. The mass of 1 cubic centimeter of water (at a temperature of about 39° F., when water is most dense) was called 1 *gram*. How much would 1 liter of water at that temperature weigh?

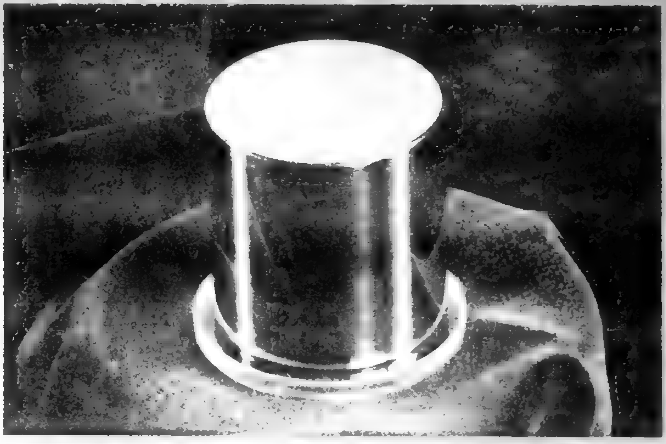
short ton, which equals 2,000 pounds. There are even two different kinds of pounds—one avoirdupois pound equals 1.215 troy pounds (also called apothecary pounds). There are 16 ounces in the avoirdupois pound, and 12 ounces in the troy pound, so one troy ounce equals 1.097 avoirdupois ounces. We have in addition scruples, carats, short and long hundredweights, grains, and drams. And for measuring volume we have such units as the bushel, gill, teaspoon, and minim. There is one group of units for measuring the volume of liquids and another group of units for the volume of dry substances.

The English system of weights and volumes is so mixed up that you would have a hard time finding one person who knows all of the units and their values. Units in the metric system do not have to be remembered in so painful a way. In nearly all cases, the name of the unit tells you its value. One *milli*meter equals 1/1,000th of a meter; one *centi*meter equals 1/100th of a meter; one *deci*meter equals 1/10th of a meter, and so on.

Switching to the Metric System

Since the metric system is so much easier to use than the English system, why don't we use it in this country? Earlier, we said that machinists and certain others have switched from the fractional inch to the decimal inch. If they were going to switch, why not switch over to meters, centimeters, and millimeters? One reason is that it was easier to think in inches and tenths of inches than to learn to think in units whose lengths are so very different from the inch.

Another reason is expense. Some machine manufacturers say that they would face at least three very big expenses if they had to change over to the metric system: 1) They would have to change all their machinery to make things according to metric measurements instead of inches.



This metal cylinder, 39 millimeters high and 39 millimeters in diameter, is our national standard of mass. Made of platinum and iridium, it is a copy of the international Standard Kilogram kept near Paris, France. Our Standard Kilogram is kept in a special chamber at the National Bureau of Standards, in Gaithersburg, Maryland.

2) For several years during the change-over, they would have to keep making spare parts for old cars and household machines by the inch system. At the same time, new machines made according to metric system units would be coming out, and their parts would not fit the old machines. 3) Workers would have to be trained to use the new system, and would probably make many costly mistakes in measuring while they were learning.

Still, there is a move toward the metric system in this country. Scientists, engineers, and others are trained in the metric system. So are people whose business is trading with foreign nations. Many high schools and junior high schools, and some elementary schools, now teach the metric system along with the English system.

The simple fact is that nearly all of the rest of the world uses the metric system. If we expect to take part in that world by selling our products and buying from others, we would do well to change over to the metric system. Any scientist can tell you the savings in time, thought, and money he enjoys because he and his fellow scientists the world over speak the same "language of measurement." As costly as it would be for a maker of ball bearings, say, to change over to the metric system, it becomes even more costly for him the longer he puts off making the change ■

THE METRIC SYSTEM

UNITS OF LENGTH		UNITS OF MASS		UNITS OF VOLUME	
10 millimeters (mm)	= 1 centimeter (cm)	10 milligrams (mg)	= 1 centigram (cg)	10 milliliters (ml)	= 1 centiliter (cl)
10 centimeters	= 1 decimeter (dm)	10 centigrams	= 1 decigram (dg)	10 centiliters	= 1 deciliter (dl)
10 decimeters	= 1 meter (m)	10 decigrams	= 1 gram (gm)	10 deciliters	= 1 liter (l)
10 meters	= 1 decameter (dkm)	10 grams	= 1 decagram (dkg)	10 liters	= 1 decaliter (dkl)
10 decameters	= 1 hectometer (hm)	10 decagrams	= 1 hectogram (hg)	10 decaliters	= 1 hectoliter (hl)
10 hectometers	= 1 kilometer (km)	10 hectograms	= 1 kilogram (kg)	10 hectoliters	= 1 kiloliter (kl)
		1000 kilograms	= 1 metric ton		

nature and science

TEACHER'S EDITION

VOL. 7 NO. 8 / JANUARY 5, 1970 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Does Hot Water Freeze...?

The phenomenon your pupils investigate in this Science Workshop is no new discovery. It was known at least 350 years ago, when the English philosopher Francis Bacon wrote: "Water slightly warm is more easily frozen than [water] quite cold." Many people have discovered this for themselves, or learned of it from others, and made use of the phenomenon as described in the article. Only recently, however, has it been investigated in a scientific way. So far as we know, none of the theories about how it happens has yet been accepted as the full explanation.

In freezing weather, or with access to a freezer, your pupils can make the suggested investigations at school. However, doing the work at home and comparing their procedures and results in the classroom will make this a more interesting and valuable learning experience. You can make it even more fruitful by reviewing with your pupils some basic concepts of heat and freezing.

Topics for Class Discussion

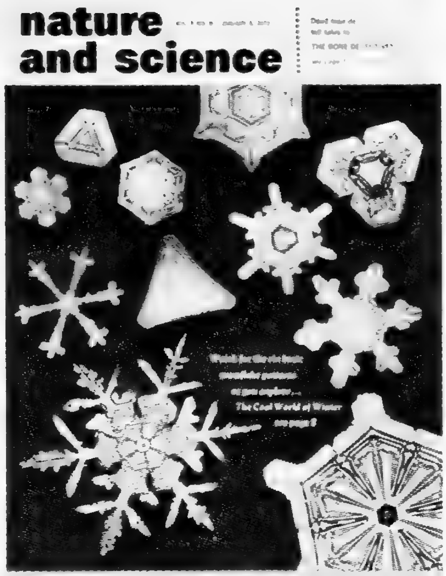
• *Are words like "warm" and "cool" useful in describing the temperature of water in an investigation like this?* No, because they mean different things to different people, and even different things to the same person under different conditions. (When you go indoors on a cold winter day, the air in your home seems "warm," but when you step out of a hot shower, the air in the room seems "cool.")

• *What is the difference between heat and temperature?* *Heat* is what we call the energy that keeps the molecules of a substance in constant motion. *Temperature* is a measure of how fast the molecules of a substance are moving. As a substance gains heat, its molecules move faster and its temperature goes up; as it loses heat, its molecules slow down and its temperature drops.

• *Why does water freeze when its temperature drops below 32° F.?* The water molecules have lost so much energy that they stop moving around freely and settle down in orderly arrangements, called *crystals*. The molecules still have enough energy to keep them vibrating back and forth, but not enough to make them break out of their crystalline "patterns," so they now form a *solid* substance—ice.

• *Why must equal amounts of water be used to compare the freezing time of water at different temperatures?* You might have your pupils find out which freezes sooner—a full glass of water or half a glass of water at the same temperature. Since each water molecule needs the same amount of heat energy to keep it moving at the same speed as the others, the glassful of water must contain about twice as much heat as the half-glassful. But the larger amount of water has less "outside" surface area compared to its total mass than the water in the half-filled glass has, so the larger amount of water loses its heat to the air more slowly. Using equal amounts of water

(Continued on page 2T)



IN THIS ISSUE

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

IN THE NEXT ISSUE

A special-topic issue discusses the nature and effects of light and shows your pupils how to investigate: 1) the bending of light rays by reflection, refraction, and diffraction; 2) the particle and wave theories of light; 3) light and color.

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

to compare the freezing rates of water at different temperatures eliminates the difference in heat loss from bodies of water of different sizes.

• *How does a glassful of water lose heat when you place it in a freezer?* Mainly through *conduction.* As the faster-moving water molecules bump into slower-moving molecules of the air at the surface of the water, they pass some of their heat energy on to the "air molecules." In the same way, the molecules that make up the glass lose heat to the air and to the bottom of the freezer, and the water molecules, in turn, lose heat to the glass.

In addition, however, some of the molecules at the surface of the water may *evaporate,* or "escape" into the air as water vapor (a gas). (The higher the temperature of the water, the more likely this is to happen, because the molecules are moving around faster.) Each "escape" like this uses up a bit more heat energy than a water molecule loses when it merely bumps into an "air molecule," and it also leaves one less molecule of water to be cooled to freezing.

A Canadian scientist used a computer to figure out that evaporation from boiling water would make it lose heat faster than water at room temperature, and his laboratory tests showed that under the same cooling conditions, boiling water freezes in about 90 per cent of the time it takes for an equal amount of water at room temperature to freeze.

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.

But evaporation may not be the only explanation for this phenomenon. As some people have pointed out, pipes filled with hot water freeze before pipes filled with cool water, and there is no air-space inside them for water to evaporate into. However, cool water usually has more air dissolved in it than hot water does, and it might be that dissolved air somehow slows the heat loss from cool water.

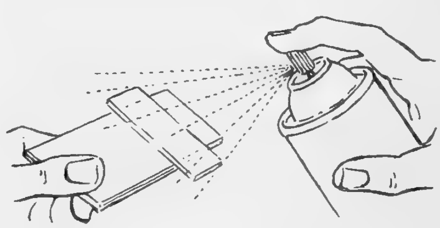
As you can see, this SCIENCE WORKSHOP is still very "open-ended."

Cool World of Winter

After studying snowflakes under a magnifying glass, some of your pupils may wish to get a better look by preserving the snowflakes and examining them under a microscope. Here's how to do it:

Get some microscope slides and a spray can of Krylon or other clear lacquer. Store the slides and lacquer in the freezing compartment of a refrigerator. When it is snowing, take the slides and spray from the freezer and get them outside quickly so they do not warm up.

Hold a slide on a piece of cardboard or wood so the heat from your hand does not warm the slide. Spray a thin coat of lacquer on the slide, and put the slide out in the snow until several snowflakes have fallen on it. Then put the slide in a sheltered place (but still outside in the cold) and let it dry for an hour. Prepare a number of slides in this way. When the slides are dry, your



pupils can bring them in and look at the snowflake shapes under a microscope.

Activities

Here are some investigations for your pupils to try with snow.

• Put equal-sized snowballs on the sidewalk, a rock, some soil, and a car. Can your pupils guess the order in which the snowballs will melt?

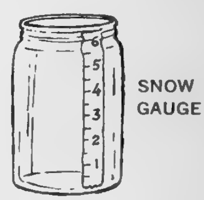
• How long will it take for a snowball to melt indoors? Bring one in and let your pupils watch it melt in a dish. It will probably take longer for it to melt than they think. Ask them to see whether a snowball will last overnight in the refrigerator (not freezer).

• Stick a snowball on a pencil and bring it inside. Ask the class to guess how long they think it will take for the first drop of water to fall from the snowball. Can anyone explain why it takes so long?

• Have pupils put different things on top of snow to see which sink into the snow fastest. Try paper, leaves, rocks, sand, sugar, and salt. What happens if the air temperature is below freezing, or if the snow is in shade?

• Color patches of snow with food coloring and look at them the next day. Does blue snow melt faster than red snow?

• You can make a snow gauge from a large, wide-mouth jar or can. Mark a piece of masking tape in inches and stick it on the jar. Put the gauge outside, away from the school and trees. Use the gauge to measure how much snow falls in each storm during the winter. When a storm ends or the jar



gets full, record the depth of the snow on a chart and dump out the snow. Have pupils compare their measurements with those given in local weather reports. If differences occur, does it mean that someone must be "wrong"?

• Measure the depth of snow in various places around your school. Where is the snow deepest and shallowest? Can your pupils explain the differences they find?

• Get a thermometer and have pupils measure the temperature of snow. Is it usually about 32° Fahrenheit? When is snow warmer than the air? Have your pupils mix some snow into a bucket of water and see how cold the water becomes. Can they make the water even colder by adding

(Continued on page 3T)

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

more snow? What happens if they put in a lot of salt?

What Kind(s) of Bird?

In attempting to understand his world, man has always found it helpful to classify, or group, things. Primitive man probably first classified plants and animals as either "useful" or "harmful." Aristotle and his pupils tried to classify the living things they knew—about a thousand kinds—in subgroups under the main categories of "plant" and "animal."

Your pupils may be able to think of examples of how they unconsciously classify all sorts of things, from weather to people. And we are vaguely aware of how others classify—the alphabetical arrangement in a dictionary, the arrangement of foods in a supermarket.

In biology, classification is similar to that in a supermarket—according to certain likenesses of objects. Taxonomists rely mainly on structural characteristics as a basis for classifying living things, although physiological and behavioral characteristics (as in the case of the Traill's flycatchers) are often helpful.

The first sorting of known organisms begins at the *kingdom* level. Formerly all life was lumped into the plant or animal kingdoms. Now some biologists favor having three or four kingdoms, since, inevitably, diverse nature sometimes doesn't fit well in the narrower classification. The chart on this page shows the classification of three organisms through the seven main levels.

Most specialists use more than seven levels, adding such groups as subphylum, superfamily, and subspecies. Besides classifying newly-discovered forms, taxonomists use new evidence to refine existing classifications, trying to get a more meaningful picture of how living things are related.

LEVELS OF CLASSIFICATION	DOG	MAN	PARAMECIUM
Kingdom	Animalia	Animalia	Protista
Phylum	Chordata	Chordata	Ciliophora
Class	Mammalia	Mammalia	Ciliata
Order	Carnivora	Primates	Holotricha
Family	Canidae	Hominidae	Parameciidae
Genus	*Canis*	*Homo*	*Paramecium*
Species	*familiaris*	*sapiens*	*caudatum*

Biologists use Latin or latinized names for groups of organisms, and these names are recognized by scientists everywhere. This is necessary because common names of organisms vary from place to place (even within the same language), and because there are so many organisms to classify—in the Old World, for example, there are more than 560 species and subspecies of *rats*.

"Searching for the 'World-Stuff'" introduces a series of seven articles on Exploring the Atom, by Roy A. Gallant, prize-winning author of science books and textbooks for children. The second article will not appear until the February 2 issue, because the January 19 issue will be devoted to a single topic—"Exploring the Ways of Light."

Temperature "Normal"?

Mammals and birds are the only "warm-blooded" animals — those whose body temperatures usually remain within a fairly narrow, relatively warm range. The body temperatures of "cold-blooded" animals vary a great deal according to the temperature of the environment. In fact, the temperature of a "cold-blooded" animal can sometimes be higher than that of a "warm-blooded" animal. The terms can be misleading, and some scientists prefer not to use them, referring instead to animals that can or cannot usually regulate their body temperatures.

Birds and mammals have many adaptations that help them keep their body temperatures constant, in spite of environmental temperature changes and changes in activity. Your pupils might be able to think of some of these adaptations: *Sweating* removes heat-carrying water from the body when the animal is too warm. *Shivering* produces heat when the surroundings are too cold. *Fur and feathers* act as insulation to help keep heat from being lost to or gained from the environment. *Behavioral adaptations* include curling up in the cold, as some mammals do. This reduces the amount of the animal's body surface exposed to the air, and so the amount of heat lost from the body. Other mammals snuggle up to one another in the cold to achieve the same effect.

There are two important adaptations that your pupils probably will not mention. A change in the amount of blood flowing through the skin changes the amount of heat that is lost through the skin to the air. Also, a change in the rate at which chemical reactions occur in the body changes the amount of heat that is produced by these reactions.

Not all "cold-blooded" animals are completely at the mercy of the environment, however. A dragonfly, for example, cannot move its wings fast enough to fly if its body temperature is below 85° F. But on a cold day it will vibrate its wings for a while—"warming up" until its body temperature is raised enough so it can fly.

Brain-Boosters

Mystery Photo. The photo was taken on a sandy beach as the tide was going out. The miniature valleys and deltas are formed as sea water runs down over the sand. Perhaps your class can find similar patterns in dirt after a rain. You could also have them build and experiment with a stream table to see how running water affects land formation *(see "Exploring Mini-Rivers,"* N&S, *Oct. 27, 1969).*

What will happen if? If you set up this demonstration in class, your pupils will see that when the two weights are unequal, the lighter weight will swing
(Continued on page 4T)

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

in a circle around the heavier weight as the latter moves slowly back and forth like a pendulum. If possible, obtain several objects of different weights and let your pupils see what happens when the two objects hung on strings are more nearly equal in weight, or less so. What happens if both are the same weight?

Can you do it? When you suck in your breath to drink through a straw, a partial vacuum is created in your mouth. Normal air pressure over the surface of the liquid in the glass forces the liquid up through the straw and into the area of lower pressure.

But, as your pupils can easily find out for themselves, it is impossible to drink through a straw while you have a short straw in your mouth that is not immersed in the liquid. Air will enter your mouth through the short straw, filling up the partial vacuum so you can't suck all the air out of the longer straw.

Fun with numbers and shapes. After the class has puzzled for a while over how to measure the thickness of a single sheet of newspaper, someone may hit upon the idea of measuring the thickness of a *whole* newspaper, and then dividing by the number of sheets. What other kinds of paper can your pupils find in the classroom that are thicker or thinner than newspaper?

For science experts only. The damage to the two cars in the collision would be about the same, since the speed of impact for both cars is the same: 60 miles per hour, the sum of the speeds of the two cars. Whenever two objects collide, it makes no difference which is moving faster, or even whether both are moving; the collision effect is determined by the *total speed at which the objects are moving toward each other* at the moment of impact. Thus, if you hit a tree while driving at, say, 30 miles per hour, the effect on your car *and* the tree would be the same as if a tree moving at 30 miles per hour hit your parked car (though you might have some difficulty with your insurance company in the second case).

In any such collision, the heavier object can generally be expected to suffer less damage, regardless of the speeds involved, because it will displace the opposing object more than it will be displaced itself. Thus a sports car might be expected to suffer more damage than a limousine with which it collides. However, an automobile collision is an extremely complex event for which it is fruitless to try to predict a hypothetical outcome.

Just for fun. If you set up this demonstration in class, give your pupils a chance to see that 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 the water to freeze.

nature and science

VOL. 7 NO. 8 / JANUARY 5, 1970

Dead men *do* tell tales to...

THE BONE DETECTIVES

see page 2

nature and science

VOL. 7 NO. 8 / JANUARY 5, 1970

CONTENTS

PICTURE CREDITS: Cover, p. 2, The American Museum of Natural History; pp. 3, 5-7, 10-13, 16, drawings by Graphic Arts Department, AMNH; pp. 3, 4 (bottom), photos by D. Gentry Steele; p. 4 (top), courtesy of William Bass and The North Dakota Historical Society; p. 5, photo by David Webster; pp. 8-9, (frost) John Gerard from National Audubon Society, (glaze) A. Devaney, Inc., (icicles) Emil Schulthess from Black Star, (snowflakes) AMNH, (hailstones) ESSA photo, (hubcap) Laurence P. Pringle; p. 11, photo by The Bettmann Archive; p. 13, photo by Franklyn K. Lauden; p. 14, photos by *The New York Times;* p. 15, photos by Robert C. Stein.

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 divison 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,

THE BON

■ It was late on a rainy Sunday afternoon, and I'd just settled back in an easy chair to read. Then the doorbell rang. I opened the front door, and two policemen stepped into my living room.

"Can you come with us, Professor?" one asked. "We've got some bones for you to read."

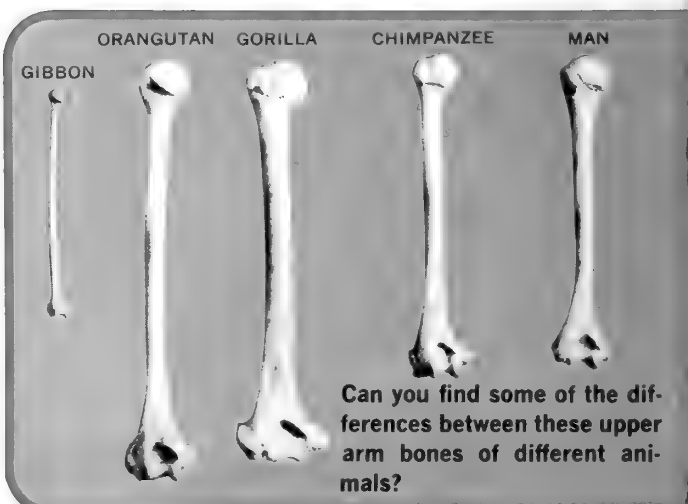
And so I had my first ride in a police car. I don't usually receive a police escort, but I do "read" bones. I'm a *physical anthropologist*—a scientist who studies the physical characteristics of different peoples. By examining certain bones, a physical anthropologist can tell much about the person to whom a skeleton belonged—such things as sex, race, age, height, body build, and often diseases and injuries the person suffered while alive.

Bones turn up constantly—at construction sites, in abandoned houses, along deserted roads and well-traveled highways, and in fields, lakes, and caves. The bones I saw that rainy Sunday had been found in a shallow grave, near a deserted barn. They turned out to be goat bones.

Man or Beast?

When bones are found, the first question that must be answered is whether the bones are human. A mysterious human-like hand found in a field in Washington, D.C., puzzled police until an anthropologist examined it. He found out that it was a paw from a recently-killed bear.

A human skull is easy to recognize. It's more difficult to tell whether small or broken bones are human. An anthropologist uses the shapes of the bones, the sizes of the ridges and grooves where muscles were attached, and other

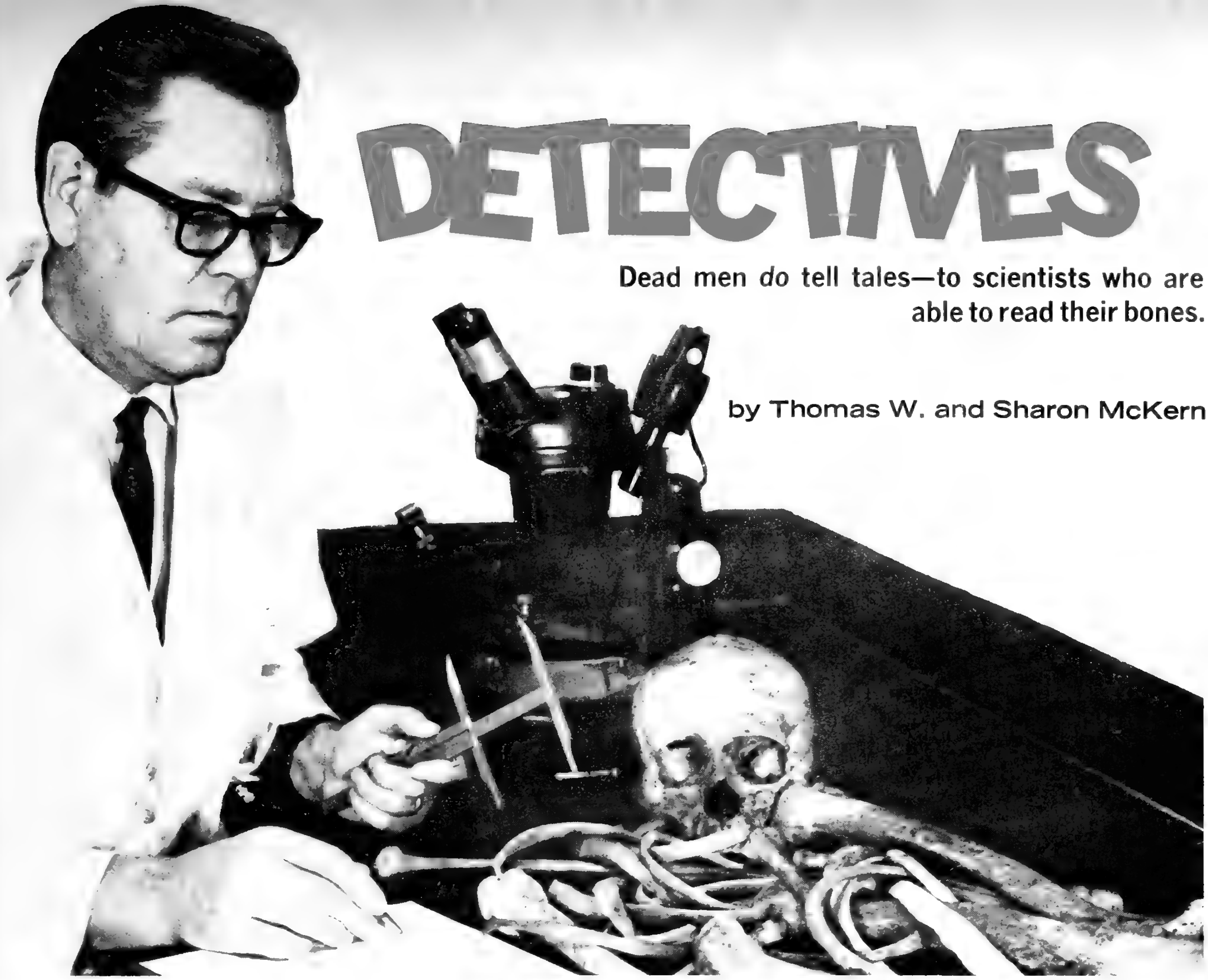


Can you find some of the differences between these upper arm bones of different animals?

DETECTIVES

Dead men *do* tell tales—to scientists who are able to read their bones.

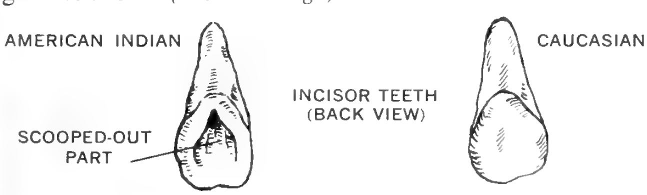
by Thomas W. and Sharon McKern



Dr. Thomas McKern examines some human bones in his laboratory at the University of Kansas, at Lawrence, where he is a Professor of Physical Anthropology.

bone details as clues *(see photo)*. But we sometimes have to turn to our microscopes, or to X-ray equipment.

Once we know that the bones are human, we try to figure out the race of the person. This is difficult in the United States, where many people have a mixed racial ancestry. The shapes and arrangements of certain bones, especially those of the face, differ from race to race. Teeth also show racial characteristics. The front teeth of the American Indian, for example, are scooped out from behind like a garden shovel *(see drawings)*.



THE OLD KENTUCKY HOME

Not long age, a man inspected the old, long-vacant Kentucky house he had just bought. He found a complete human skeleton buried under the cellar floor. Shaken, he told the police, who called in a "bone detective." The anthropologist found that the bones had belonged to an American Indian who had died of natural causes and been buried there more than 300 years ago. The relieved owner of the house donated the skeleton to a museum.

Whether bones are from a male or female is easier to determine. Bones from males are usually longer and thicker than those from females, and have larger markings where the muscles were attached. The shape of the hip bone also differs between males and females. Even the bones of the skull are different.

Telling Your Age

We can tell the age of a child at death by looking at his long bones (those of the limbs, fingers, and toes) and at

(Continued on the next page)

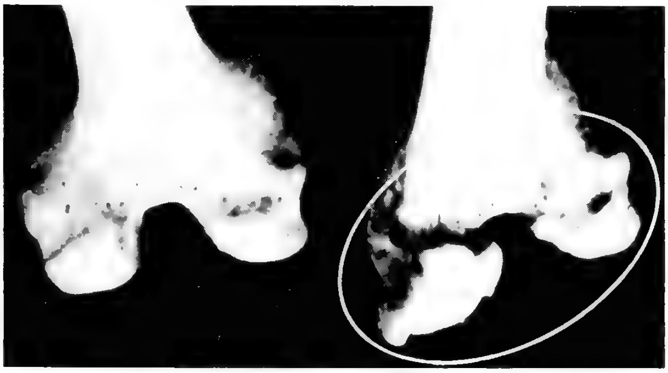
his teeth. At birth, each long bone begins as three separate pieces—a piece at each end, and a middle one.

These tiny pieces of bone grow toward one another, until by the age of 12 they meet to form a single long, narrow bone. Scientists know the rate at which these pieces grow toward one another, so they can tell the age of a "young" skeleton by how close the pieces are to meeting.

Teeth are another clue to the age of a person at death. How many "baby" teeth a skeleton has, and how many have been replaced by permanent teeth, helps tell the age of the young person whose skeleton it was. (Often, this method can't be used by itself, because the age and order in which the teeth appear differ from person to person.) How worn-down the teeth of an older person's skeleton are can tell his age at death within ten years or so.

We can figure out the height of a dead person by measuring just one leg bone and then multiplying the length by certain numbers. Scientists are now trying to develop a way of figuring out height from *broken* bones. The bones found by *archeologists*—scientists who study the lives of ancient peoples—are usually broken.

Injuries and diseases during life often leave their marks on the skeleton. Breaks that have healed show up in the bones. Malnutrition, arthritis, tuberculosis, and other body conditions and diseases make their marks on certain bones *(see photo)*. Using microscopes and X rays, scientists can find even more medical information in the bones. With X rays, they have discovered gallstones, tooth decay, and sinus trouble in Egyptian mummies.



The human thigh bone on the left is normal. The odd shape *(circled area)* of the other bone shows that the person to whom it belonged had arthritis, a disease that can affect a person's knee and other joints.

A metal arrow-point pierced this upper arm bone of a Sioux Indian.

Arrowheads and Kitchen Sinks

Some of the bone detective's work helps the police to identify bones that have been found. But most of the physical anthropologist's work in the United States is with ancient Indian skeletons. *(See "A Race Into the Past," N&S, October 27, 1969.)* For scientists who want to learn all they can about the prehistoric peoples of America, it isn't enough to examine objects such as pottery and arrowheads. How the people who made these objects looked is just as important, and the bones help tell how the people looked.

Bone detectives can also make life more comfortable for the living by using knowledge gained from skeletons. Furniture and appliance manufacturers sometimes use skeleton measurements in designing their products. The kitchen sink, for example, is the height that it is because that height was calculated to be the most comfortable for the average American housewife.

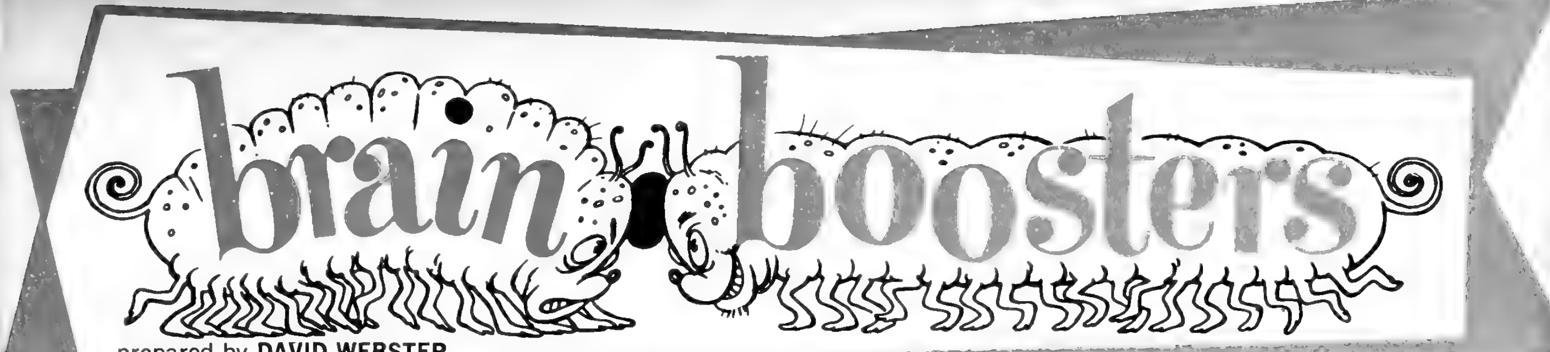
Clothing manufacturers use the measurements of growth made by physical anthropologists to design clothing for people of various ages. Some cars, trucks, and airplanes are designed with the measurements of the "average person" in mind. Space capsules are constructed to suit the size of the astronauts. The tales dead men tell work in this way to help the living ■

ALL IN A DAY'S WORK

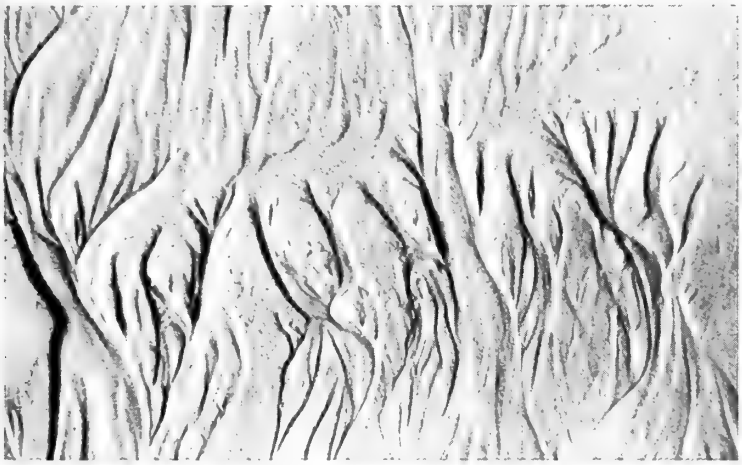
A few years ago, a stranger burst into my office. He was wearing fishing clothing, and carrying a human skull. Excitedly, he told his story. He'd been fishing at the lake near town. He had felt a tiny weight on his line, and had reeled in. He had hooked a skull.

After asking him to notify the police, I set about to identify the grisly catch. The skull's flattened face bones and some of its other features showed that it had belonged to a Japanese male. But what was the skull doing in the middle of the lake?

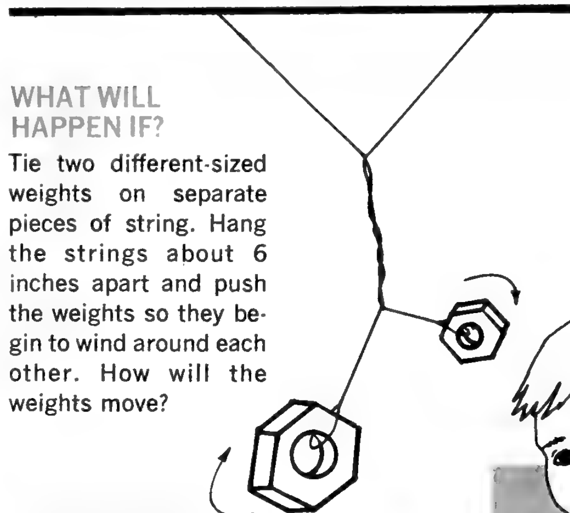
The local newspaper ran a story about the riddle of the skull. Less than a week later, the answer came in a letter to the police from a man who had read the newspaper article. The man had bought the skull many years ago from a museum in Japan. Until he married, he kept it on his mantelpiece. Then his wife found that she couldn't live with the skull. So the man threw the skull into the lake, where it stayed until the fisherman reeled it in.



prepared by **DAVID WEBSTER**



MYSTERY PHOTO What made these patterns?



WHAT WILL HAPPEN IF?

Tie two different-sized weights on separate pieces of string. Hang the strings about 6 inches apart and push the weights so they begin to wind around each other. How will the weights move?

CAN YOU DO IT?

Get two straws and cut three inches off the end of one. Put both straws into your mouth, and dip them into a glass of water so that the long straw is in the water but the short one isn't. Can you suck up any water?

Submitted by Steven Smith, Madison, Kansas

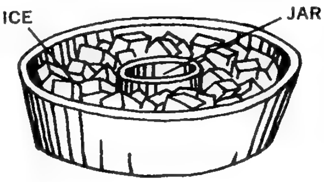
FOR SCIENCE EXPERTS ONLY

Suppose a car traveling at 20 miles per hour collides head-on with a car of the same size going 40 miles per hour. Which car would be damaged more?

Submitted by Jeff Harber, Streator, Illinois

JUST FOR FUN

Put a small jar in the middle of a pan, and pack ice around the jar. 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 salt?



FUN WITH NUMBERS AND SHAPES

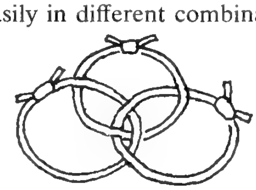
How thick is a newspaper page? Can you make some measurements to find out?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: When a car's windshield wipers are used, tiny pieces of dirt are caught under the blades and scratch the windshield in curved lines. Dust then collects in the scratches while the wipers are not in use. The frost tends to form first around the dust particles in these scratches.

What would happen if? The water from melted ice has the same weight as the ice itself. A tiny amount of water might evaporate before you looked at the balance scale again, but this change in weight would be too small to affect an ordinary scale. What would happen if you left the water uncovered on the scale for a long time? What if you covered the water (and balanced the cover with an equal weight on the other side of the scale)?

Can you do it? Probably the hardest combination of fingers to move together is your middle finger and little finger. Much practice and exercise is necessary to move all the fingers easily in different combinations.



Fun with numbers and shapes: Here is how to arrange three loops of string so that all three will come apart if any one of the three is cut.

For science experts only: The "backward" compass directions were on a light fixture for the ceiling. Hold the compass directions over your head, with the arrow for "north" pointing behind you. Are east and west now correct? Would the directions be right if you looked at them in a mirror or through the back of the paper?

The Cool World of Winter

■ The next time snow falls, catch some snowflakes on a piece of chilled black paper or cloth. Look at the flakes through a magnifying lens. How many different shapes do you find? Can you find a way in which the shapes are alike? (If no snow falls where you live, examine the snowflakes pictured on these pages.)

Snow, rain, sleet, and hail are all forms of precipitation, or water that falls to earth from the atmosphere. Each day millions of tons of water—from lakes, streams, oceans, and the leaves of plants—are changed to water vapor, a gas, mainly by heat from the sun. As the water vapor rises through the atmosphere, it loses heat to the air and changes back into tiny water droplets that we see as clouds. These water droplets are so small that they float in the air, but gradually they combine to form larger, heavier particles that fall to the earth.

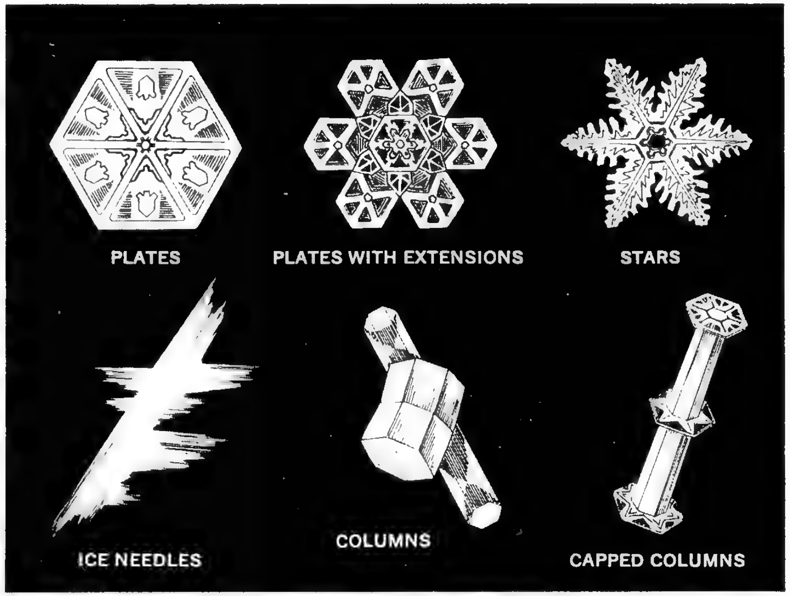
Whether the water falls as snow, rain, sleet, or hail depends on the temperature within the cloud and the temperature of the last layer of air that the particles fall through before reaching the ground. For instance, when the temperature in a cloud is about 5° Fahrenheit to −15° F., the water vapor and tiny droplets turn directly into ice crystals.

As more and more of these ice crystals cling together, they form snowflakes heavy enough to fall to the ground.

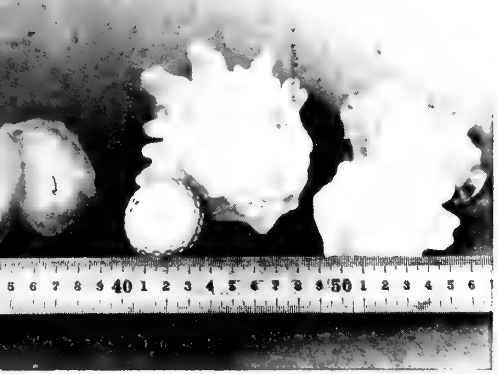
Glaze ice forms when raindrops hit the freezing-cold surfaces of trees, roofs, and sidewalks. Glaze is glass-like and heavy. It snaps tree limbs and power lines with its weight.

they stick together and reach the ground as large, soggy flakes. The small, dry flakes you see have fallen through drier, colder air. On this WALL CHART you will see how the air in our atmosphere forms various kinds of winter precipitation ■

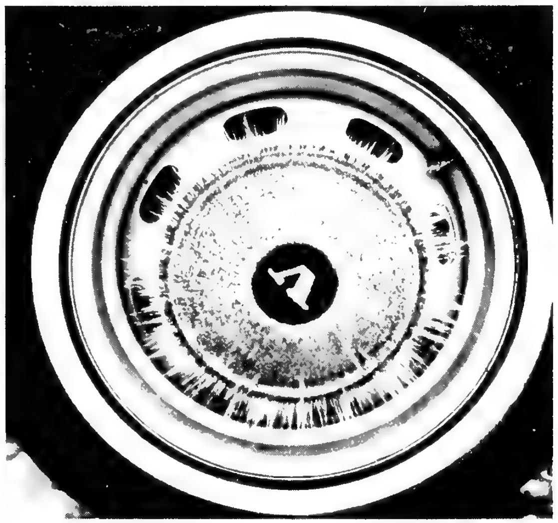
Here, the snow's surface has been melted by the sun, then refrozen, leaving icicles.



No one has ever found two snowflakes that are exactly alike, but most snowflakes seem to follow one of the six basic patterns shown here. As you can see, snowflakes usually have six sides. Water molecules are shaped like triangles. When the triangular molecules freeze, they combine to form *hexagonal*, or six-sided, crystals. Many of these crystals join to form each snowflake.



Hailstones are formed as wind lifts raindrops into the cold, upper part of a cloud. The drops freeze into ice pellets and begin to fall, but the wind carries them back to the upper part of the cloud again and again. Eventually the pellets become so heavy that they fall to the ground. The hailstones shown here are larger than average. (Sleet is formed when a raindrop or partly melted snowflake falls through a layer of cold air and freezes into an ice pellet.)



This unusual ice pattern formed on an automobile hubcap on a snowy day when the temperature was near freezing. As the car sped along, melted snow splashed onto the hubcap. Can you figure out why it froze in this pattern?

The background of this WALL CHART is a photo of frost crystals on a window. Such crystals form when water vapor that is in the layer of air nearest the ground touches a surface that is at or below freezing temperature.

Searching for the "WORLD-STUFF"

by Roy A. Gallant

This is the first of seven articles about man's seemingly endless discoveries about and uses for the atom. These articles will describe how men of ancient times first imagined what the "world-stuff" is made of, what scientists since then have discovered about the atom, and how it supplies power to our homes and factories, helps the medical profession, and pollutes our oceans, rivers, and air.

■ How many times have you used the word "atom"? Many times, probably. And perhaps you have at least some idea of the way scientists picture an atom.

For instance, you probably know that an atom has a central lump of matter with one or more tiny bits of matter darting around it. And you may even know that there are a few more than a hundred different kinds of atoms.

If you do know those things, then you know more than anyone knew about atoms until less than a hundred years ago, even though the ancient Greek thinkers "invented" the atom. The man usually given credit for first thinking about atoms is Democritus, who lived almost 2,500 years ago. (Actually, it was his teacher who first had the idea.)

The Tiniest Particles

Democritus taught his students that all things in the universe—from stars to rocks to fingernails—were made of tiny particles, which he called *atoms*. He said that if you kept hammering a rock into smaller and smaller pieces, the smallest possible piece of rock-matter would be an atom. But it would be so small that you couldn't see it, feel it, or weigh it. He said that atoms are hard and solid ball-like objects that cannot be broken apart or chipped into smaller pieces. In fact, the word "atom" is an old Greek word—*a-tome,* which means "not-divide."

As we do today, Democritus imagined that there were many different kinds of atoms. Some, he said, are very light and free to dart about this way and that, and they can move far apart from each other. The air and other gases are made of such atoms, Democritus said.

But water had different kinds of atoms, thought Democritus, and they were arranged differently. He pictured the atoms of water and other liquids as larger and heavier than atoms of gases, because the atoms of liquids tend to stick together. And since anyone could see that liquids flow, their atoms must be slick and smooth. If they were not, they would not slip and slide over and around each other.

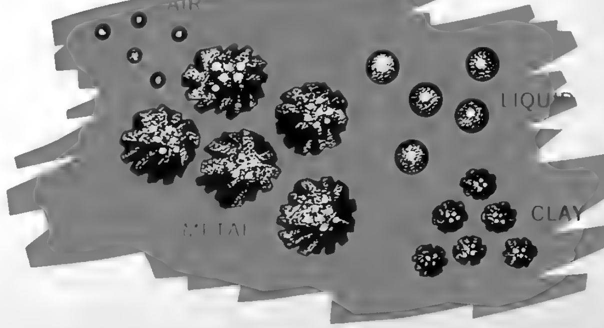
Atoms that make up copper, iron, rocks, and other heavy solid objects must be even larger and heavier than atoms of liquids, Democritus thought. And since it is hard to break apart such solid objects, their atoms must have very rough and jagged surfaces that cause the atoms to lock together tightly.

Democritus probably took that idea a step further by supposing that solids such as wood and soft clay are made of less jagged atoms whose surfaces do not lock together so strongly. He could explain the slow movement of "stiff" liquids, such as pitch oozing out of trees, in the same way.

For Democritus and a few others, the idea of a world made of atoms worked well enough. By thinking of all things as being made of atoms, they could explain the actions of liquids, solids, and gases, just as we can today.

But Democritus and the other Greek scholars of his time were thinkers, not experimenters. They were like

DEMOCRITUS'S ATOMS

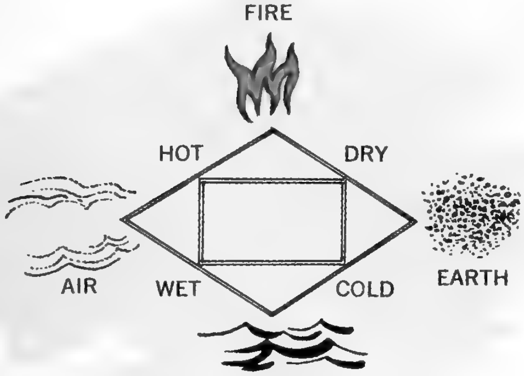


mathematicians, not scientists. A mathematician can think out a problem, then solve it and prove the answer on the chalkboard. A scientist can also think out a problem and come up with an answer, but nearly always he must test the answer by doing experiments. The Greeks did not work that way. And since Democritus had only his thoughts to back up his theory, he had no way of proving that his ideas about matter were any "better" or more accurate than those of anyone else.

Earth, Air, Fire, and Water

As it turned out, the atom theory of Democritus did not catch on well at all. The idea about matter that did catch on was a very confusing one. According to that idea, there were four "elements"—earth, air, fire, and water. All things were made of one or more of these "elements." Wood, for instance, was made of earth, or so it seemed at first glance. If you heated wood, you could see that it also contained fire and air.

Perhaps the atoms of Democritus seemed too simple a way to explain something as big and important as the world. Anyway, the idea didn't catch on. The earth, air, fire, and water idea of elements did, and it stayed popular



for about 2,000 years. Several men over those long centuries found atoms a little more convenient to explain the behavior of matter, so the idea did not die completely. But during all that time, no one came up with any strong objections to the "four-element" theory of what the "world-stuff" was made of.

Then in the 1600s and 1700s, discoveries came thick and fast. In the 1600s, the English chemist Robert Boyle said that the four elements of the ancient Greeks couldn't begin to explain the many, many different kinds of matter around us. He felt that there must be many more "elements." When Boyle used the word "element," he meant what we mean when we use the word today—any substance that cannot be broken down into a simpler substance or built up from simpler substances.

Gold, silver, oxygen, and hydrogen, for example, are elements. On the other hand, carbon dioxide, the waste gas you breathe out, is made up of the two elements carbon and oxygen. Boyle had an idea that there must be many elements, but he could not guess how many. (Today, we know there are about 105.)

Elements, Atoms, and Molecules

John Dalton, an English chemist who lived after Boyle's time, took Boyle's idea of elements still further. He made the idea of atoms so convincing that few scientists of the time could doubt that atoms existed—even though they still couldn't see them, weigh them, or feel them.

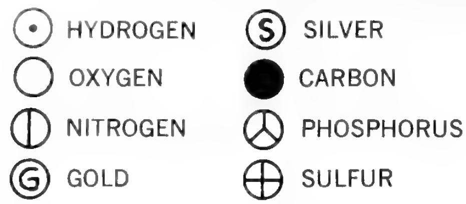
In the centuries when people believed that all substances were made up of earth, air, fire, and water, men called "alchemists" tried to find a way to change a common metal such as lead into gold. This cartoon drawn in the 1500s shows an alchemist working in his crude laboratory.

About the only "experimenting" Dalton was able to do with his atoms was on paper, not in a laboratory. He began with the idea that all the atoms of any one element were exactly the same. The atoms of different elements were somehow different.

Dalton used a kind of picture-writing to work out his ideas. As the diagram shows, he drew a black circle to stand for a carbon atom, an open circle to stand for an

(Continued on the next page)

DALTON'S ATOMIC ALPHABET

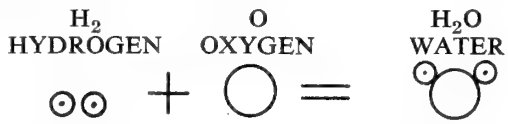


Searching for the "World-Stuff" (continued)

oxygen atom, and so on. Dalton thought that when matter changes—wood into fire, for example—atoms of one kind must join with or break away from atoms of another kind. He pictured a particle of water as being made up of one atom of the gas hydrogen joined to one atom of the gas oxygen, like this:

He called the pair a "complex atom."

Dalton's idea about atoms of hydrogen joining with atoms of oxygen and forming a new substance, water, was sound even though it was not perfectly correct. You have heard water called H_2O. That means that for each atom of oxygen in a particle of water, there are two atoms of hydrogen. If Dalton were around today, he would picture a particle of water like this:



Another scientist of Dalton's time gave the name *molecule* to Dalton's "complex atoms." He said that a molecule is the smallest possible amount of any substance that still acts exactly like larger amounts of the substance.

By 1844, when Dalton died, scientists all over the world had come to accept the idea of elements, atoms, and molecules. It was a very exciting idea, for it was bringing man the closest he had ever been to understanding what matter —including his own flesh and blood—was made of, and how it was put together. And eventually it was to lead men toward an understanding of life itself.

But at the time, perhaps even more exciting were these questions that began to be raised: How are atoms held together in a molecule? What force locks them together at one moment, then releases them the next moment? Would man ever be able to measure the size of atoms? Was it possible that atoms were not the solid, unbreakable objects that everyone pictured them to be?

Not only could such questions be asked, but answers could be found. For science had begun to move into the laboratory, where ideas could be tested and measured ■

Part 2 of this series, in the February 2, 1970 issue of Nature and Science, *will describe how scientists after Dalton's time first broke their way into the not-so-solid atom.*

Fun

Counting rabbits led a thirteenth-century mathematician to discover an unusual set of numbers. Here's how you can use these numbers to have . . .

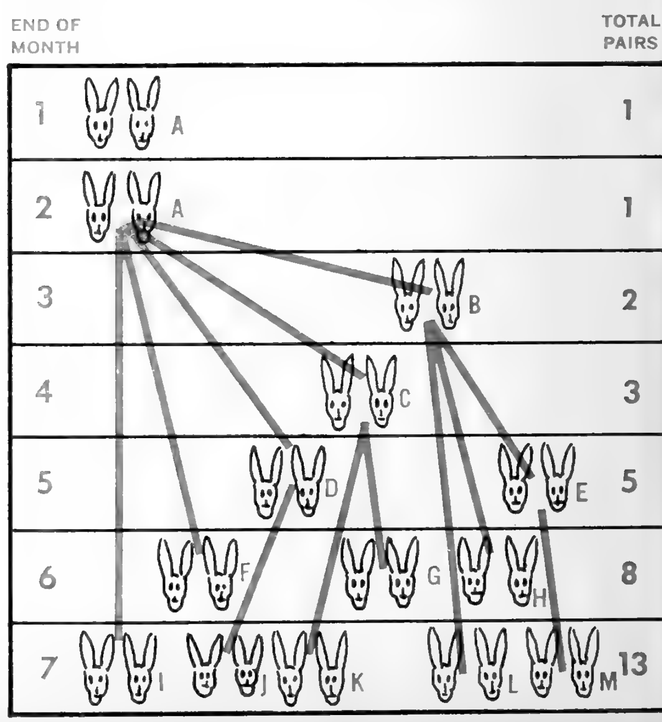
by Diane Sherman

■ In the thirteenth century an Italian mathematician named Leonardo Fibonacci discovered a most unusual set of numbers. They appeared as the solution to a problem in a book he wrote about mathematics. Here is the problem. Can you figure out some way to go about solving it?

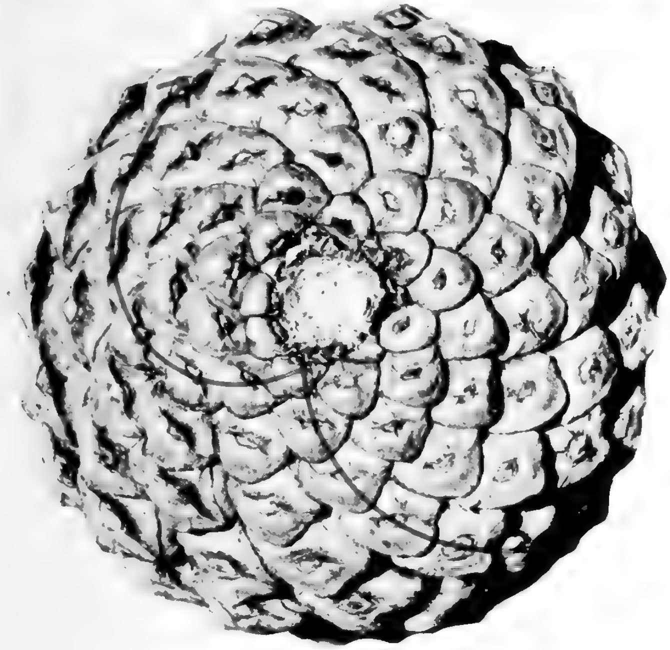
Suppose there are two baby rabbits in a pen, one male and one female. At the end of two months, they produce another male-female pair of rabbits, and they continue to produce a new male-female pair each month thereafter. After each new pair is two months old, it too starts producing one new male-female pair a month, and so on. How many rabbits will there be in the pen at the end of a year?

Let's try keeping track. We'll let each line on the chart shown stand for one month. The first and second lines show A, the pair of rabbits we started with. The third line shows B, the pair born in the third month, making a total of two pairs of rabbits at the end of the third month. (Be careful not to count pair A twice.) The fourth line shows C, the pair of rabbits born in the fourth month. In the fifth month, pair A has another pair, D. Also in the fifth month, the B pair is two months old and has its first new pair, E.

On the chart you can see what has happened by the end of the seventh month. Run your eye down the figures show-



with FIBONACCI



Count the clockwise and counterclockwise spirals of seeds on this pine cone. You should find 8 clockwise spirals and 13 counterclockwise spirals. Do these numbers look familiar?

ing the total number of rabbit pairs at the end of each month. Do the numbers seem to be related in any way? Keep looking until you figure out their relationship. Without drawing more rabbits, can you predict what the numbers might be at the ends of months 8, 9, 10, 11, and 12?

The numbers in the right-hand column are the first in a series that have come to be called "Fibonacci numbers." As you may have noticed, each number in the series (except the first two) is the sum of the two numbers before it. Fibonacci himself didn't investigate the series very thoroughly, but later mathematicians have found it fascinating. For one thing, they have discovered that Fibonacci numbers occur often in nature.

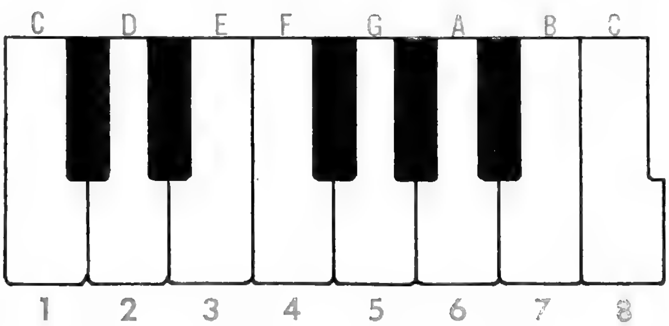
Flowers and Fibonacci

The next time you see a sunflower, notice its center part, made up of spirals of seeds. Some of the spirals curl in a clockwise direction, and some of them curl in a counterclockwise direction. If you count the number of clockwise spirals, and the number of counterclockwise spirals, you will probably come up with two numbers that come one after the other in the Fibonacci series.

If you have chosen an average-sized sunflower, you may find 34 counterclockwise spirals and 55 clockwise spirals. Larger sunflowers may contain 55 and 89 spirals, or 89 and 144. The record sunflower was found in Vermont, with 144 and 233 spirals. Can you find a sunflower to beat that?

You may also find Fibonacci numbers by counting the numbers of petals of different kinds of flowers. Irises and some lilies have three petals. Five-petaled flowers are the most common of all, and there are many species with eight petals. Thirteen petals are common on such flowers as ragwort, corn marigolds, and mayweed. Garden and wild flowers often have 21 petals. Thirty-four petals is the commonest number for the daisy family, but some field daisies have 55 petals, and Michaelmas daisies may have 89 petals —all Fibonacci numbers.

If you play the piano, you may find another example of the Fibonacci series. The diagram shows an *octave,* or eight notes, beginning with the note C and ending with the



C that is one octave higher on the musical scale. To make a C-major chord, you can play the third note of the octave (E), the fifth note (G), and the eighth note (C). So your chord is made up of notes 3, 5, and 8, a Fibonacci series. Perhaps you can find other ways in which musical scales and chords are related to Fibonacci numbers.

Some mathematicians have become real Fibonacci hunters. There is even a magazine called *Fibonacci Quarterly.* Brother Alfred Brousseau, who teaches mathematics at St. Mary's College of California, helped start the magazine. He claims that once people start looking for Fibonacci numbers, they find them everywhere.

Do you want to become a Fibonacci hound? Start looking around and counting. The numbers pop up in some unexpected places. Maybe you can find examples that no one has noticed before ■

Birds of the Traill's flycatcher species don't all sing the same song. This led scientists to ask...

What Kind(s) of Bird Is This?

by Margaret E. Bailey

■ Television and radio sponsors are not the only advertisers that use catchy songs. Male songbirds "advertise" that they are looking for mates by singing a song. Females of their kind *(species)* recognize the "advertising" song as a mating call. Most *ornithologists*—scientists who study birds—agree that birds of the same species sing the same song, but that the songs are different for different species.

In the 1930s, an ornithologist reported that he had heard birds of the Traill's flycatcher species singing two different "advertising" songs. The songs sounded like "fitz-bew" and "fee-bee-o." Scientists were puzzled. Could this mean that Traill's flycatchers were really two species instead of one?

Ordinarily, scientists do not have much trouble deciding whether living things belong to a single species. Members of the same species look alike, live in the same kind of *habitat* (living area), eat the same kinds of food, breed at the same time of year, and behave in much the same way. The members of a species will mate with each other, but almost never with members of other species. If they should, usually their offspring will not be able to reproduce.

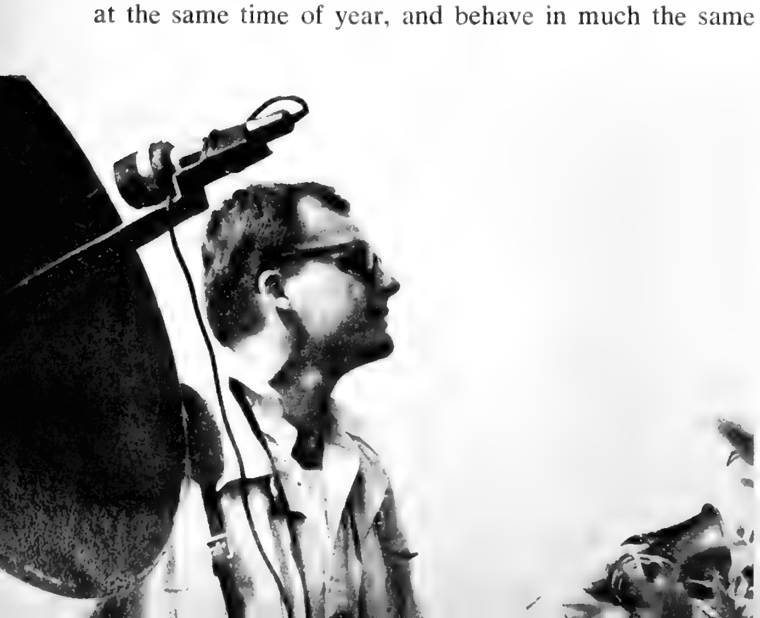
But occasionally, differences between two species are very slight. Then scientists may have trouble deciding whether some living things, such as Traill's flycatchers, belong to one species or two.

In the 1950s, Dr. Robert Stein studied Traill's flycatchers in the United States and Canada to see whether he could find enough other differences between birds that sang "fitz-bew" and "fee-bee-o" to divide them into two species. He began to call the birds "fitz-bews" and "fee-bee-os." (Dr. Stein is a professor of biology at the State University College at Buffalo, New York.)

"Love" at First Sight—or First Sound?

Dr. Stein's first test was to play a tape recording of the two Traill's flycatcher "advertising" songs, and the songs of other species of flycatchers, over a loudspeaker in places where Traill's flycatchers nested. He put a model of a Traill's flycatcher near the loudspeaker and watched to see whether any birds were attracted by sight to the model bird.

When he played the recordings, fitz-bews almost always answered only fitz-bew calls, and fee-bee-os almost always answered only fee-bee-o calls. None of the birds paid attention to the model flycatcher when the recordings were not



Dr. Gorski is shown here recording fitz-bew songs in the Litchfield swamp. The large, round object at the left reflects the sound waves of the bird calls into the microphone, which is connected to a tape recorder.

played.

Since the birds mostly answered only mating songs like their own, Dr. Stein decided that fitz-bews and fee-bee-os probably did not mate with each other.

Dr. Stein made careful studies to see whether there were other differences between the birds. Here are his findings:

	FITZ-BEW	FEE-BEE-O
habitat	taller bushes bordering on grassy areas	shorter bushes bordering on wooded areas
nests	neat, tightly-woven	loosely-woven, untidy
body structure	shorter wings longer bills	longer wings shorter bills
coloring	light, grayish backs	dark, greenish backs

Fitz-bew nests are tightly-woven and neat.

Fee-bee-o nests are loosely-woven with long streamers of grass.

These differences convinced Dr. Stein that fitz-bews and fee-bee-os were two separate species. But some ornithologists believed that more evidence was needed to show that the two groups did not mate.

In 1966 another ornithologist, Dr. Leon Gorski, began to study Traill's flycatchers in a breeding area near Litchfield, Connecticut. (Dr. Gorski is now an assistant professor of biological sciences at Central Connecticut State College, in New Britain.) In one test he put colored bands on the legs of birds he captured, then released the birds. For three years he kept records of which colors belonged to fitz-bews and which to fee-bee-os. The birds returned to the breeding area each year, but Dr. Gorski never found a banded fitz-bew nesting with a banded fee-bee-o. This was strong evidence that they did not mate.

South for the Winter

Dr. Gorski next wanted to see whether fitz-bews and fee-bee-os spent the winters in the same place. He went to Panama, where some of the birds had been found, and played flycatcher calls over loudspeakers in likely nesting areas. Many birds answered the fitz-bew calls, but none answered the fee-bee-o calls.

Dr. Gorski decided that the fee-bee-os might have migrated longer distances for the winter, since they have longer wings than fitz-bews. After looking in several places, he finally found birds that answered the fee-bee-o calls in the jungles of northern Peru, at the headwaters of the Amazon River.

Dr. Stein and Dr. Gorski think there is enough evidence now to divide the Traill's flycatchers into two species. Dr. Gorski believes that the species developed, or *evolved*, from one species only recently. This could have happened when two groups of Traill's flycatchers began living in different places and became completely separated. Then each group would have developed slightly different characteristics to help them live in different environments ■

Why Scientists Search for Species

Scientists have so far found almost one-and-a-half million species of plants and animals, and they are continually looking for new species. Why do they bother to do this?

One reason is that grouping living things makes the study of nature more orderly. It is easier to divide the countless numbers of living things in the world into groups and study each group than to try to study each living thing separately. Scientists also learn about how living things are changing as they study how different species have developed and how they interact with each other. Because all scientists accept this method of grouping, they can exchange information more easily.

Each year, scientists add about 15,000 new species of plants and animals to those already *classified*, or grouped. Many of these new species are insects, a group that contains about three times as many species as all the other animal species combined. Scientists expect some day to have classified more than three million species of animals alone. So it will be quite a while before *taxonomists*, scientists who specialize in grouping living things, will be out of a job.

Is Your Temperature "Normal"?

by Nancy M. Thornton

■ When that winter cold begins to paint frost on the window *(see page 8)*, be glad your body is "warm-blooded" —able to stay at about the same temperature most of the time, even though the air around you is somewhat cooler or warmer.

Each species of warm-blooded animal has a certain average temperature. This may range from as low as about 90° Fahrenheit for a ground squirrel to as high as about 107° F. for an English sparrow. The "normal" for man is 98.6° F. You may have noticed this point on a fever thermometer. It is usually shown by a small arrow, or a change in the color of the numbers above that point on the thermometer scale. Is the temperature of your body *exactly* 98.6° F., and does it stay *exactly* the same?

How Warm Is Your Blood?

You can find out with a fever thermometer. Wash the thermometer well with soap and *cool* (never hot) water; then dip the thermometer in rubbing alcohol and *rinse the alcohol off* with cool water. As you look at the thermometer, you will see the silver-colored line of mercury coming from the bulb end. You read your temperature wherever that line stops on the thermometer's scale. Each line on the scale stands for 2/10ths (0.2) of a degree. Most thermometers are marked with a number every two degrees. Before taking your temperature, be sure that the mercury line on the thermometer is no higher than the 97° mark. If it is higher than the 97° mark, you will have to shake it down below that mark. To do this, hold the thermometer at the end opposite to the mercury bulb and flick your wrist sharply. Make sure not to crash the thermometer into anything, or it will break. (If you break a thermometer, sweep together all of the glass and mercury, and throw it all away. Mercury is poisonous, and should not be used as a toy.)

To take your temperature, put the bulb end of the thermometer under your tongue, and close your mouth firmly. Hold the thermometer in your mouth for three minutes before you read it. Is your temperature 98.6°? Higher? Lower? Do you think your temperature is the same all the time?

Measure your temperature for three days in a row. Take your temperature in the morning right after you awaken (before you get up). Take it again just before breakfast, before lunch, and before supper. Then take your temperature just before going to sleep. Each time, note the time and temperature on a chart like the one shown, and mark down what you were doing just before you took your temperature

Saturday, January 10

TIME	ACTIVITY	TEMP.
8:00 AM	SLEEPING	97.4
9:00 AM	DRESSING	98.0
12:15 PM	FOOTBALL	99.2

(resting, studying, playing ball, or whatever). Be sure to shake down and rinse the thermometer with cool water after each reading.

Is your temperature always "normal"? When is it lowest? When is it highest? Is it *ever* exactly "normal"? What do you think the term "normal temperature" means? ■

INVESTIGATIONS

- Can you control your temperature by thinking about it? Take your temperature while sitting down, then start thinking about feeling either hot or cold. Think very hard for a few minutes, and then take your temperature again. Were you able to make your temperature go up or down by thinking about it?
- Does activity change your temperature? Take your temperature after you have been resting, running, standing, studying, walking, writing, or doing other things. Does exercising seem to raise your temperature more than studying?
- Ask several of your friends and relatives to let you take their temperatures. How much difference is there between the highest and lowest temperatures you record? Does age or sex seem to have anything to do with a person's temperature? (Remember to shake down, wash, dip in alcohol, and rinse the thermometer after each person has used it.)
- Does the temperature of the food you eat affect the reading you get from the thermometer? Try taking your temperature just before and just after you have had some hot soup or a cold drink. How long does it take for your mouth to cool off or warm up enough so that you can get an accurate thermometer reading?

nature and science
TEACHER'S EDITION

VOL. 7 NO. 9 / JANUARY 19, 1970 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

■ This special-topic issue features three SCIENCE WORKSHOP-type articles showing your pupils how to investigate the behavior of light, its "composition," and the phenomenon of color. These investigations can be made at home or in the classroom, by individuals or small groups, using simple equipment and common materials.

"The Ways of Waves and Particles" shows your pupils how to test the particle and wave theories of light against certain "behaviors" of light—reflection, refraction, and diffraction—observed in investigating "The Ways of Rays," so the ray investigations should be made first. Have your pupils keep notes on their findings, compare and discuss them in class, then try to sum up their findings in generalized statements about light and its ways.

The Ways of Rays

Here are some concepts your pupils can develop from their findings in this investigation:

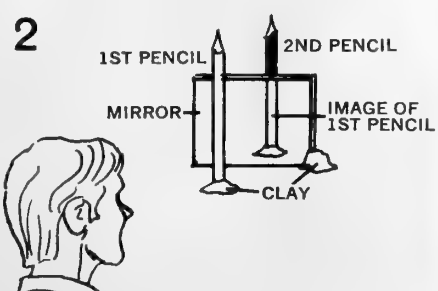
- Light rays spread out from the light-box opening because light travels in all directions from an "ordinary" light source *(see pages 8-9).*
- The angle at which a ray of light is reflected away from a surface is equal to the angle at which the ray meets that surface. (This is true whether the surface is plane or curved.)
- A mirror image of the slit in the light box is formed by rays that spread out from the slit, hit the mirror, and reflect back to your eyes. Since the reflected rays appear to be coming to your eyes from a point *behind* the mirror, that is where the image of the slit appears to be.

Your pupils can check this by the *parallax method:* With one eye closed, line up one finger of each hand as shown in Diagram 1. Then close that

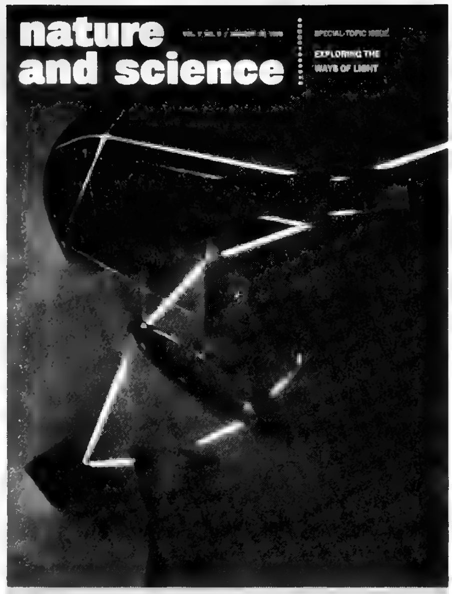
1

eye and open the other one. Since the two fingers no longer appear lined up, you can tell that they are at different distances from you. Now stand two pencils on clay on each side of a mirror, as shown in Diagram 2. Move the

2



(Continued on page 2T)



IN THIS ISSUE

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

● **The Ways of Rays**
Your pupils can investigate the reflection, refraction, and diffraction of light with an easy-to-make light box, some mirrors, and jars.

● **The Ways of Waves and Particles**
Can the ways of rays be explained by thinking of light as "a stream of particles" or as "waves"? Your pupils can use a ball and a baking-dish ripple tank to find out.

● **Brain-Boosters**

● **The New Kind of Light**
This WALL CHART shows how "ordinary" light and laser light are made, and how they are different.

● **What's in a Rainbow?**
Your pupils can separate different colors (wavelengths) of light from sunlight and see what happens when they are added to or subtracted from one another.

● **How Light Affects Life**
This article tells how scientists have discovered some of the many ways that light affects plants and animals; also, how we see colors.

IN THE NEXT ISSUE

Finding out what atoms are made of . . . How do penguins navigate in the Antarctic wastes? . . . How frogs defend their territories . . . SCIENCE WORKSHOPS: melting ice and snow; gathering and growing bacteria . . . Benefits from bacteria.

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

second pencil until it is lined up with the *image* of the first pencil when you view the pencils with *either* eye. This means that the pencil behind the mirror is at the point where the *image* of the first pencil appears to be—as far behind the mirror as the first pencil is in front of it.

• A concave mirror reflects rays from the light box so that they meet in front of the mirror and pass through each other. The image you see appears to be at the point where the reflected rays meet, and since it is *in front* of the mirror, the image is closer to you and appears larger than the image of the same object that you would see "behind" a plane mirror. (This larger image is what makes a concave mirror useful for shaving or applying cosmetics.)

• By bringing together in front of the mirror some of the light rays spreading out from each point of a distant object, a concave mirror can produce a *real image* of the object—one you can see on a screen, which "captures" the reflected rays at the points where they come together.

• A *convex mirror* produces only behind-the-mirror, *virtual* images, but it catches light rays from a wider area in front of the mirror than a plane mirror does, so it is useful in stores to watch for shoplifters, or as a rear-view mirror on trucks.

• A *convex lens* "bends," or *refracts* light rays as they enter and leave the lens. When it refracts rays from a light-box slit so they are brought together at a point beyond the lens, a screen placed at that point "captures" a real image of the slit.

When a distant object is viewed through a convex lens held at arm's length, light rays from the top of the object are refracted so they reach the bottom of your eye, while rays from the bottom of the object reach the top of your eye, so the image is upside down. The investigation with Diagram 8, page 4, shows how this takes place. *(For additional investigations of lenses, see "A Look at Lenses,"* N&S, *Feb. 17, 1969.)*

• When a light source is viewed through a very narrow slit, the light seems to "spread apart" after it has passed through the slit, and produces tiny "rainbows" of colored light (best seen when rays are reflected between the grooves of a phonograph record as shown in the article).

Ways of Waves, Particles

• A ball bounces away from a surface at an angle equal to the angle at which it meets the surface, so the particle model of light could explain reflection.

• A ball given pushes as shown in Diagrams 2 and 3 *(page 7)* speeds up as it "enters" the "transparent material," and slows down as it leaves the material. But light *slows down* as it moves from air into glass or water, and *speeds up* when it moves back into the air. So the particle theory cannot explain refraction.

• A stream of particles passing through a narrow slit does not do anything that seems to explain the diffraction of light.

• Dipping one finger into a ripple tank makes waves that spread out from the source somewhat as light does, though only through the surface of the water. (Light normally spreads out in *all* directions from its source.)

• When water waves from a "point source" (dipped finger) are reflected from a flat "mirror," the shape of the reflected waves makes them appear to be coming from a point behind the "mirror." This is what happens when light rays from the slit on the light box are reflected from a plane mirror.

• A straight water wave, representing a number of parallel light rays from a distant source, is reflected from a flat "mirror" just as the light rays would be.

• The parts of a straight wave (representing parallel light rays) are reflected from a concave "mirror" (bent hose) to the *focal point* of the mirror. Circular (point-source) waves made by dipping a finger (or dropping water from an eyedropper) at the focal point of the concave mirror reflect from the mirror as straight waves (parallel rays), much as rays from a spotlight bulb are reflected by the concave metal reflector.

• Water waves slow down as they pass from deeper water into shallower water, and speed up as they move back into deeper water, just as light waves do when they move from air into water or glass, for example, then back into the air. When water waves move into shallower water at an angle to the "edge" of the shallower water, the waves are refracted in the same way that light rays are refracted.

• Water waves passing through a narrow slit spread out just as light does after passing through a narrow slit.

• As the article points out, light also acts in some ways as if it were a stream of "particles" — individual "bundles" of energy. But scientists have discovered that moving electrons, or other tiny particles of matter, often behave like waves. For example, two streams of electrons passing through each other can produce an *interference pattern* like the ones produced by water waves from two sources *(see photo on page 11)*. As a result, scientists now think that light may consist of a stream of particles that often behave like waves.

The New Kind of Light

This WALL CHART shows how light is made—both "ordinary" light (the only kind there was until 1960) and laser light. (This explanation uses only the wave theory of light; a more detailed explanation requires the combined wave-particle theory.)

Whether or not your pupils understand fully how light is made, they

(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.

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

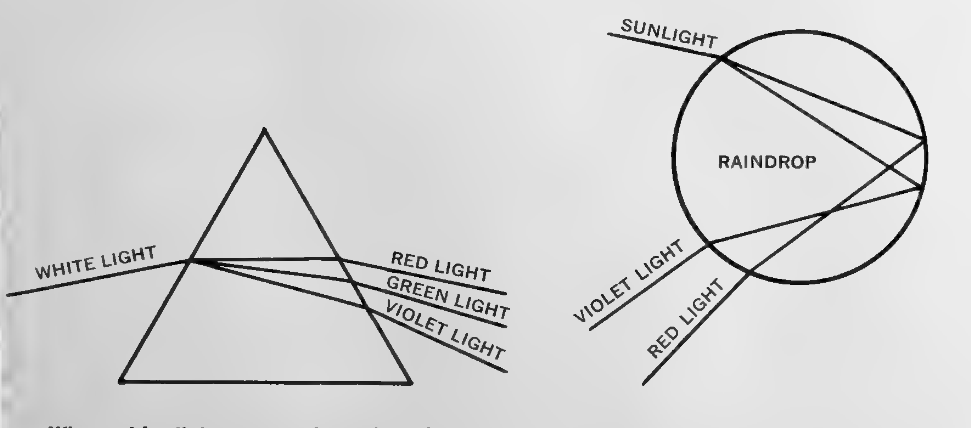
should be able to see how and why ordinary light and laser light are different: 1) Laser light is more *directional* because all of its waves are traveling in the same direction. 2) Laser light is the *purest* in color of any light ever produced, because its waves are all the same length *(see definition of wavelength at bottom of page 12)*. 3) Laser light is *coherent* (its waves are all "in step" with each other, so they reinforce each other, instead of interfering with, or canceling, each other as waves of ordinary light tend to do). 4) Because it is so coherent and directional, all of the energy of a laser beam can be focused (with a concave mirror or a convex lens) at a very tiny point in space where the light is more *intense* (concentrated and powerful) than any other kind of light.

The ability of focused light from certain lasers to burn holes in metal or burn tumors off internal parts of the human body may lead some of your pupils to suggest that a laser beam is a kind of "death ray," like those described in the more violent science fiction. While light from certain lasers is dangerous to objects in its path, it would probably not be very effective as a military weapon. Other laser beams are less intense, and can be safely used for many purposes.

Laser light promises to be an extremely useful tool for man. Because it is truly a "new kind of light," not found in nature, it might be well to investigate its effects on living things before putting it into wide use, instead of using it without concern about how it might change our environment and ourselves.

What's in a Rainbow?

- By passing a ray from the bulb in a light box through a glass prism, your pupils can also obtain a spectrum (light from a fluorescent tube does not contain all the wavelengths of visible light).
- Strictly speaking, the light that is reflected from an opaque object is not the same light that strikes its surface. Waves of certain lengths in the incident light are absorbed by pigments in the object. Other waves in the incident light excite electrons in atoms of the surface material and make them give off waves of slightly different lengths *(see "How Light is Made," pages 8-9)* as what we call "reflected light."
- While we can properly describe light as *waves of electromagnetic energy (see bottom of page 12),* this does not mean that we know what light "is," because we do not know what *energy* is; we only know what energy can *do*. It can move objects (light can move electrons, as shown on pages 8-9). We know that light, as well as radio waves, X rays, and other forms of electromagnetic energy, moves through space in waves that cause electrical and magnetic "disturbances" in space. (Waves of mechanical energy passing through water push the water up and down.)



When white light passes through a glass prism, light of shorter wavelengths is refracted more than light of longer wavelengths. A raindrop (like a "water prism") both refracts and reflects sunlight to produce a rainbow.

How Light Affects Life

No life can exist without sunlight. Even those organisms that live in darkness, such as cave animals, depend for food on material that once got energy from the sun *(see page 2)*.

Beyond the knowledge that light supports all life on earth, man still has much to learn about its other effects. This article touches briefly on some effects of day length. These are most pronounced in plants and animals from temperate and arctic areas, where there is a seasonal change in day length. Most tropical organisms are not adapted for seasonal variations, because the length of the tropical day varies little during the year. As it turns out, changes in day length can disturb tropical animals. They seem to do better in captivity if they are given their natural 12 hours of light and 12 of darkness.

Your pupils may not have heard of the *endocrine* system, although they probably know of some of the glands that make up the system. These glands release chemicals directly into the circulatory system that are then carried through the body in the blood. The word "endocrine" means "without tubes or ducts"; these glands differ from those that produce tears, sweat, and saliva. It is the endocrine system and the nervous system, working together, that keep a living organism functioning normally.

Brain-Boosters

Mystery Photo. The workman on the unusual-looking trailer is spraying trees to control insects.

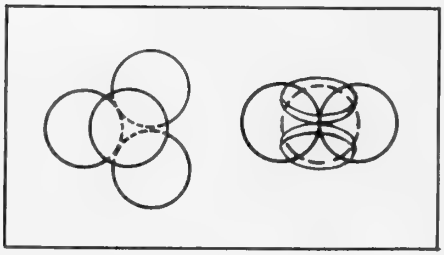
What would happen if? So long as the jar is kept tightly sealed, there will be no change in its weight. There will be changes in the composition of the food substances and gases in the jar as the food decays, but since the jar is sealed, nothing can enter or leave it to change its weight.

You might let the class experiment with other changes that occur within "closed systems." They could try placing a young plant in a closed jar; sealing some wet steel wool in a jar; covering a jar that has a candle burn-
(Continued on page 4T)

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

ing inside it. In each case there will be changes that your pupils will be able to see and perhaps offer explanations for. But in each case the weight of the system will remain constant.

Can you do it? The diagram shows how to arrange four or five pennies so



that each one touches all the others. In puzzles such as these, the biggest problem is often getting people to think in three, rather than just two, dimensions. If your pupils seem to be just sliding pennies around on their desks without nearing a solution, point out to them that the pennies need not be flat on the desk. Then see whether this hint "breaks the ice" sufficiently to enable someone to solve the problem.

Fun with numbers and shapes. Since the hands of a clock pass one another 11 times in 12 hours, dividing 12 hours by 11 will give you the amount of time between each two meetings of the hands: 65 minutes, 27 seconds. (It will be easiest for your pupils to do this division problem if they first convert 12 hours into seconds.)

For science experts only. As the air temperature goes down, the rocks and soil along the shore of a lake lose their heat to the air faster than the water loses its heat to the air. This makes the water near the shore lose its heat (to the soil and rocks) faster than the water in the middle of the lake loses its heat (to the air).

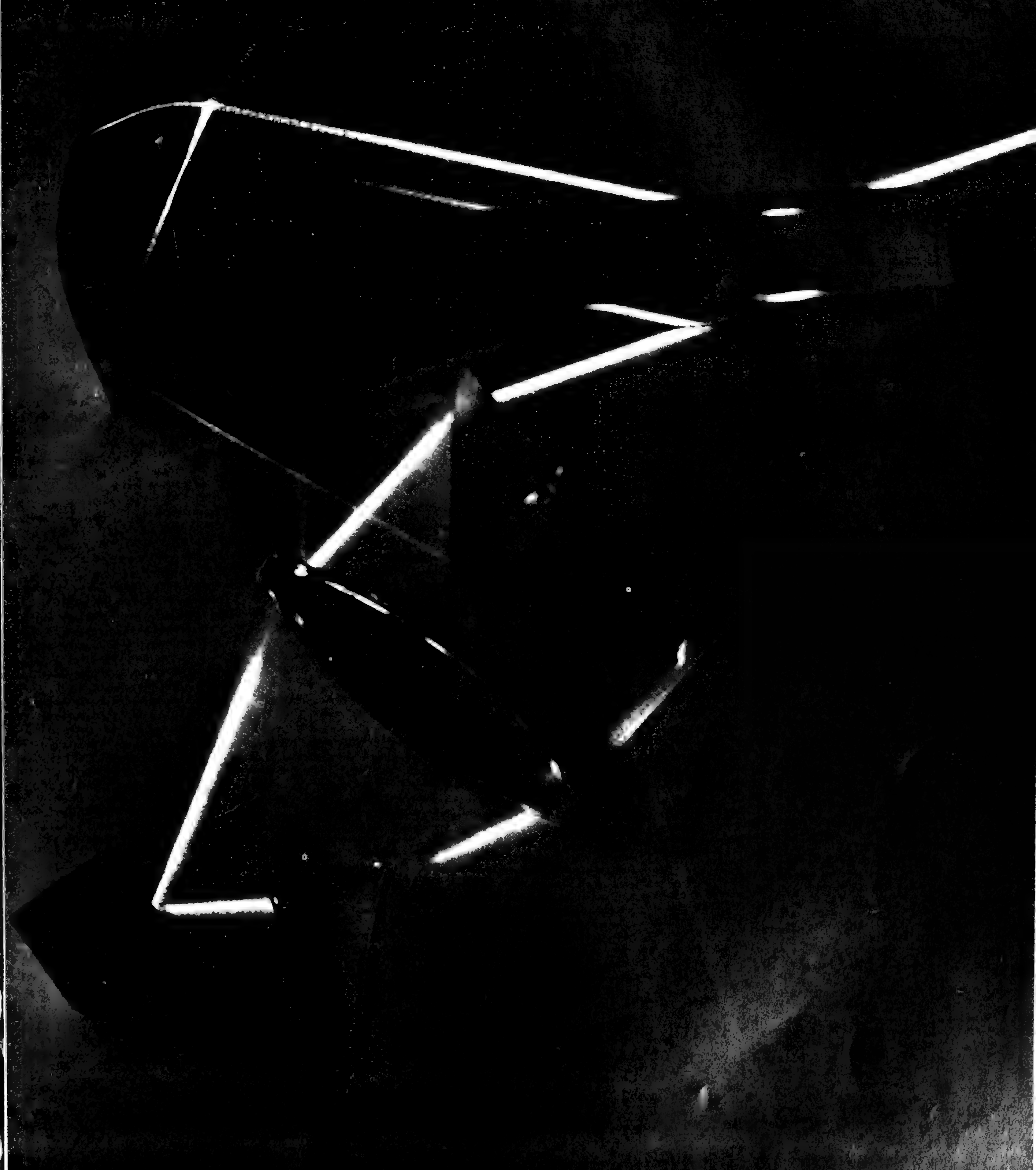
When the air gets warmer, the soil and rocks of the shore take heat from the air faster than the water takes heat from the air. This makes the water near the shore warm up faster than the water in the middle of the lake. Thus the same basic process accounts for the ice both freezing and melting first along the shore.

nature and science

VOL. 7 NO. 9 / JANUARY 19, 1970

SPECIAL-TOPIC ISSUE

EXPLORING THE WAYS OF LIGHT



nature and science
VOL. 7 NO. 9 / JANUARY 19, 1970

CONTENTS

PICTURE CREDITS: Cover, George Resch, Fundamental Photographs; p. 2, Laurence Pringle; pp. 3-13, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 7, photo by David Webster; pp. 8-9, top photo courtesy The Bendix Corporation, bottom photo courtesy American Optical Co.; p. 11, photo by Robert Gardner; p. 14, John Verde from Photo Researchers, Inc.; p. 15, photos from AMNH; p. 16, Leonard Lee Rue III.

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

EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

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.

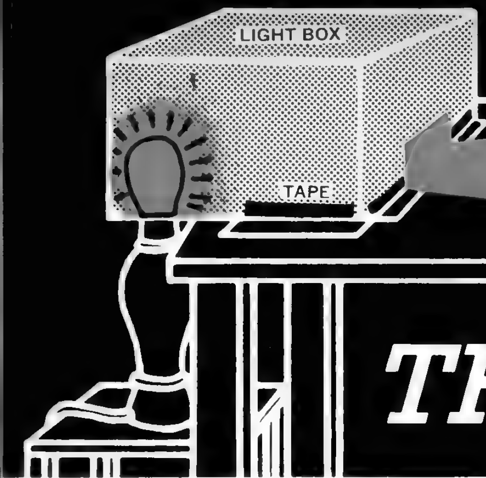
■ Light brings to your eyes pictures of objects as far away as the distant stars, or as close as your eyes themselves. But light is not an object, so it can't bring you pictures of itself. You can find out quite a bit about light, though, from the pictures light brings you when it follows different paths from an object to your eyes *(see next page)*.

What you learn about how light rays behave will help you test some ideas scientists have suggested about what light "is" *(see page 7)*.

Until just 10 years ago, there was only one kind of light. The WALL CHART on pages 8 and 9 shows you how this "ordinary" light is made, and how an amazingly powerful and pure *new* kind of light is made and used.

Ordinary light is a mixture of light of all colors, and the article on page 12 shows you how to separate the colors in sunlight and put them back together again.

Light does more than just bring pictures of the world (in "living color") to your eyes. It also provides the energy that plants need to change water and carbon dioxide into food and give off oxygen into the atmosphere. Animals must have this food and oxygen to live. The article on page 14 tells how scientists have discovered still more ways that light affects living things ■



What happens when light gets "bent" on its way from an object to your eyes? You can make a simple light box to investigate—

THE WAYS OF RAYS

by Robert Gardner

■ Have you ever taken a close look at your *image*? Not at *yourself*, but at the "picture" of yourself that you see in a mirror? Do you think your image looks exactly like you? Wink your right eye, and see which eye your image winks. Raise your right hand, and see which hand your image raises.

Hold this page up facing the mirror and look at its image. How are the images of the words and letters different from the way the words appear when light travels directly from the page to your eyes, instead of going to the mirror first? Can you explain the difference?

Move to one side of the mirror and look into it. What do you see? If someone stands at the other side of the mirror, can you see his image? Can he see yours? Is it possible for you to see his image without having him see yours, if you are both looking at the mirror?

When you look into the mirror, where does your image seem to be? (Can it really be there?) Move back from the mirror, then toward it, and see how your image moves. Can you see the images of objects that are in front of you and behind you? Where do their images seem to be? How can you make the image of your finger touch the image of your nose?

You can investigate the images you see in a mirror by making a simple light box, as shown on this page. With it, you can trace the paths of just one or two "rays" (tiny beams) of light, instead of all the light you saw when you looked into the mirror.

Tracking a Ray of Light

When your box is ready, turn on the light inside it, and darken the room. Look at the beam that comes through the hole in the box. Why does it spread out? Can you reflect the beam with a small mirror?

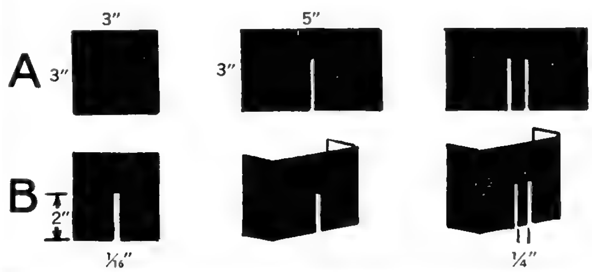
To get a narrow beam, or "ray," of light, tape the black square over the opening in the box as shown in Diagram 1. Then place the rectangle with the single slit about two or three inches in front of the first slit. When you put a mirror in the ray's path, which way does the ray go after it hits the mirror? *(Continued on the next page)*

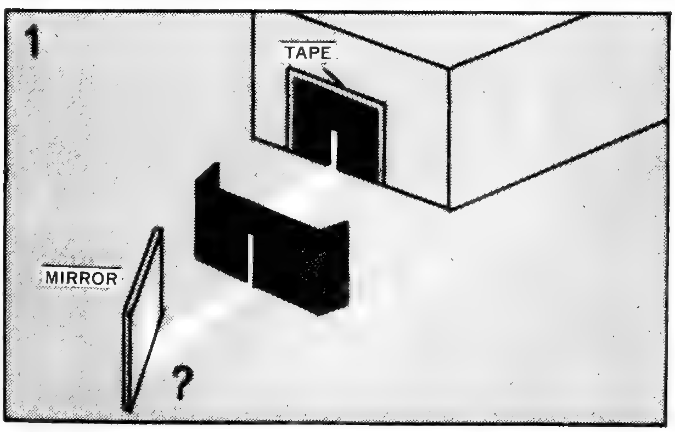
HOW TO MAKE A LIGHT BOX

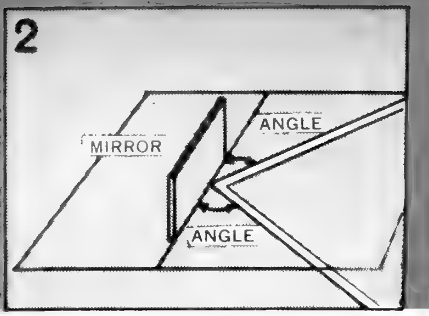
You will need a cardboard box, a lamp with a 100- or 150-watt bulb, scissors, tape, a small pocket mirror, pencils, black paper, and aluminum foil. The diagram above should help you make your light box.

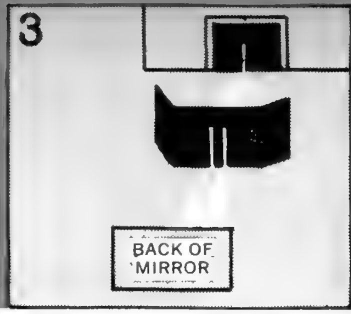
Cut a hole about two inches long and two inches high in one end of the box. Place the box on the end of a table, with enough of the box sticking out over the edge so that a light bulb will fit inside. The round part of the bulb should be just above the level of the tabletop and directly behind the opening at the other end of the box. *Be sure that the hot bulb is not touching the box.* So that the box won't move and bump the bulb, tape the box to the table.

From a sheet of black construction paper, cut out a square and two rectangles as shown in Diagram A. Then cut a slit about two inches long and 1/16 inch wide in the square (see *Diagram B*). Cut a similar slit in one of the rectangles. In the other rectangle, cut two such slits, about 1/4 inch apart. (It may be hard to cut narrow slits with scissors. If a slit is too wide to make narrow rays, you can cover part of it with masking tape.) Fold back the outside inch of each side of the two rectangles so that they will stand up.









The ray that hits the mirror is called the *incident* ray. How does the angle between the mirror and the incident ray compare with the angle between the mirror and the *reflected* ray? To find out, stand the mirror on a sheet of paper and draw a line along the front edge of the mirror, another line along the incident ray, and another along the reflected ray *(see Diagram 2)*. Then either cut out the angles with scissors or measure them with a protractor. How do the angles compare?

Change the angle at which the incident ray hits the mirror. How does this change the angle between the mirror and the reflected ray? Do your findings help explain what you saw when you stood to one side of a mirror and looked into it?

Now place the rectangle with two slits several inches in front of the slit in the light box. Place the mirror as shown in Diagram 3. (You can use some pieces of clay to support it.) When the rays from the two slits reach the mirror, what happens to them?

You can see that if the two reflected rays were stretched out behind the mirror, they would meet. How far behind the mirror would they meet? How far is the mirror from the single slit in the front of the light box? Does this tell you anything about how you see images where they can't really be?

Suppose the two slits were your two eyes, and the rays coming from them were rays of light reflected from your eyes to the mirror. Which ray would be coming from your right "eye"? Now look *from behind the mirror* at the two reflected rays. Is the one that started at your right "eye" still on your right? Can you explain now why your image winks its left eye when you wink your right eye?

Reflections from Curved Mirrors

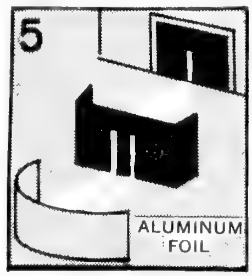
You have probably seen mirrors that are curved, instead of *plane* (flat). A curved mirror whose center bulges out toward you is called a *convex* mirror; one whose center curves inward is a *concave* mirror.

The most common concave mirrors are those used by men for shaving, or by women for putting on makeup. If you do not have one, you can probably buy one for 25 cents to $1 at a variety store. When you look at your image in a concave mirror, how is it different from the image you see in a plane mirror? What happens to your image as you move farther away from the mirror? Can you see why a concave mirror is useful for shaving or putting on makeup?

Unlike a plane mirror, a concave mirror can form *real* images; that is, images that you can see on a screen. To "capture" such an image, have someone move a "screen" (a sheet of paper or cardboard) away from the front of the mirror while you hold the mirror facing a window *(see Diagram 4)*. By turning the mirror, you can reflect light from the window onto the screen to form a real image of the window and the view outside. Is the image right-side up or upside down?

Try capturing the image of a lighted bulb. Can you make the bulb's image larger? Smaller? How?

From your investigation of reflections in plane mirrors, can you guess how a concave mirror will reflect two light rays from your light box? You can use a curved strip of smooth, shiny aluminum foil, as shown in Diagram 5, to find out. What happens if you curve the "mirror" more? Less? From your findings, can you explain how a concave mirror produces real images on a screen?



How will a *convex* mirror reflect the rays? To find out, curve the aluminum foil so its shiny side bulges toward the light source. Do you think a convex mirror will form real images? Why? Where will the images in a convex mirror appear to be?

Bending Light with Lenses

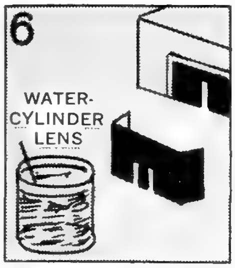
Do you think that light rays from, say, a tree outside your window are bent very much as they pass through the glass to your eyes? You can tell by comparing how the tree looks when you see it through the glass, then through the open window.

Now hold a magnifying glass at arm's length, and look through it at a tree (or at a lighted lamp across the room). Do you see the *tree*, or its *image?* How can you tell? (Because a magnifying glass bulges outward in the middle, it is called a *convex lens.*)

By holding a sheet of paper behind the lens, you can "capture" an image of the tree. (How does this image compare with what you saw when you looked through the lens at the tree?)

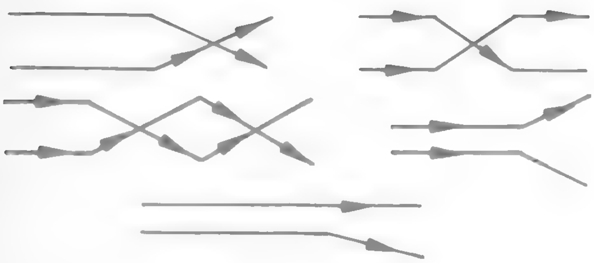
From these investigations, and from what you have learned about reflections from concave mirrors, can you explain how light rays change direction as they pass through a convex lens? You can test your explanation with your light box.

Find a clear plastic or glass jar, drinking glass, or pill bottle that has straight sides, and fill it with warm water. (How is this water cylinder like a convex lens?) Place it in the path of the two rays from the light box, as shown in Diagram 6.



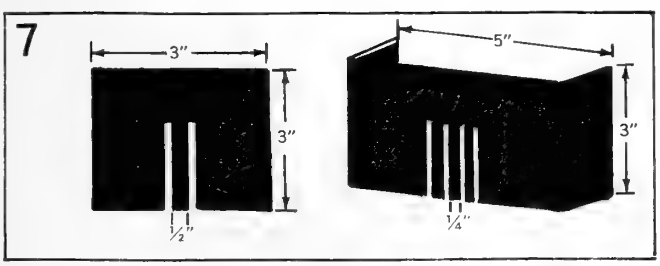
What happens to the rays as they pass from the air into the water, and from the water back into the air? What happens if you use a water cylinder that has a larger diameter? A smaller diameter?

Using one or two "water lenses," see whether you can make ray patterns like these:



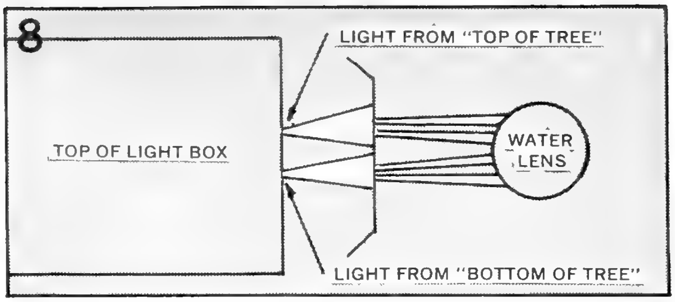
Can you get at least one of the rays to pass through the lens without being bent? How? What will happen to the point where the two rays cross if you move the lens closer to the light box? Farther from it?

To find out why the real images you captured with a magnifying lens were upside down, cut and slit two pieces of black paper as shown in Diagram 7. Tape the piece



that has two slits in it over the opening in the light box. Then stand the four-slit piece so that two rays come through it from each slit on the light box. Place the water lens as shown in Diagram 8.

Now, looking straight downward at the rays, imagine that the top rays from the light box are coming from the top of a tree, and that the bottom rays are coming from the bottom of the tree *(see Diagram 8)*. Where do the rays

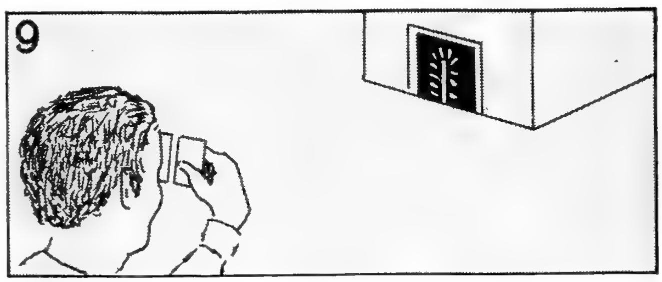


from the "top of the tree" come together? How about the rays from the "bottom of the tree"? (If you have trouble deciding which rays are which, slide a piece of black paper over one slit in the light box.) Can you explain now how a convex lens forms a real image of an object?

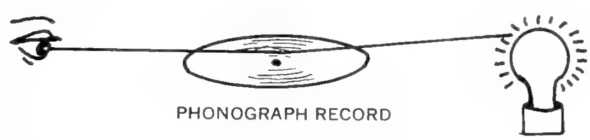
Another Way To Bend Light

You have seen how light is bent by reflection, and how it is bent as it passes through transparent materials such as water, glass, or plastic. (This kind of bending is called *refraction.*) There is still another way to bend light, called *diffraction.*

To see what happens when light is diffracted, cover the opening of your light box with the single-slit square of black paper. As you look straight into the slit, bring the edges of two mirrors (or other objects with straight edges) very close together in front of one eye *(see Diagram 9)*. What do you see?



You can see even more clearly the colors produced when light is diffracted if you look at light that is reflected from the narrow grooves in a phonograph record. Hold the record up in front of your eyes so that the light from a lamp just skims the surface of the record, as shown.



There is nothing more that you can do with your light box to help you understand diffraction. To find out why light is bent as it passes through a narrow slit, you will have to think of light as something other than a group of "rays" *(see page 7)* ■

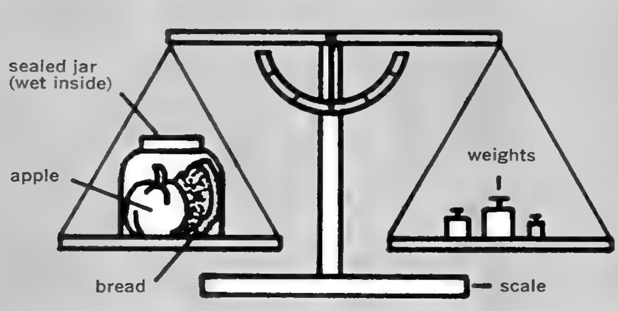
brain boosters

by DAVID WEBSTER

Just for fun
Do you know how fast your fingernail grows? You can find out by scratching a line on your nail at the cuticle. Use a fingernail file or a triangular metal file. See how long it takes for the mark to move a quarter of an inch. You could try marking a toenail, too.

Can you do it?
Here are three pennies arranged so that each one touches the other two. Can you arrange four pennies so that each touches the other three? Can you arrange five pennies so that each touches the other four?

What would happen if?
Suppose a piece of bread and an apple are sealed in a jar that is wet inside. The jar is then balanced on a scale and left for a month. As the food becomes moldy and decays, will the jar get lighter, heavier, stay almost the same weight, or stay exactly the same weight?



For science experts only
The water in a lake freezes first around the lake's edge. But when spring comes, the ice *melts* first along the lake's edge. Can you explain why?

Fun with numbers and shapes
How much time passes between the time the minute hand and the hour hand on a clock meet, then meet again?
Submitted by Charles Robinson, Bethesda, Maryland

Mystery Photo
What is this man doing?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The photo was taken on a sandy beach as the tide was going out. The miniature valleys and deltas are formed as seawater runs down over the sand.

What will happen if? The smaller weight swings in a circle around the string of the heavier weight while the heavier weight moves slowly back and forth like a pendulum. How long do the weights continue to move? What would happen if the two weights were equal?

Can you do it? It is impossible to drink water through the long straw unless you close the end of the short straw with your finger. Can you figure out why?

Fun with numbers and shapes: To find the thickness of a sheet of newspaper, measure the thickness of a whole newspaper, and divide by the number of sheets. Can you find a kind of paper that is less than half as thick as newspaper?

For science experts only: The two cars would be damaged about equally, even though one was traveling faster. What would happen if one car were much heavier than the other?

If light were a "stream of particles," would it behave as light rays do? What if light were a series of "waves"? You can find out by investigating—

THE WAYS OF WAVES AND PARTICLES

by Robert Gardner

■ By investigating "The Ways of Rays" *(see page 3)*, you found out what happens to light when it "bounces" off a mirror, or moves from one transparent substance into another, or passes through a narrow opening. But *why* do those things happen? What is it about light that causes it to be reflected, refracted, or diffracted, as you have seen?

To explain the way light behaves, scientists developed two theories, or "models," of light. One model "pictured" light as a stream of tiny particles traveling to your eyes from any object that you can see. The second model pictured light as some kind of "waves" traveling from the object to your eyes.

The Paths of Particles

If you think of a light ray as a stream of particles, for example, will this idea help you explain reflection? Use a rubber ball to represent just one of the light particles, and bounce it against the floor as a "mirror." Throw the ball at different angles against the floor. How does the angle at which the ball *leaves* the floor compare with the angle at which it *meets* the floor? Is this like the reflection of light?

The English scientist Sir Isaac Newton explained refraction quite well using a particle model. He said that when a particle of light gets very near a substance like glass or water, the substance pulls on the light particle, causing its path to bend as the particle enters the material *(see Diagram 1)*. Once inside the glass or water, the particle does not turn any more because it is pulled equally in all directions by the substance. As light particles leave the substance and enter the air, they are again pulled by the glass or water, causing their path to be bent again.

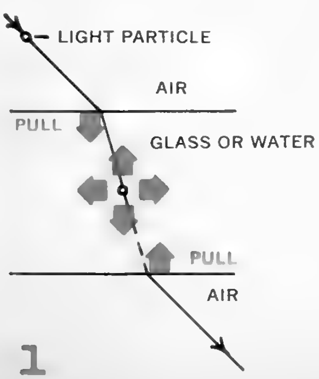
You can see how this works by rolling a ball along the floor. As it crosses a line that represents the surface of a transparent material, give it a push toward the line *(see Diagram 2)*. Then as it crosses another line that represents the other side of the substance, give it another push to represent the pull of the substance on a light particle *(see diagram)*. Is its path like the path light would follow?

Now place a large circle of thread on the floor. The area inside the thread can represent the water in a jar or the glass in a lens. Roll a ball toward the circle. Give it a push as it enters and leaves the circle *(see Diagram 3)*. Does the ball follow a path like the path a light ray follows when it passes through a cylinder of water *(see "The Ways of Rays," page 3)*?

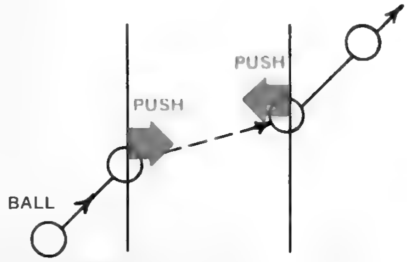
When you give the ball a push into the "substance," does it seem to speed up, or slow down? What does this suggest about the speed of light when it passes from air into water or glass?

In 1849 a French scientist named Armand Fizeau measured the speed of light through air. He found that it traveled at about 190,000 miles per second. (That means it could cross the earth's diameter in about 1/25th of a second!) In 1862 another Frenchman, Jean Foucault, measured the speed of light through water. Instead of finding a speed greater than 190,000 miles per second, as

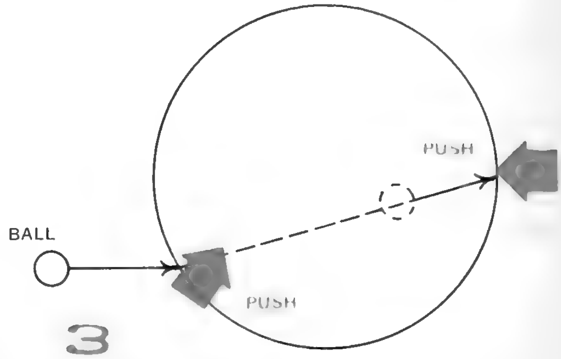
(Continued on page 10)



1

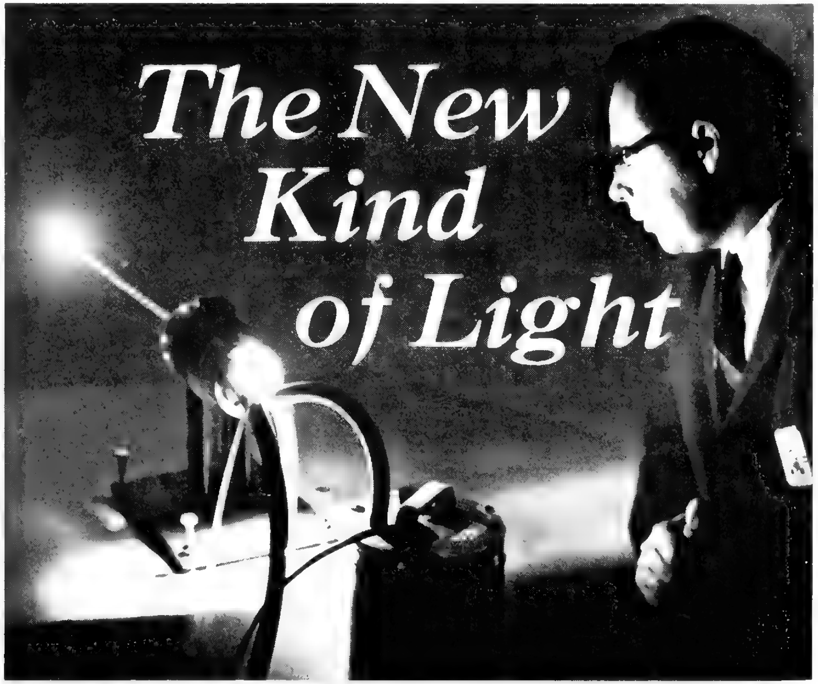


2



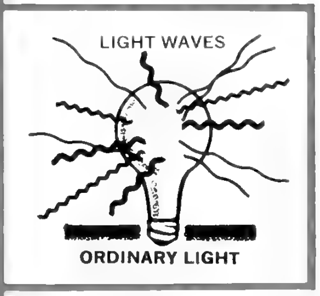
3

The New Kind of Light

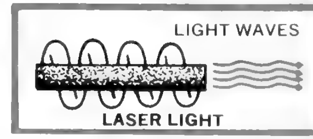


■ Just 10 years ago, scientists first made *laser light*—a new kind of light that is more powerful, brighter, purer in color, and travels in narrower beams than ordinary light from the sun or a light bulb. The diagrams *(below and right)*, showing how both ordinary light and laser light are made, will help you understand how and why they are different from each other.

Ordinary light waves come from the sun, or a flame, or a light bulb, in wild disorder *(see diagram)*. The waves are of all different lengths (colors), so you see them as white light *(see page 12)*. Moving in all directions from the source, the waves get farther and farther apart, so the farther you are from the source, the fewer waves can reach your eyes. Ordinary light is *incoherent*—the waves are "out of step" with each other. Where two of these waves meet in space, they may reinforce each other, making the light stronger at that point, or they may interfere with each other, making the light weaker at that point. The out-of-step waves may even cancel each other, so there is *no* light at that point *(see photo, page 11)*.



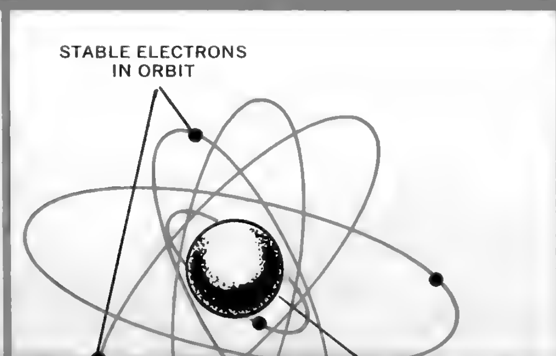
Light comes from a laser in waves that are all the same length, all *coherent* (in step) with each other, and all moving in the same direction *(see diagram)*. This makes laser light much purer in color, brighter, and more powerful than ordinary light. And laser light spreads out so little that it can travel to the moon and back and still be detected through a telescope on earth.

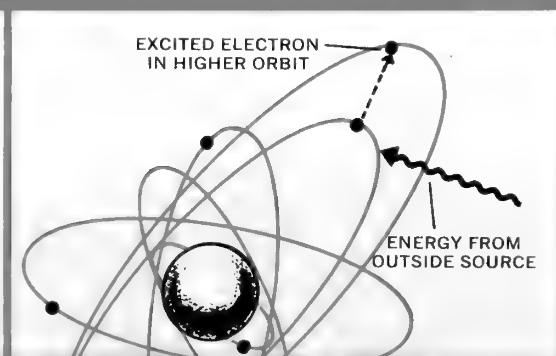


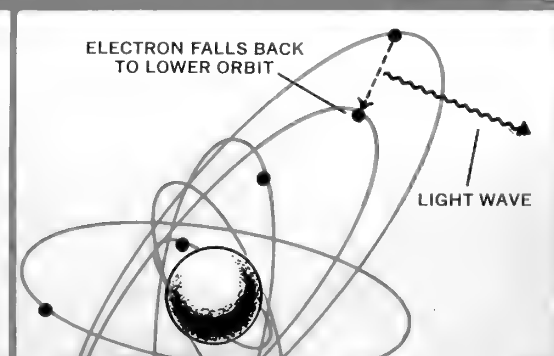
Laser light can now be made in many different colors and strengths, in pulses or steady beams, by exciting different kinds of atoms with different kinds of energy. This WALL CHART shows a few of the ways this amazing new light can be used. Can you think of other ways?

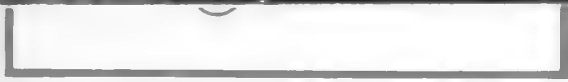
—F.K.L.

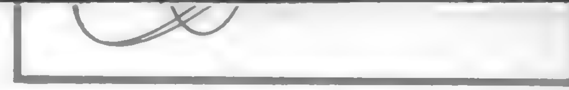
HOW LIGHT IS MADE











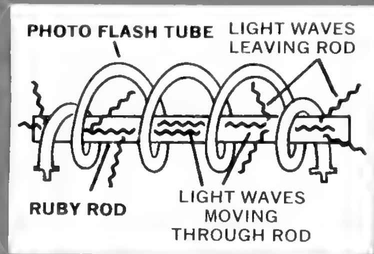
Light is made by the activity of electrons, the tiny, electrically charged particles that orbit the *nucleus* (center part) of an atom like artificial satellites orbiting the earth. Each kind of atom has only a certain number of orbits in which its electrons can move. When the electrons are moving in the lowest possible orbits of an atom, the electrons are said to be "stable."

When a stable electron gets energy from an outside source, it becomes "excited" and jumps from its stable orbit into an orbit farther from the atom's nucleus. (Electrons in the outer part of the sun are excited by the heat from atomic reactions at the center of the sun; electrons in the wire filament of a light bulb are excited by heat from the flow of electric current through the filament.)

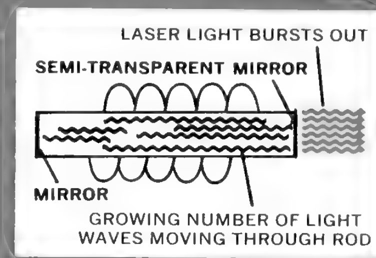
Within a fraction of a second, the excited electron falls back into a lower orbit, giving off its extra energy in the form of *electromagnetic waves* – waves that cause electrical and magnetic "disturbances" at each point in space that they pass through. If the waves are between 15 and 18 millionths of an inch in length, and enough of them reach your eyes, you see light.

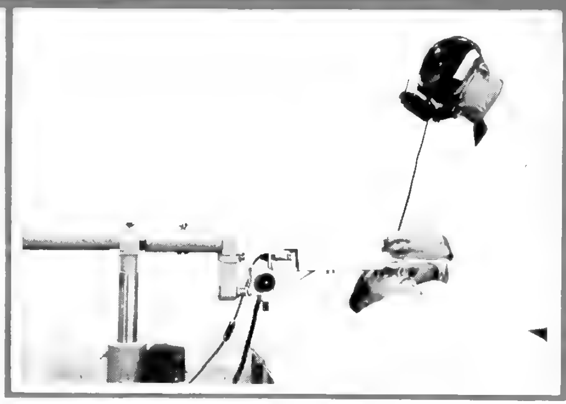
HOW LASER LIGHT IS MADE

The first laser was a rod of synthetic ruby with a photographic flash tube coiled around it. The flashes of light excite electrons in the chromium atoms of the rod. As some of the excited electrons give up their extra energy, the light waves they make "trigger" other excited electrons to give off light sooner than they ordinarily would. Light waves made this way are all the same length and "in step" with each other, but they move in all directions.

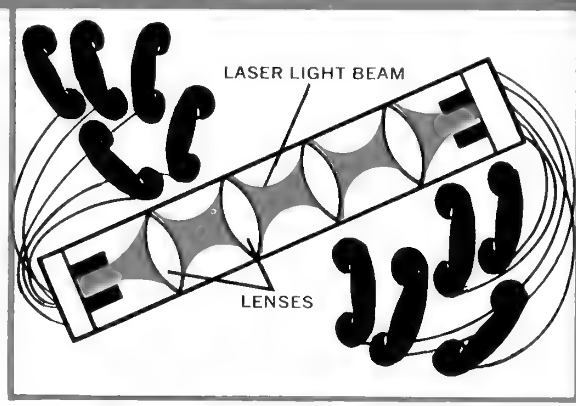


The light waves that move toward the ends of the rod hit mirrors that bounce them back through the rod, making them trigger still more excited electrons that make more waves. Many escape from the sides of the rod, but some join the "march" through it. When billions of waves reach the partly-silvered mirror at one end together, they burst through it in a pulse of immensely powerful, pure red light.

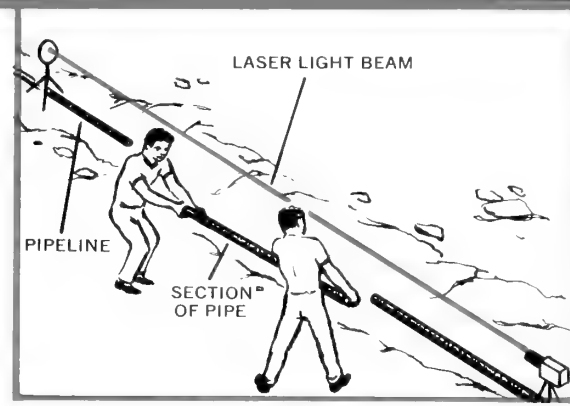




A curved mirror sends light from this laser through a human eye without harming it and brings the beam to a sharp focus to burn off a tiny growth on the retina, or inner lining of the eye. Other lasers can melt a hole in hard steel plate in less than a thousandth of a second.



A beam of laser light can carry many more messages at one time than a telephone cable, or even a beam of very short radio waves. While laser light is blocked by rain or snow, it can be beamed through a pipeline with lenses inside to bend the light around the earth's curved surface.



A laser beam that can be seen only by persons in its path helps them lay pipe or dig tunnels in straight lines. Long and short distances can be measured more accurately with laser light, and it can be used to detect tiny movements caused by strains in a dam or a layer of rock.

the particle model predicted, Foucault found the speed to be about 140,000 miles per second.

Something was wrong with the particle theory of light. It did not agree with the results of Foucault's experiment. There were also other problems with the particle model; for instance, can a particle theory explain diffraction?

A Look at Waves

The second theory suggested that light can best be understood if we imagine that it behaves like waves. To see how this "model" works, you can make and observe small waves in a simple *ripple tank.*

You will need a clear plastic pan or box at least eight inches wide. (A rectangular glass baking dish with a smooth, flat bottom will do. Or you can get a clear plastic "sweater box" at a variety store.) Place the pan beneath a ceiling light so the light shines through it onto the floor. You can support the pan at each end with chairs or table ends *(see Diagram 4).* Once the pan is level, pour water in until it is about ½ inch deep.

Make a wave by dipping your finger into the water, or by letting water from an eyedropper fall into the water. You can see the image of the wave on a large sheet of white paper on the floor beneath the plastic dish. What shape does the wave have? How does it move? Does it move from your finger or from the splashing drop as light would move from a point source of light? What happens when the wave reaches the walls of the plastic dish? (To prevent unwanted reflections, line the walls of the plastic container with strips of soft cloth.)

Are water waves reflected in the same way as light? To find out, use a flat piece of wood (or a mirror supported by clay) to represent the "mirror." Place the "mirror" in the water near one end of the dish. Use your finger to make a wave that represents the light coming from a pinpoint source of light *(see Diagram 5).*

What happens to the wave when it hits the "mirror"? Where does the reflected wave seem to be coming from? Is that where the *image* of the "pinpoint of light" would seem to be? What will happen to the place where the image seems to be as you move the "pinpoint of light" toward or away from the "mirror"?

How does the angle at which the "light" hits the "mirror" compare with the angle of reflection? To find out, place the flat piece of wood across a corner of the pan *(see Diagram 6).* Then make a *straight* wave by gently rolling a piece of wooden dowel, a test tube, or some other thin cylinder along the bottom of the pan. Try not to jiggle the pan as you move the wave-maker; rolling it only a very short distance will make a wave.

The straight wave could represent a large number of parallel rays moving toward the "mirror." Compare the angle at which the wave strikes the "mirror" with the angle at which it is reflected. What happens if you change the angle between the wave and the "mirror"?

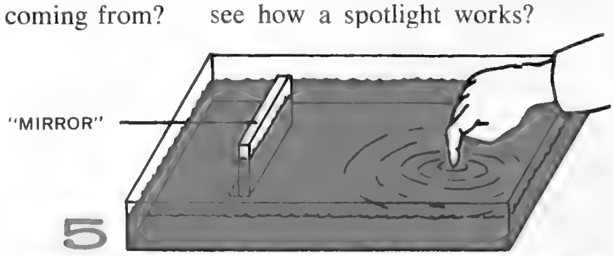
Reflections from Curved Mirrors

You can make a curved "mirror" by putting a piece of stiff coathanger wire inside a piece of rubber tubing, to keep the tubing shaped the way you bend it. Placed in the tank as shown in Diagram 7, the tubing will act as a *concave* "mirror."

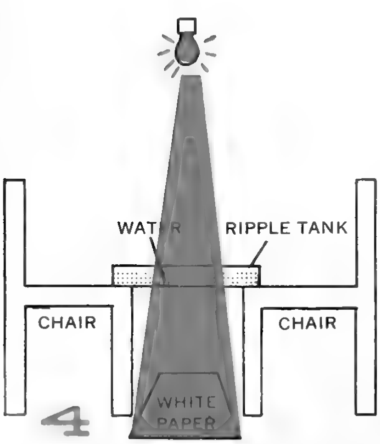
Can you predict how a straight wave will be reflected by this concave "mirror"? (Remember, a straight wave represents a group of parallel light rays, not a wave from a "pinpoint of light.") Make one and see.

Now use your finger, or an eyedropper, to make waves from a "pinpoint of light." Where do the waves reflected from the concave "mirror" form an "image" of the "pinpoint of light"? What will happen to the image if you move the "pinpoint of light" closer to the "mirror"? Farther from it?

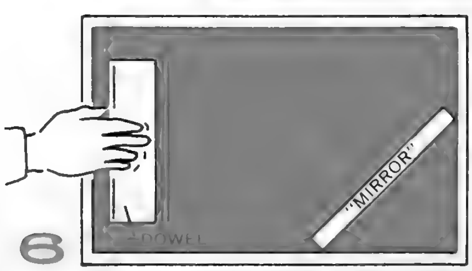
Can you find a way to make the waves from a "pinpoint of light" change into "parallel rays of light" (straight waves) as they bounce off the "mirror"? Does this help you see how a spotlight works?



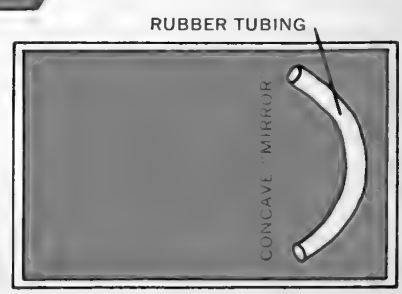
5



4



6



7

Bending Waves by Refraction

Can the wave model of light explain how light changes direction when it passes from air into water or glass? To find out, you need a way to change the speed of the waves. You can do this by letting a wave travel from deep water into very shallow water.

Place a stack of two or three glass plates about four inches square (or a clean plastic sandwich box filled with water and covered) in the center of the ripple tank. Add enough water so that the glass or box is covered with a thin layer of water. Now make a straight wave in the deep water with your cylinder wave generator *(see Diagram 8).*

Watch what happens to the wave when it reaches the shallow water over the glass plates. Does the wave move faster in deep or in shallow water? If the wave in deep water represents the movement of light in air, what could the motion of the wave in shallow water represent?

Turn the glass plates so that the wave will hit the shallow water at an angle *(see Diagram 9).* (Stand a piece of cardboard at each end of the glass plates so the part of the wave that does not enter the shallow water is reflected away.) What happens to a straight wave when it passes from the deep water to the shallow water?

As you can see, the wave model of light explains reflection as well as the particle model does, and it explains refraction better than the particle model does. But the particle model can't explain the diffraction of light when it passes through a narrow opening. Can the wave model explain it?

To find out, stand two mirrors, or flat pieces of wood, in your ripple tank with a narrow opening between their ends *(see Diagram 10).* Send a straight wave toward them and see what happens to the part that passes through the opening. What happens if you change the width of the opening? Does the same thing happen to a circular wave?

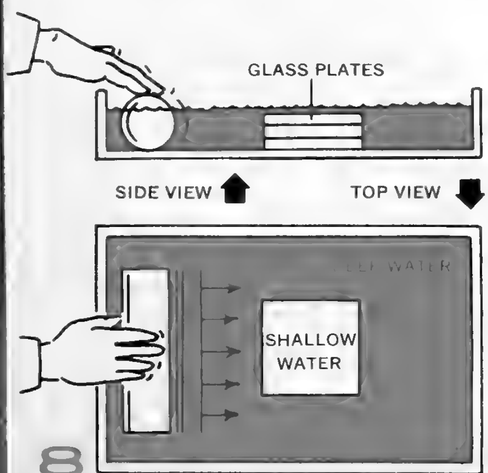
A New Model of Light?

While the wave model of light explains diffraction, as well as reflection and refraction, it cannot explain certain other behavior of light. It cannot explain, for example, how light falling on a *photocell* makes an electric current flow from the cell. (A photocell makes a television camera or a photographer's light meter work.)

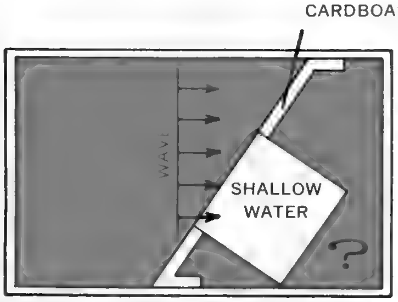
This photograph shows what happens when waves generated from two "pinpoints of light" (or waves that have passed through two narrow slits) overlap each other. Notice how the waves cancel each other out along certain areas, and cause very bright bands along other areas. Have you ever seen such an effect with light? When? Can you make a similar pattern by dipping two fingers of one hand up and down at an even pace in the water of your ripple tank?

To explain this behavior, you have to think of light as being made up of tiny "bundles" of energy, called *photons.* (How is this like the particle theory?) As each photon of light strikes the photocell, it knocks an electron out of the metal "face" of the cell, and the moving electrons form an electric current.

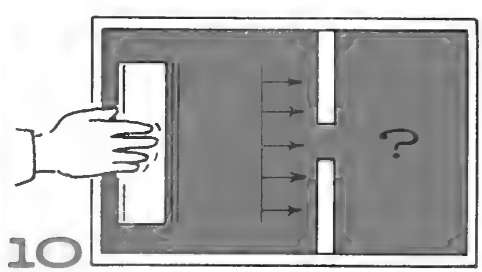
It may seem odd to have two such different models of light, but after all, these are just two different ways of "looking" at light. The wave model explains some of the ways of light; the particle model explains others. Scientists use whichever model works best for the job at hand ■



8

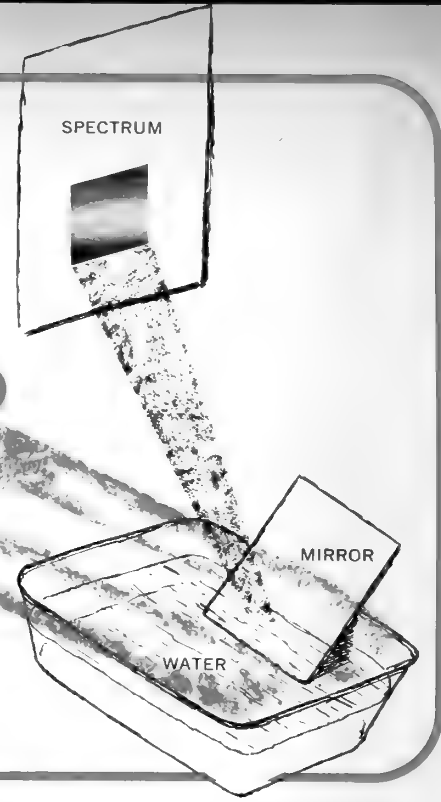


9



10

What's in a Rainbow?



by Diane Sherman

By splitting white light into different colors and adding and subtracting colors, you can find out why things appear red, orange, yellow, green, blue, or violet (or any other color).

■ When you looked at light through a narrow slit, or at light reflected from the grooves of a record *(see page 5)*, did the colors you saw remind you of a rainbow?

You can see these colors even better if you place a small mirror in a pan of water about one or two inches deep, and place the pan where a ray of sunlight strikes the mirror under water *(see diagram)*. Move a white card or piece of paper around until you "catch" a "rainbow" of colored light on the paper. Move the card until you get the sharpest separation of colors.

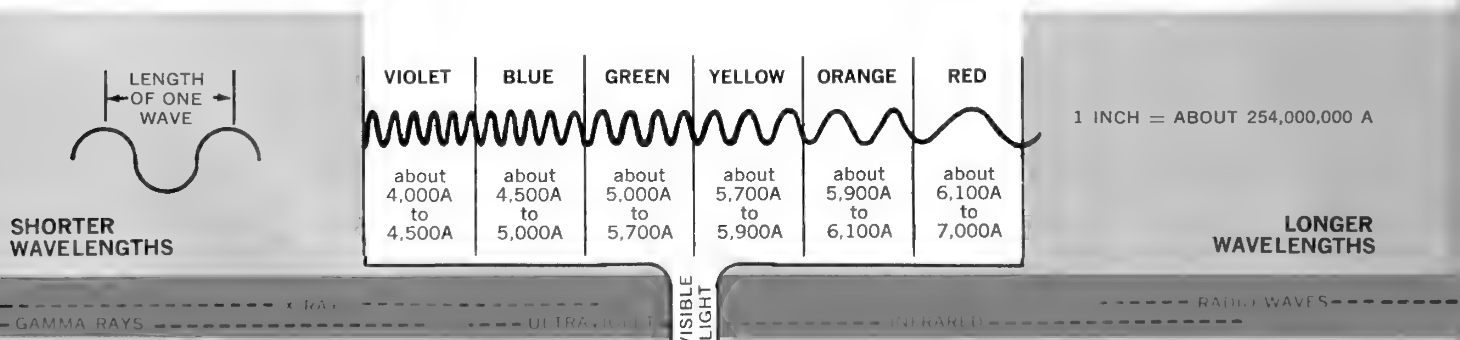
The spread of colors in a rainbow is called a *spectrum*. In the spectrum you captured on the card, are the colors arranged in the same order as the ones in the diffracted light that reached your eyes from the record grooves? Do you think the spectrum on the card was made by reflection, or by refraction? (Can you get a spectrum by using only a mirror, and no water?)

As you can see, all of the individual colors are in sunlight. The water separates the white sunlight into its different parts. You can see how this happens if you think of light as traveling in waves of different lengths.

You can make waves of different lengths in your ripple tank *(see page 10)*. Dip your finger into the water a few times and observe the distance between the waves. What happens to this distance when you dip your finger more rapidly? Less rapidly? If you could suddenly freeze the waves, and then measure the distance from the top of one wave to the top of the next wave, you would know the *wavelength* of those particular waves.

The waves that light seems to travel in are much shorter than the ones you can make in a ripple tank. Scientists usually measure light waves with a unit called the *Angstrom* (A). There are 254,000,000 Angstrom units in one inch! Your eyes can detect light waves ranging in length from about 4,000 A to about 7,000 A only *(see diagram)*.

When sunlight, or light from a lighted bulb, reaches your



The spectrum of light waves is only a small part of the spectrum of *electromagnetic* waves (waves of energy that cause electrical and magnetic "disturbances" as they pass through space). Sunlight also contains ultraviolet and infrared waves, which can be recorded on photographic film, even though your eyes don't detect them *(see page 14)*. Radio waves are much longer than light waves; X rays and gamma rays are much shorter.

eyes, waves of all of those lengths are present, and you see white light. It is when the longer waves are separated from the shorter ones that you see colors. (In the spectrum you catch on a card, can you see all the colors listed in the spectrum diagram? Are the divisions between the colors sharp or fuzzy? Can you explain why?)

Separating Colors from White Light

When the sunlight moves from the air into the water, is reflected from the mirror, then moves from the water into the air, the light is refracted. But the shorter light waves are bent more than the longer waves are, so the waves of different lengths come out of the water moving in slightly different directions. This is also what happens when you see a rainbow. Small drops of water in the air separate the sunlight into waves of different lengths by bending them different amounts before they reach your eyes. You can make your own rainbow in the early morning or late afternoon. Stand with your back to the sun and use a hose to spread a fine spray of water in the air in front of you. You should be able to see a rainbow in the spray.

All the colors in sunlight pass through clear materials, such as window glass or clear cellophane. But colored glass or cellophane lets waves of only certain lengths through; light of other wave lengths is stopped, or *filtered out.*

You can see how this works by propping a white card where it will catch the spectrum of sunlight. Hold a piece of red cellophane between the card and the mirror. What happens to the spectrum? What color does this filter let through? Now try a piece of blue cellophane. Each color of cellophane *absorbs,* or soaks up, some of the colors of white light.

Subtracting and Adding Colors

You may have guessed by now why different objects—books, carpets, houses, butterflies—appear different in color. They have "filters" of a sort, called *pigments.* Pigments absorb light of some colors and reflect light of other colors to our eyes. A certain pigment in our blood absorbs light waves shorter than about 6,100 A, so our blood appears red. A certain pigment in green plants absorbs waves shorter than about 5,000 A and longer than about 5,700 A. That is why grass is "green"; the light waves it reflects are those between 5,000 A and 5,700 A in length.

Pigments subtract some colors from the spectrum by absorbing them. Most of the colors we see in nature are caused by this kind of "subtraction." A black object is black because it absorbs, or subtracts, *all* of the light shining on it. It does not reflect any of the colors.

You can get colors by adding colored light, too. One way to do this is with three flashlights. (If you don't have three flashlights, can you find a way to do it with your light box and two mirrors?) Tape two or three layers of red cellophane over the lens of one flashlight, two or three layers of green over the second, and two or three layers of blue over the third. In a dark room, prop up the red flashlight so it makes a spot of red light on a white card. With the other two flashlights at the same distance as the red one, shine first the green light, then the blue light, then both on the spot of red light on the card. What happens?

If the light from each of your flashlights were the same strength, and if your filters were exactly the right colors, the spot of light you saw would be white. But usually white light can be made in this way only with special equipment.

Red, green, and blue light can be added together in pairs to produce other colors of light. You can test this with your filter-covered flashlights or by making a color wheel *(see instructions below).*

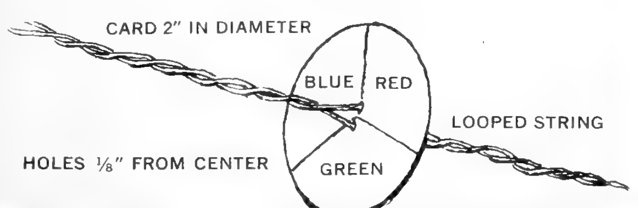
Can you guess what would happen if you put layers of both red and green cellophane over a single flashlight and switched it on? Try it. Can you explain what you see? (Remember that a red filter subtracts light of every color but red from the white light, and a green filter subtracts light of every color but green.) Does it make any difference which filter is closer to the light bulb? Do other combinations of red, green, and blue filters produce the same result?

You can see that there is more to color than meets the eye. There is even more to color than we have explored here. For example, what happens when you mix pigments of different colors together? Mix your watercolors to find out ■

HOW TO MAKE AND USE A COLOR WHEEL

Use a compass to draw a two-inch circle on a piece of cardboard. Cut it out and mark the circle in three equal parts. Color one section blue, one red, and one green *(see diagram).* Use strong, bright colors, like poster paint. Now punch two holes in the wheel. Each one should be about ⅛ inch from the center. Loop a long piece of string through the two holes and tie the ends together. Hold one end in each hand with the wheel hanging loose, and swing it around in circles about a dozen times. Then pull the ends of the string to start the wheel spinning.

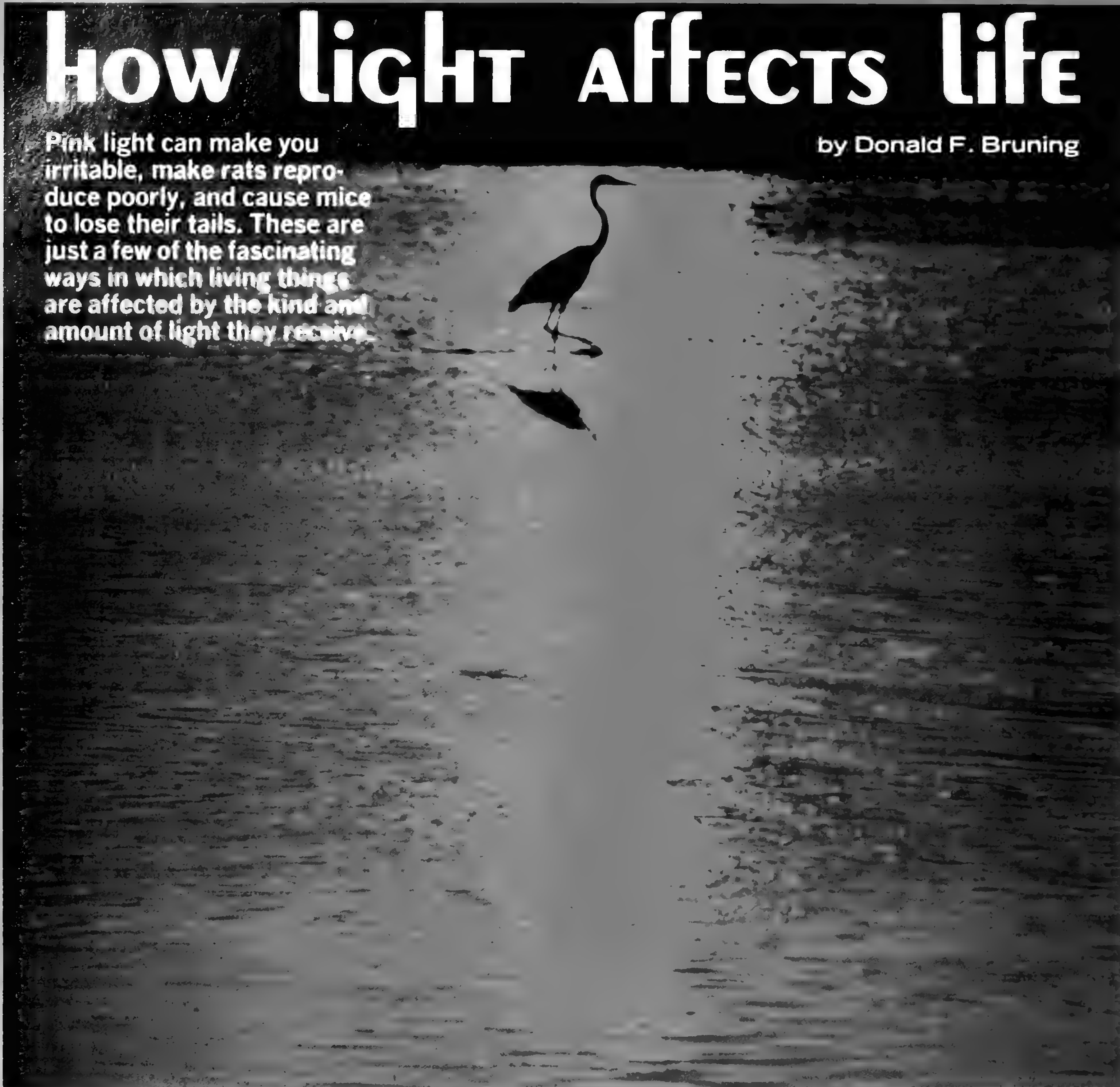
What happens to the colors? Try mixing different colors. Make a wheel half blue and half yellow, for example. What colors do you see when you spin the wheel? (Your eye sees the two colors of light that are reflected from the spinning wheel as if they were added together.)



How light affects life

Pink light can make you irritable, make rats reproduce poorly, and cause mice to lose their tails. These are just a few of the fascinating ways in which living things are affected by the kind and amount of light they receive.

by Donald F. Bruning



■ Recently, a biologist wanted to raise some whip-tailed lizards in order to study how they reproduce. But he couldn't keep them alive, even though he gave them plenty of food. Finally, starting with a new group of lizards, he gave them a few minutes of light from a sunlamp each day. The lizards lived, and from then on he had no trouble keeping them.

The whip-tailed lizards needed ultraviolet light *(see page 12)* in order to live. Exactly *why* they need it is still not known. But this is just one example of the way in which light affects living organisms.

Biologists have known for many years that the *amount* of daylight affects many plants and animals. Some plants, for example, produce flowers only when they receive 15 hours of sunlight each day. If they receive only 14½ hours, they will not bloom. The length of day also triggers breeding and migration in birds, color changes in both birds and mammals, and growth changes in insects.

Light That Burns and Kills

Biologists have also learned that the color, or wavelength, of light affects living things. The longer wavelengths of ultraviolet light, for example, cause vitamin D to be produced in the cells of your skin. And you may get a sunburn if you get too much short-wave ultraviolet. The shortest wavelengths of ultraviolet can be harmful—even deadly—to some plants and animals. (On your next trip

Donald F. Bruning is Assistant Curator of Ornithology at the New York Zoological Park (Bronx Zoo), in New York City. This article is adapted in part from the June 1969 issue of Animal Kingdom.

to a barber or beauty shop, look for a special lamp used to kill germs on equipment. The lamp gives off very shortwave ultraviolet light.)

Biologists are continually finding more and more ways in which light of all wavelengths and strengths affects animals. In one experiment, a group of rats was kept under pink fluorescent light while another group was kept under natural sunlight. The rats kept in pink light had fewer and smaller litters, and they didn't survive as well as the rats kept in sunlight.

There have been many other experiments to determine the effects of different colors of light on animals. A Florida biologist found that female chinchillas gave birth to more male young when kept under pink light, while under blue light they had more female young.

Under pink fluorescent light, one kind of white mouse develops growths called *tumors* at a much faster rate than normal. And other kinds of mice, kept in either pink or blue light, develop spots on their tails within three months. Within six months they lose their tails almost completely.

When the small fish called guppies are raised under natural light, they usually produce equal numbers of male and female young. But in one experiment, under pink light, four out of five young born were females (and the males developed poorly). Under blue light, the reverse happened —four out of five young were males.

About 10 years ago, thousands of trout eggs died at a new fish hatchery on Long Island, New York. The biologists working there were puzzled for a time, but then they noticed that some eggs that had been shielded from the light had not died. With this clue, they tested the effects of the hatchery's fluorescent lights on fish eggs. The "cool white" bulbs, they discovered, gave off a lot of blue light,

Chinchillas and whip-tailed lizards seem to need a full range of light wavelengths in order to live normal lives.

and this seemed to kill the eggs. Once bulbs giving off less blue light were installed at the hatchery, the problem was solved.

Humans look especially attractive under pink light, taking on a healthy glow. You might think that pink light would be used more in businesses, restaurants, and other gathering places. But experiments have shown that humans working under pink fluorescent lights are more irritable and more apt to get sick than those working under natural light.

To the Brain—and Beyond

Gradually, scientists are learning why light causes these effects in man and other animals. One key idea is that

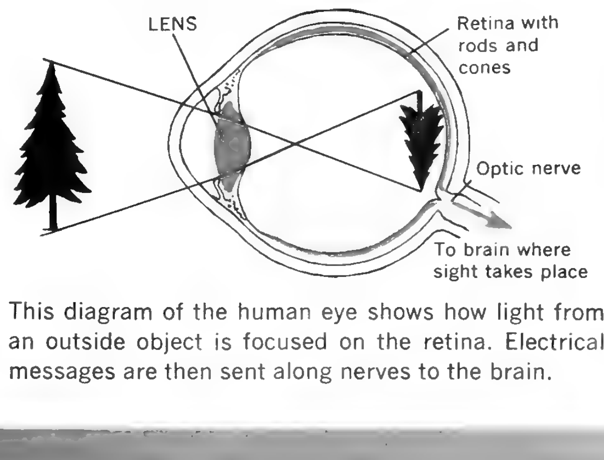
(Continued on the next page)

Color—To See or Not To See

Biologists know much more about human eyesight than they know about the eyesight of other animals. However, many of the things that make up your eye are also in the eye of an owl, a lizard, or a fish. For one thing, all of these eyes have a lens that receives light rays from outside the eye and focuses them on the back of the eye, called the *retina (see diagram).*

Each of your eyes has about 115 million rod cells and about 6.5 million cone cells. You may wonder why you see colors so well, if your eyes have so many more rods than color-sensitive cone cells. The number of rods and cones is not so important as their size and position. Human eyes have about 20 rods for every cone, but the rods are much smaller. How clearly an animal sees also depends on which kind of cell is more plentiful in the central part of the retina. In your eyes, only cones are present in the center, so you see well—and in color—when there is a lot of light.

Since sight takes place in an animal's brain, we can only guess at what the world looks like to other animals. But by knowing the numbers, sizes, and positions of rod and cone cells in the eyes of an animal, we can get an idea of what it sees.



This diagram of the human eye shows how light from an outside object is focused on the retina. Electrical messages are then sent along nerves to the brain.

the effects are probably caused by the colors or wavelengths of light that are *missing,* rather than by the wavelengths of light that are present. The full range of light seems to be needed for most animals to lead normal lives.

When light enters your eye, it strikes special cells—called *rods* and *cones*—at the back of your eye *(see diagram on page 15).* The rod cells are sensitive to dim light and do not detect color. Cone cells are sensitive only to bright light and to color.

From the rods and cones, electrical messages are sent along nerves to your brain. At this point, you "see" color. But that doesn't end the process. Messages are also sent from your brain to your *endocrine* system—a system of glands that produce chemicals that help control many of the processes within your body. If the light is not normal, it may affect certain endocrine glands. The glands, in turn, may give off more or less of the chemicals they produce, and this may affect the workings of other parts of your body.

"Popeye," Penguins, and Puffins

Biologists who work at zoos and aquariums are using their knowledge of how light affects life when they plan the lights for animal exhibits. A biologist at the Miami Seaquarium noticed that fish kept under natural light seldom had a disease called "popeye." But "popeye" was very common among certain fish kept under artificial lights. The biologist then began giving all fish exposure to at least 15 minutes of ultraviolet light each day. The results: Most existing cases of "popeye" were cured; there were few new cases; other injuries and diseases healed quickly. The changes seemed to be due to the new lighting.

Adelie penguins, brought from Antarctica to the New York Zoological Park (Bronx Zoo) in New York City, began breeding and raising young once they were given "day" lengths like those of their Antarctic breeding grounds. A similar thing happened when a new lighting system was installed in an exhibit of sea birds. After showing no interest in breeding during their first four years at the zoo, all of these birds changed their ways within a couple of months after the new lights were put in. One pair of puffins, in fact, mated and produced an egg (which was accidentally broken just two days before it would have hatched).

At the Bronx Zoo and several other zoos, there are special exhibits of animals that are usually active in the dark of night. Normally these animals sleep during the day, when the zoos are open to visitors. To keep the animals awake and lively during the day, zoo biologists keep the exhibits dimly lit all day with red light. Most of these animals cannot see red light. Apparently, even a strong red light is the same as darkness to them. At night, when the zoos are closed, bright white lights are turned on. It seems like daytime to the animals, and they go to sleep. The next morning, as the "darkness" of red light falls, the animals become active again.

As man learns more about light and its effects on life, he may be better able to take care of captive animals and, perhaps, of himself ■

By adjusting the amount and color of light, zoo biologists were able to keep puffins healthier and to make a more lively display of night animals such as flying squirrels.

nature and science

TEACHER'S EDITION

VOL. 7 NO. 10 / FEBRUARY 2, 1970 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Water from Glaciers

The simple investigations suggested in this article can be made in the classroom, and you can help your pupils relate what they find out about heat and color to the concepts of light and color in "What's in a Rainbow?" (N&S, *Jan. 19, 1970*). Your pupils can also discuss the advisability of melting glaciers before we know what effects this might have on our environment.

Topics for Class Discussion

• *How does the color of a material affect the amount of heat it absorbs from sunlight?* As explained in "What's in a Rainbow?", sunlight is made up of light of all the wavelengths (colors) that our eyes can detect. It also contains shorter waves (ultraviolet) and longer waves (infrared), which we can't see, but which carry energy from the sun just as visible light does. The color of a material is determined by the wavelengths of sunlight that are reflected from the surface of the material; the light of other wavelengths is absorbed by pigments in the surface of the material. The light energy that is absorbed changes into heat energy and spreads out through the material and into other materials (including air) that are in contact with the heated material.

Light of shorter wavelengths *(see diagram on page 12,* N&S, *Jan. 19)* has more energy than light of longer wavelengths, so a material that reflects only the less energetic waves of red light is heated more by sunlight than a material that reflects the more energetic waves of, say, yellow light, and absorbs the light of other wavelengths. Aluminum foil reflects nearly all the wavelengths of sunlight, so it does not absorb much heat. A black substance absorbs all of the wavelengths of sunlight, so it is heated more by sunlight than a substance that reflects at least some of the sunlight.

• *Why did a* thick *layer of soil on Sherman Glacier* slow down *the melting of its surface ice by sunlight when a* thin *coating of dust on Cotón Glacier made its surface ice melt* faster? Both layers were black, so they probably absorbed energy at about the same rate. But after the heat had spread down through the thick layer of soil (and through the air between the particles) and reached the surface of the glacier, the heat was "spread too thin" to melt the ice there. The thin coating of dust passed the heat energy it got from sunlight directly to the ice beneath the dust.

• *What is* new *about Dr. Marangunic's idea?* Glaciers already serve as "frozen reservoirs"; their meltwater feeds streams that flow through the lands below on their way to the ocean *(see "The Water Cycle,"* N&S, *Oct. 27, 1969, page 2T)*. Dusting a glacier simply makes its surface ice melt faster in summer sunlight.

• *How might dusting affect the size of a glacier?* In Chile, where the climate is sometimes dry, sometimes wet, a glacier that is dusted only in dry

(Continued on page 2T)

IN THIS ISSUE

IN THE NEXT ISSUE

Your pupils can investigate the behavior of mealworms, and make an amazing variety of patterns by refolding the same sheet of cardboard . . . How scientists discovered X rays and radioactive elements . . . World of the saguaro cactus, and why biologists are studying it.

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

summers might "recover" in wet years when winter snows are heavy. Most of the world's glaciers, however, have been gradually *receding,* or melting back, for many years, because—on the average—the winter snow does not replace all of the ice that melts in summer.

● *Do you think dusting should be put to work at once wherever glaciers are available to supply more water in dry years?* Probably not; at least not until it has been tried in one place long enough to be sure that tampering with a natural process in this way does not have more bad effects than good ones. Too many of the things we have been doing to make life more "comfortable" for ourselves are changing our environment in ways that threaten the survival of *all* living things: polluting the air, water, and land; changing the climate *(see "A City Makes Its Own Climate,"* N&S, *March 31, 1969),* and so on.

Your pupils might be interested to know that some of the leading organizations of scientists are suggesting that every new machine, process, or other technological development should be studied carefully *before it is put into use* to find out how it might affect our environment.

● Dusting spots on a frozen pond melts holes that admit air to the water. Sometimes fish in ice-covered ponds die for lack of oxygen.

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.

Lost and Found Penguins

This SCIENCE MYSTERY will introduce your pupils to one of the most fascinating and puzzling aspects of animal behavior. After more than 10 years of study, scientists are still trying to discover how Adelie penguins find their way from strange locations back to their rookeries.

The mystery of navigational abilities applies not just to penguins, however, but to all other migratory species as well. Your pupils can probably list other bird species they have observed migrating.

Topics for Class Discussion

● *What signs or senses might birds use to navigate?* It is important for your pupils to understand that a bird's ability to navigate probably depends upon some of its senses, and also on signs in the environment. Your pupils might first list *sight* as one sense a bird might use. (The article notes that penguins seemed confused when they could not see the sun well.) A bird's vision is usually its most highly-developed sense, and most evidence seems to point to vision as playing the primary role in a bird's navigational ability. Other ideas have been tested though, including the idea that birds may possess a "kinesthetic" sense unknown to man by which the patterns of their routes could be formed through pressures on the inner ear. It has also been thought that birds might respond to the earth's magnetic field, possibly even to the earth's rotational movement. But none of these ideas has been supported by experiments.

As for environmental signs, your pupils might first mention the sun, since that seemed to be a prime aid to Dr. Penney's penguins. You might point out, though, that many species of birds migrate at night. Perhaps someone will suggest that birds navigate by using the stars, which seems to be the case. A German scientist, E.F.G. Sauer, tested this idea by placing night-migrating birds in a round cage with a clear top so that only the night sky was visible to them. The birds seemed to orient themselves by the stars, and became confused when a cloud hid the stars.

Even if birds do set their directions by the sun and other stars, this still does not explain how they reach the exact location of their nests. Perhaps landmarks become more important as they near their destination.

● *Is navigating behavior learned, or inherited?* Since your pupils probably will not be able to answer this question, you might ask them to think of experiments that would help them discover the answer. The routes of migratory birds do not vary from year to year, but the way in which the routes are followed differs among species. In some species the young and old birds fly together; in others the parents may set off first, leaving the young to fend for themselves. The fact that the young can follow the permanent routes unvaryingly and without their parents suggests that they may possess an inherited ability to fly continuously in a particular direction; and in order to maintain any direction, they must be able to navigate.

To test this idea, Drs. Penney and Emlen took two-month-old Adelie penguin chicks from Cape Crozier and released them on the Ross Ice Shelf. Most of the chicks took up the north-northeast direction, as the adults had done. But this was not proof that it was an inherited response. Adelie chicks are constantly alerted to this direction, because it is the direction in which they observe their parents traveling from the nest to the sea to get food. Often the chicks will follow the parent a short distance. So it is possible that the cues that mean "seaward" to the chick become associated with the celestial cues of the north-northeast.

However, in other experiments, when scientists released birds of other species that were raised without ever seeing the sky, they took up the direction in which their species always migrates. They apparently had an inborn knowledge of the star patterns, if this is really the means by which they navigate.

● *How would you try to learn more about bird navigation?* Your pupils will probably decide that the main problem is tracking birds on their migrations. Ask them to think of how

(Continued on page 3T)

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

they might do this. They will probably think of many ways that are actually being tried. So far, the most common method of studying bird navigation is by banding. This method was highly effective in the experiments with penguins, because they could be banded at the beginning of a journey and recovered at a known destination. However, this method normally is much less precise, since it allows an experimenter merely to pick out a bird at two random points in its travels. So much information from banding has been obtained, however, that the migratory routes of many bird species have been established by this method.

Another method that has produced good results is spray-painting or dyeing birds brilliant colors. Observers are quick to note and report such birds along the birds' migratory routes. Great numbers of migrating birds show up on radar screens, and devices such as tiny flashlights and miniature radio transmitters have been fitted on birds to transmit data. Equipment has also been devised to record the sounds of birds migrating at night. Some scientists have attempted to follow birds by using airplanes.

Grow Your Own Bacteria
A Bow to Bacteria

Both the SCIENCE WORKSHOP and the WALL CHART will help your pupils understand what a bacterium is.

Topics for Class Discussion

• *Why do we call bacteria living things? Life* is a difficult word to define, but your pupils should be able to think of several characteristics that living things have in common—growth, reproduction, responsiveness to environmental changes, and—sometimes—movement. That bacteria can grow and reproduce should be clear from the bacterium photo on page 10, and from the investigations. Bacteria have the ability to respond to stimuli; some, for example, become heat-resistant *spores* when the temperature is high. Some kinds of bacteria can move themselves, by whipping hairlike structures back and forth.

• *Are bacteria plants or animals?* One characteristic of most bacteria is their inability to make their own food—a characteristic that can be thought of as animal-like. The WALL CHART points out some bacterial food sources—sugar, cellulose, substances in sewage. A plant-like characteristic is that each bacterial *cell* (which is one entire bacterium) is surrounded by a protecting *cell wall* (see bottom photo on page 10). Bacteria are not the only organisms with characteristics of both plants and animals. Algae, protozoa, and other microorganisms cannot be easily fitted into either kingdom, and are often grouped into a third kingdom *(see "What Kind(s) of Bird?",* N&S, *Jan. 5, 1970, page 3T).*

• *When a bacterium lives in close contact with another living thing, which benefits—the bacterium, or the other organism?* The WALL CHART has several examples of relationships in which *both* living things are *helped* by the close association (called *mutualism*). Bacteria that cause disease, on the other hand, get food and shelter from their hosts, but they *harm* their hosts. (This is called *parasitism.*) The bacteria that your pupils are sure to find on their skin usually do not cause disease, and may not affect the host at all (*commensalism*). But some scientists think that the skin bacteria, which may number as many as 2½ *million* per square centimeter (about one-sixth of a square inch) may actually benefit the person they live on, for if the harmless bacteria were not on the skin, there might be more disease-causing bacteria there. Your pupils may be able to think of other examples of close associations between two kinds of organisms *(see "Partners,"* N&S WALL CHART, *Jan. 30, 1967).*

• *Why are scientists investigating the use of bacteria to provide food?* There is an urgent need to develop both present and new sources of food for a world whose population is increasing by 7,500 people per hour. Bacteria, and other microorganisms such as yeast, grow rapidly and reproduce rapidly. (You might ask your pupils to figure out the number of offspring of one bacterium after five hours, if each divides once every 20 minutes.) Growing bacteria does not take up much land space, and some bacteria have very simple requirements for growth and can feed on substances that would otherwise be wasted.

Exploring the Atom—Part 2

Your pupils might be interested to know that the cathode ray tube J. J. Thomson was investigating when he discovered the tiny particles of matter called *electrons* was a forerunner of the television picture tube.

Can anyone explain why a stream of electrons hitting the end of the glass tube produces a glow of light there? Perhaps someone remembers the diagrams showing "How Light Is Made" (N&S, *Jan. 19, 1970, page* 8).

When the moving electrons hit the end of the tube, they give some of their energy to electrons in the atoms that make up the glass. This excites the electrons in the glass and they jump into orbits farther away from the nuclei (centers) of their atoms. Then, in a fraction of a second, these electrons give off their extra energy as light waves and fall back into their former orbits.

The same thing happens in a television picture tube. But there, two sets of electromagnets in front of the cathode keep pulling the stream of electrons back and forth, up and down, so that the stream reaches each part of the screen many times each second. The signal from the TV station keeps changing the electric current passing through the tube so that different numbers of electrons reach each point on the screen. Where many electrons strike the screen, it glows brightly; where few or no electrons hit the screen, it glows dimly or not at all. And that is how a TV picture tube works.

Brain-Boosters

Mystery Photo. As the tide came in, waves carried floating seaweed farther and farther up on the beach.

(Continued on page 4T)

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

When the tide ran out, the seaweed was left at the high-tide mark.

What would happen if? The construction of the balance shown is such that all the weight on a platform acts on the point where the platform is attached. Thus, it makes no difference *where* on the platform a weight is placed; so long as the weights on both sides of the balance are equal, they will balance one another.

A pan balance is constructed on this principle, so that the weights or the object being weighed can be placed anywhere on the pans without affecting the results.

Can you do it? A large ice cube almost always drifts from the center of a glass to touch the sides. You can make it stay longer in the center, though, by adding some soap to the water. The soap retards the drifting of the ice by reducing the water's *surface tension* – that property of the water that makes it behave as though it has an elastic "skin" pulling on the ice cube.

Fun with numbers and shapes. Perhaps by trial and error one of your pupils will come up with 1-1/6 (or 7/6) as a number that will give the same answer when added to or multiplied by 7.

You might encourage the class to find a general formula that will produce such a number for numbers other than 7. Perhaps someone will discover that for any number x, the number that will give the same answer when added to or multiplied by x is $x \div (x-1)$. Thus, for 7 the number is 7/6; for 6, it is 6/5; for 8 it is 8/7; and so on.

For science experts only. By examining the veins on the undersides of their forearms, your pupils can see that the veins appear blue. This is because the blood in veins is "used" blood that has given up its oxygen to the body, and is on its way back to the lungs to get a fresh supply of oxygen, which will make it turn red again. When you bleed from a vein, oxygen in the air immediately mixes with the blue blood and changes its color to red, so that you never see blue blood outside of a vein.

nature and science

VOL. 7 NO. 10 / FEBRUARY 2, 1970

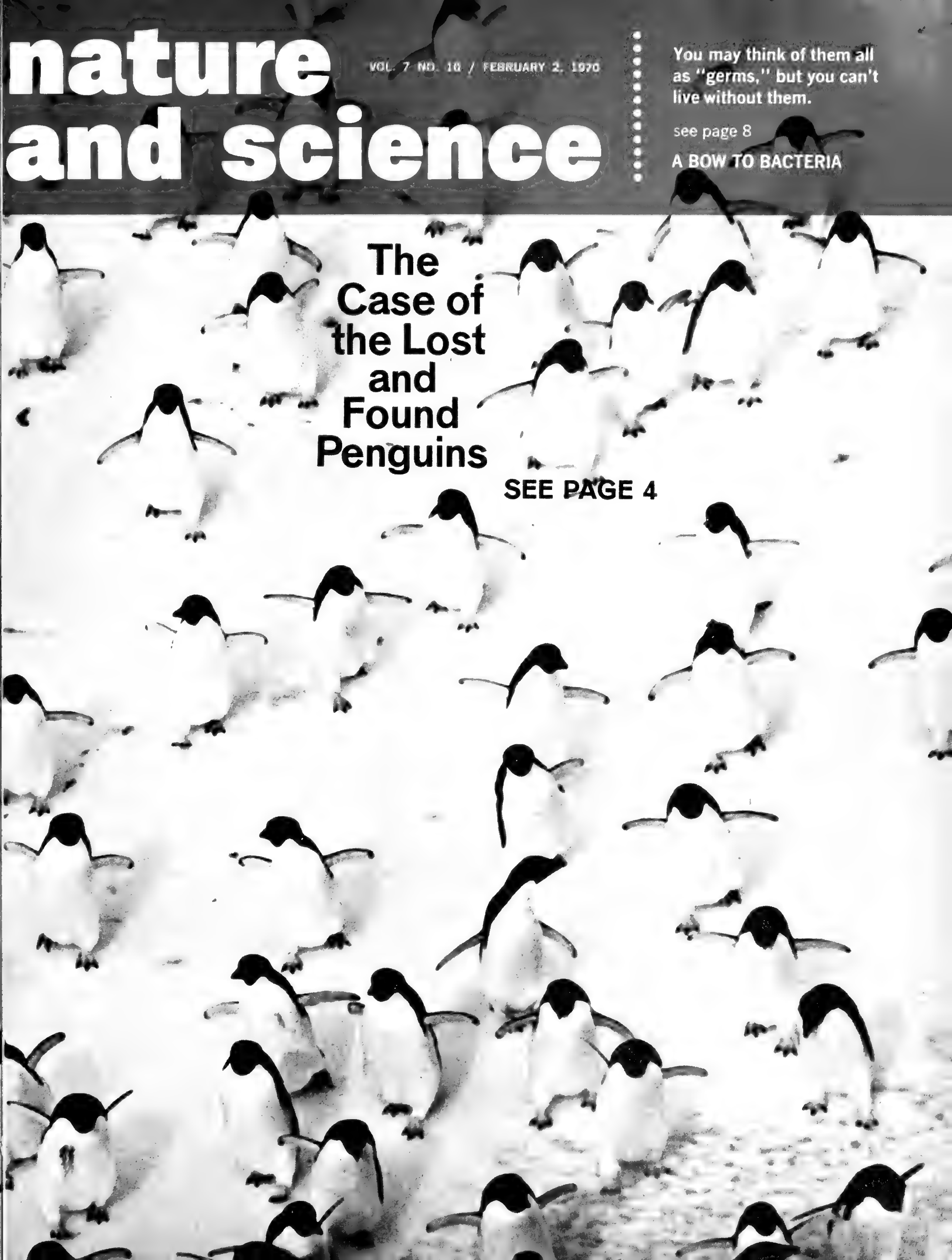
You may think of them all as "germs," but you can't live without them.

see page 8

A BOW TO BACTERIA

The Case of the Lost and Found Penguins

SEE PAGE 4



nature and science
VOL. 7 NO. 10 / FEBRUARY 2, 1970

CONTENTS

PICTURE CREDITS: Cover, Michael C. T. Smith from National Audubon Society; p. 3, photo courtesy of Ohio State University News Service; pp. 3-4, 7-9, 11-14, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 4-6, photos by Dr. Richard L. Penney; p. 7, photos courtesy of Bausch & Lomb, Rochester, N.Y.; p. 8, top photo courtesy of The NITRAGIN Company, bottom photo courtesy of Switzerland Cheese Association, Inc.; p. 9, top left photo courtesy of Water Pollution Control Federation, top right photo courtesy of TRW, Inc., bottom photo courtesy of United States Department of Agriculture; p. 10, top photo courtesy of the Hallmark Gallery, bottom photo by Dr. Alexander Tomasz; p. 11, photo by David Webster; p. 15, Dr. Wesley Lanyon, from AMNH; p. 16, *The New York Times.*

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

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.

SCIENCE WORKSHOP

Getting Water from Glaciers

A landslide in Alaska gave a geologist an idea for boosting the water supply in Chile. You can investigate how the idea works.

by Robert Gardner

■ The 1964 earthquake in Alaska caused a landslide that poured four feet of soil and rock over four square miles of the surface of a huge river of ice called Sherman Glacier. Up to that time, Sherman Glacier had been getting smaller as more of its ice melted each summer than was replaced by the following winter's snow.

But the landslide *insulated,* or shielded, the ice from the sun's heat, slowing up the melting so that the glacier began to grow in size. During the next three summers, this *phenomenon,* or "happening," was investigated by Cedomir Marangunic, a young geologist from Chile who was then working for his doctor's degree at Ohio State University's Institute of Polar Studies, in Columbus, Ohio. What he found out at Sherman Glacier gave him an idea.

Chile often has long periods of dry weather that reduce its supply of water for growing farm crops and producing electricity from flowing water. There are many glaciers in the high Andes mountains there. Dr. Marangunic wondered whether he might be able to get water from these glaciers by spreading a *thin* layer of black dust over the surface of the ice. Instead of insulating the glacier, as the thick layer of soil had done in Alaska, a thin layer of dust should absorb heat from the sunlight and transfer it to the glacier, making the ice melt *faster* than it ordinarily would.

In January 1969 summer came to the Southern Hemisphere, and Dr. Marangunic had a chance to test his idea. Using airplanes, scientists dusted a mixture of lampblack (carbon) and other substances on a glacier in the Andes *(see photo).* The glacier began to melt faster, supplying more water to streams that watered farmlands and powered electric generators.

Why Use Black Dust?

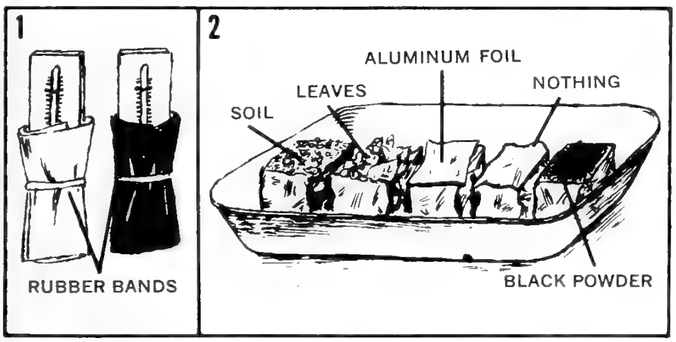
Why did Dr. Marangunic think a black powder would help melt the glaciers? You can find out by making some simple investigations. Wrap the bulb end of one thermometer with black paper, and the bulb end of another ther-

To test Dr. Maranguníc's idea for getting water from glaciers, this plane flew across Cotón Glacier in the Chilean Andes mountains, spraying a cloud of dust that settled in a thin layer on the snow surface of the glacier.

mometer with white paper *(see Diagram 1)*. Then set them both in sunlight. Compare the temperature readings of the thermometers after 15 minutes. (If you have only one thermometer, wrap the bulb end in white paper, put it in sunlight for 15 minutes, and record its temperature. Then wrap the bulb in black paper and do the same thing again.)

How do the temperatures compare? How do they compare with the temperature of an *unwrapped* thermometer left in the sun for 15 minutes? Try the test with thermometers wrapped in aluminum foil and in construction paper of different colors.

Which colors of wrapping do you think absorb the most heat from sunlight? Which colors absorb the least heat? From what you found by investigating light and color *(see "What's in a Rainbow?",* N&S, *January 19, 1970),* can you explain why some colors absorb more heat than others?



Melting Mini-Glaciers

You can try to speed up the melting of miniature "glaciers" in several ways.

Place several ice cubes of the same size in a paper-lined tray. Put the tray outdoors in the sun. Cover each of the ice cubes with a different material, such as aluminum foil, dry soil, pepper, or bits of dry leaves *(see Diagram 2)*. If you have some lampblack, powdered charcoal, or bone black, try them also. If you don't have any of these, you could make some black powder by scraping a piece of charcoal or the point of a pencil that has thick, black "lead" (graphite). Leave one ice cube uncovered as a "control."

From the results of your thermometer tests, can you predict which "glacier" will melt the fastest? Will they melt outdoors if the temperature is below 32° F.?

Can you predict what will happen if you sprinkle charcoal powder or dry soil on some natural ice or snow that is in sunlight? How does the area that you dusted compare with the area around it after several hours of sunlight? ■

Things To Try or Think About

- In places where ponds and small lakes are covered by ice and snow in winter, people sometimes dust black powder in large spots scattered over the surface of the snow or ice. Can you guess how this might help fish in the lakes to survive the winter?
- Will ice melt faster in the air of a warm room or in cold water? How can you find out?
- Does the shape of an ice cube affect how long it takes for it to melt? To find out, freeze water into various shapes. Make some thin ice "cubes" in flat pans, some round ones in balloons, and some cylinder-shaped ones in large pill bottles. What other shapes can you make? (Be sure to use the same amount of water to make each ice "cube." Why?) Put the ice "cubes" in a pan or other container where each can be placed so it does not touch any others. See how long it takes for each to melt.

The Case of the Lost and Found Penguins

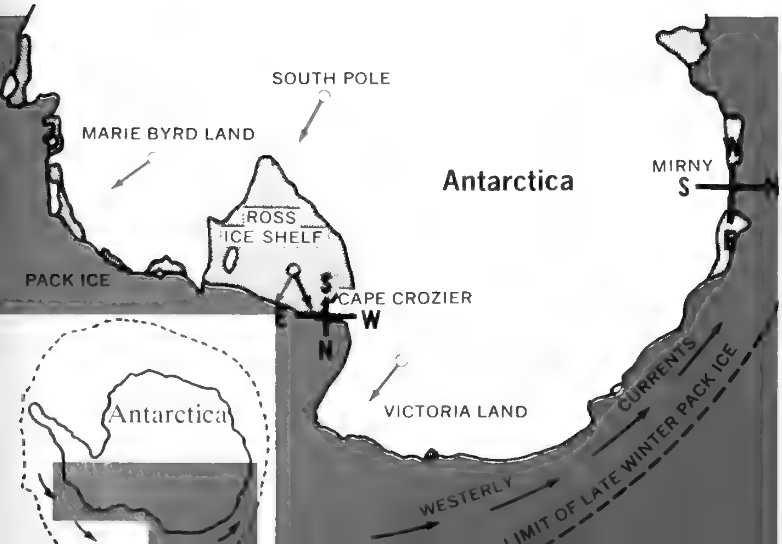
How do Antarctic penguins taken to unfamiliar locations on the continent find their homes by starting out in the opposite direction? Here's how scientists are trying to solve . . .

by Mary P. Goodwin

■ In December of 1966 three Adelie penguins came home to their *rookery,* or nesting place, at a place in Antarctica called Mirny *(see map).* They had traveled over 3,000 miles around the continental coast by swimming, walking, and sometimes sliding along on their stomachs.

The penguins were fat and healthy, and right away they began looking for their mates and piling up little stones into nests—as though they had been away for only a day or two. But in fact, biologists had taken these three penguins one quarter of the way around Antarctica and 110 miles inland and released them in a strange, white wilderness two *years* before. The biologists wanted to see whether the birds could find their way home. The birds did.

The green arrows show the directions taken by Cape Crozier penguins released at various places. The black arrow shows the direction taken by Mirny penguins released on the Ross Ice Shelf.



They did it on foot and without anything to eat for many weeks. They had no mountain ranges or other landmarks to help them recognize the land, no other birds flying overhead to follow, not even the smell of water to give them a clue. Yet they found their nesting places by the sea, walking there in an almost straight line.

Each spring, millions of Adelie penguins do much the same thing as they travel over many miles of ice and snow to reach their rookeries. Biologists have been trying for about 10 years to find out how the Adelie penguins are able to do this. By studying Adelies, they hope to learn more about how penguins and other far-ranging birds find their way back to their nesting grounds.

During the Antarctic winter, the Adelies live on the outer fringe of the pack ice (floating ice) that surrounds the Antarctic continent. There they are near the sea, which is their only source of food. But each spring they travel south many miles over the pack ice to reach their nests on the coast of the continent. While they are building nests and hatching eggs, the penguins go without food for several weeks.

Cold Comfort for Scientists

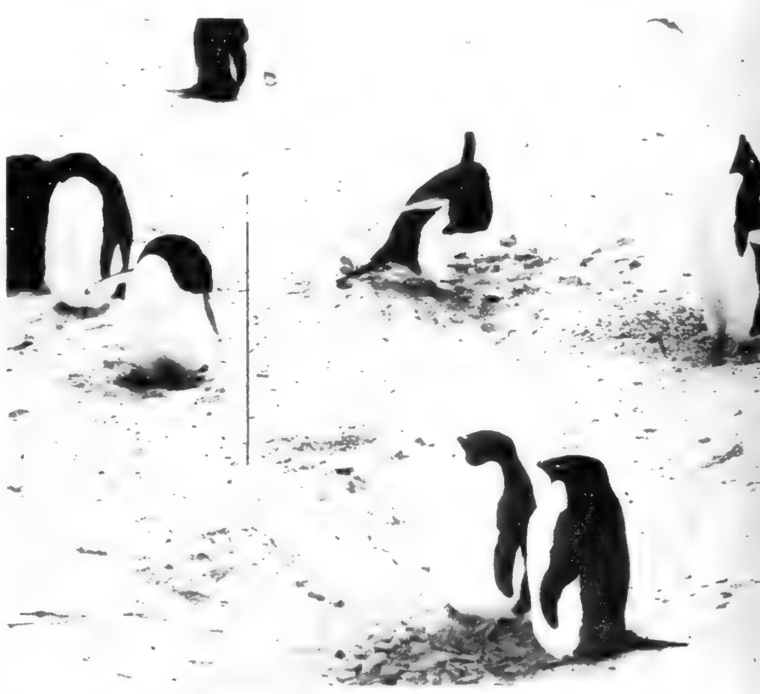
There are other birds to study that live in places that might be more comfortable for scientists than the cold Antarctic continent. But most of these are flying birds that are very hard to follow. Penguins do not fly, and their black backs make them easy to spot against the snow-covered landscape. There are millions of Adelie penguins, and scientists are able to catch them easily at their rookeries.

Two biologists who have studied Adelies are Dr. Richard L. Penney, a research zoologist at the New York Zoological Society (Bronx Zoo) and an assistant professor at Rockefeller University, in New York City, and Dr. John T. Emlen, a Professor of Zoology at the University of Wisconsin, in Madison. They wanted to find out what special senses and "signs" penguins use to guide them to their rookeries each spring, and how far the birds could travel to get there.

To find out, Dr. Emlen and Dr. Penney captured some fat, male penguins at an Adelie rookery at Cape Crozier *(see map)*. They flew the penguins to a place 180 miles southeast on the Ross Ice Shelf, a 150,000-square-mile floating ice shelf. The landscape there was bare, flat, and white, with no visible landmarks to guide the birds.

The biologists marked each bird with a numbered band on one wing. Then they let the birds go one at a time, and watched each bird's behavior.

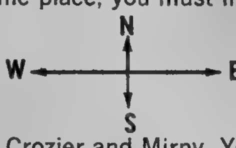
Usually a bird made short dashes in many directions, but eventually steered toward the northeast. Other penguins from Cape Crozier were released at other places in Antarctica, and they also all headed in a direction that would take them to a place northeast of their rookeries if they kept going that way *(see map)*. With the help of Russian biologists, the scientists also captured some penguins at the Russian research station of Mirny. When they were released on the Ross Ice Shelf, these penguins also headed in a direction that would take them to a place northeast of their rookery *(see box)*.



Adelie penguins build nests of small stones. Dr. Penney put numbered stakes beside nests of banded penguins. He found that the penguins returned to the same nests each year.

North Can Be South in Antarctica

Look at the map showing the paths taken by penguins from Cape Crozier and Mirny when they were released on the Ross Ice Shelf. The article pointed out that the penguins headed in a direction that would take them to a place northeast of their rookeries. But you will see that penguins from Cape Crozier and Mirny did not all head the same way according to the map. Actually, if the Cape Crozier birds went northeast, it looks as if the Mirny birds headed northwest. This is true if we are talking about directions from the Ross Ice Shelf. But in Antarctica, north, south, east, and west change from place to place. In order to find directions on a map for a specific place, you must line up the symbol shown here over the place, with the "south" arrow pointing to the South Pole. That is what



you see on this map at Cape Crozier and Mirny. You can see that directions are about the same for Cape Crozier and the Ross Ice Shelf. But look at Mirny. Have the directions changed? Can you see why scientists said all the birds headed toward places that were northeast of their rookeries?

Why Take the Long Way Around?

Dr. Penney and Dr. Emlen wondered why the birds all headed northeast of their rookeries, instead of directly toward them *(see map)*. One explanation was that the birds were taking the shortest way to the sea. There they could travel faster than on land and also find food.

The ocean currents also might have affected the penguins' direction. The currents around Cape Crozier and

(Continued on the next page)

Dr. John Emlen *(above)* records information during the penguin-navigation experiments. The instrument shown is a *transit*, a kind of telescope that was used to help track the penguins. Below, a scientist holds a penguin's head between his knees while placing a numbered band on the bird's wing.

Lost and Found Penguins (continued)

Mirny flow westward. A penguin drifting on the pack ice would be slowly carried westward away from its rookery. So the biologists thought the penguins might have taken a slightly eastern course to make up for the westward currents.

But how are penguins able to choose a direction to follow in the first place? In the Antarctic wilderness of snow, the only guide these birds have is the sun. The biologists found proof of this when they observed how the penguins behaved in cloudy weather.

When the sun was covered by a thin layer of clouds, the penguins had trouble finding the northeast direction. When heavy clouds covered the sun, the penguins were even more confused—choosing many different directions.

Setting a Sun Course

Using the sun's position in the sky to set a course is not easy, though. The sun does not "move" just from the east to the west each day. It also appears to move to different positions on the horizon. And in the Antarctic summer, the sun does not rise or set, but shines continually.

The penguins, however, were able to keep on their northeasterly courses even with the sun's different "motions." For instance, when birds released in the morning set off northward, that direction was to the left of the sun. At noon the birds were still traveling north, but they were going *toward* the sun because it had "moved." In the afternoon the birds were still on a northerly course, but they were heading to the *right* of the sun.

Because the birds were able to make up for the sun's constantly changing position as they used it to guide them, it seems that they must have a time sense that lets them know where the sun is at a particular time of day. Scientists call such a time sense a *biological clock*.

Not all of the penguins the scientists took inland and released made it back home, but many of them did—even though they had started out in the opposite direction. At least half of the Cape Crozier birds were back at their rookery within 25 days. And even though it seemed that the birds used the sun as a compass to guide them to the sea, the scientists still wondered how they finally found their way back home, since their rookeries were in the opposite direction. Dr. Penney and Dr. Emlen think the birds may find other clues to guide them to their rookeries when they reach the sea.

Dr. Penney is investigating more questions about penguin navigation in a special laboratory at the Bronx Zoo in New York City. There he can reproduce Antarctic weather conditions and even the sun's changing positions. Dr. Penney studies penguins he brought back from Antarctica and some he raised in this special laboratory.

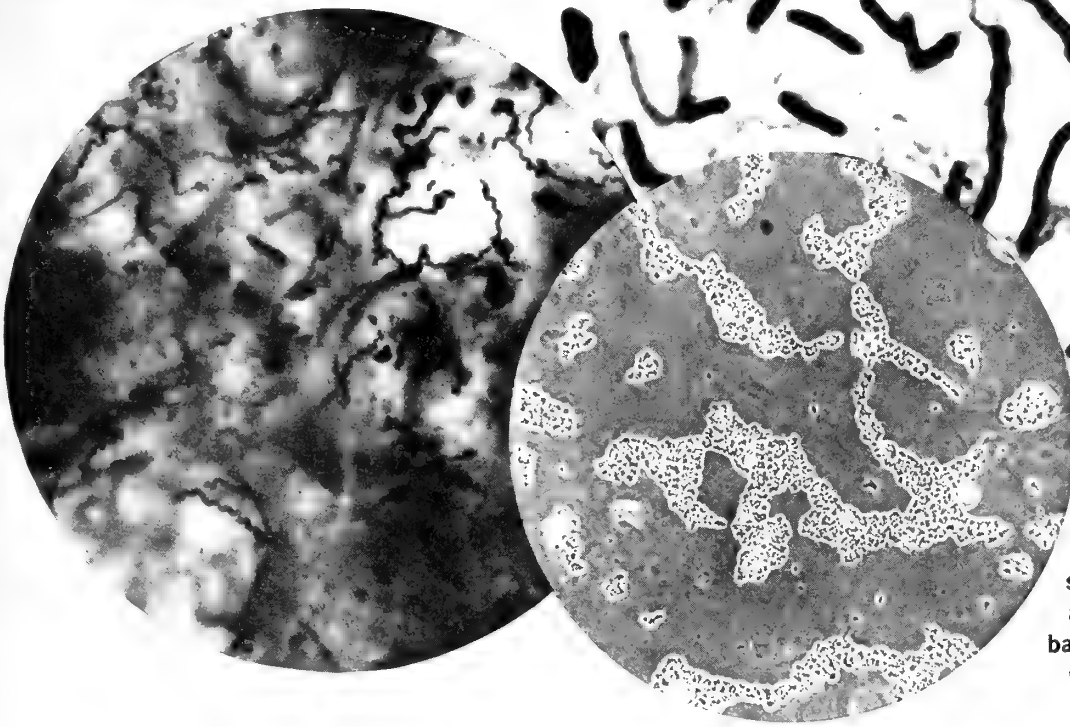
He hopes to find more clues to the mystery of how the Adelie penguins navigate in Antarctica's vast wastes, where man can find his way only with complicated instruments ■

■ Dr. Richard L. Penney has written a book for children (ages 4 to 8) about some of his penguin studies (**The Penguins Are Coming,** Harper & Row, New York, 1969, $2.50). Also look in your library or bookstore for these books about penguins: **Penguins,** by Bernard Stonehouse, Golden Press, New York, 1968, $3.95; **The Penguin Book,** by Margaret Rau, Hawthorn Books, New York, 1968, $3.95; **Penguins: The Birds With Flippers,** by Elizabeth Austin, Random House, New York, 1968, $1.95.

grow your own bacteria

In the air and just about everywhere, you can find bacteria that will grow and reproduce quickly.

by Nancy M. Thornton



The rod-shaped organisms in the top photo are bacteria that cause typhoid. The disease syphilis is caused by spiral-shaped bacteria *(left)*, and skin infections by round bacteria *(right)*. The bacteria were photographed through a microscope.

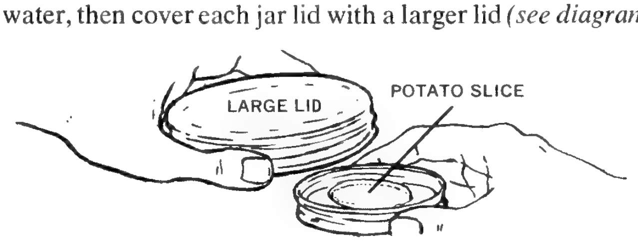
■ Bacteria have been found alive and growing in hot springs. They live on the snow-covered ground of Antarctica. Bacteria seem to be just about everywhere. In this SCIENCE WORKSHOP, you can investigate some that are in you, on you, and about you.

Although bacteria are very small, you can see them if there are a great many of them. Bacteria usually reproduce by growing to a certain size and then dividing in two. Some bacteria will divide as quickly as once every 20 minutes. As more and more bacteria are produced, the mass of bacteria, called a *colony,* becomes big enough so that you can see it without a microscope.

Make a "Home" for Bacteria

Before you start collecting bacteria, you should make a good growing place for them. Get some small-mouth jar lids and an equal number of large-mouth lids. (If you cannot get them at home, you can buy them at a supermarket.)

Cut a peeled potato into slices about ¼ to ⅛ inch thick. Place a slice in each small jar lid. The potato will provide food for the bacteria. Add about a tablespoon of water, then cover each jar lid with a larger lid *(see diagram).*



Put several dozen toothpicks or cotton-tipped swabs in a metal can or a small pan, and cover the can with aluminum foil. Place the can and the covered jar lids on a cookie sheet, and put the cookie sheet in an oven that has been preheated for 10 minutes at 250°F. Heat the can and jar lids for about an hour; then remove them and let them cool.

The heat of the oven should kill any living things that

(Continued on page 10)

nature and science | WALL CHART

February 2, 1970

A BOW TO BACTERIA

Say "bacteria" and many people think of dangerous, disease-causing "germs." Some kinds of bacteria do cause disease. Tuberculosis, typhoid, and some kinds of food poisoning are bacterial diseases.

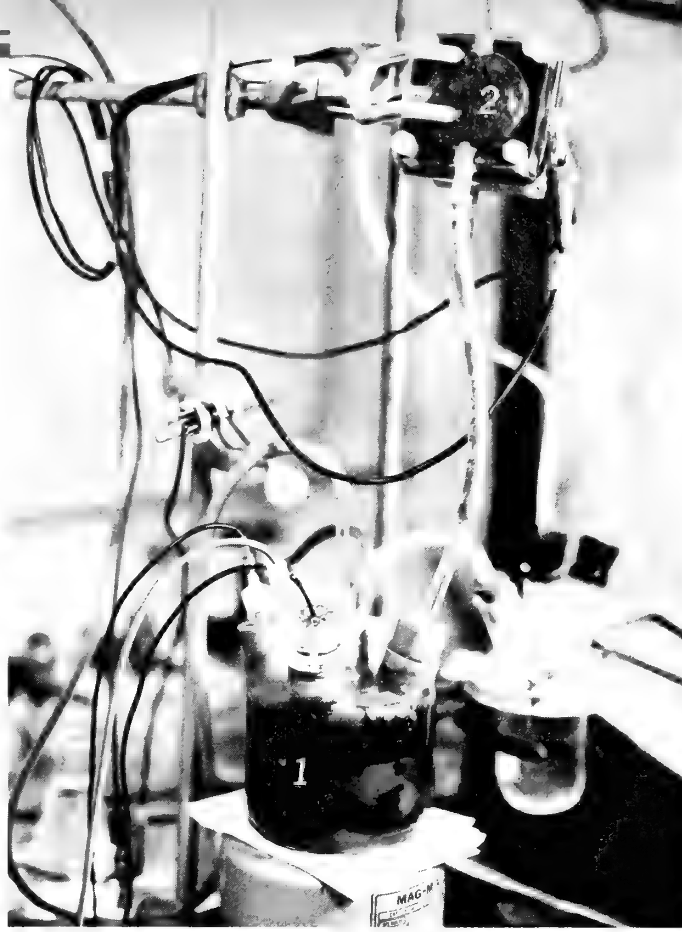
But many kinds of bacteria are helpful to man and to other living things. As these bacteria digest food and grow, the chemical reactions that go on inside them produce substances that are useful to other living things. This WALL CHART shows some of the good effects that bacteria have on other organisms, and some of the ways man may use bacteria in the future.—SUSAN J. WERNERT

Green plants need nitrogen in order to grow, but they can't use nitrogen gas in the air. Some bacteria combine nitrogen with other substances to help make *nitrates*, which plants *can* use. These bacteria, called *nitrogen-fixing bacteria*, live in soil or in bumps on the roots of plants such as soybeans (*see photo*). The bacteria on the roots get food from the plant they live in.

The cheese-making industry depends on certain kinds of bacteria. When added to warm milk, these bacteria produce an acid that helps curdle the milk. The photo (*below*) shows one step in the manufacture of Swiss cheese; the man is breaking up some of the curd that has already formed. The holes you see in Swiss cheese are "bubbles" of carbon dioxide, a gas produced by bacteria.

Plants have a tough substance called *cellulose* in their cell walls, and most animals cannot digest it. Billions of bacteria that *can* digest cellulose live in a special part of the stomach of cows and a few other mammals. As the bacteria digest cellulose from the plants the cow has eaten, they change it to substances that the cow can use. The bacteria also benefit—they get cellulose food and shelter from the cow. The diagram shows a cow's stomach; the part where the bacteria digest cellulose is in color.

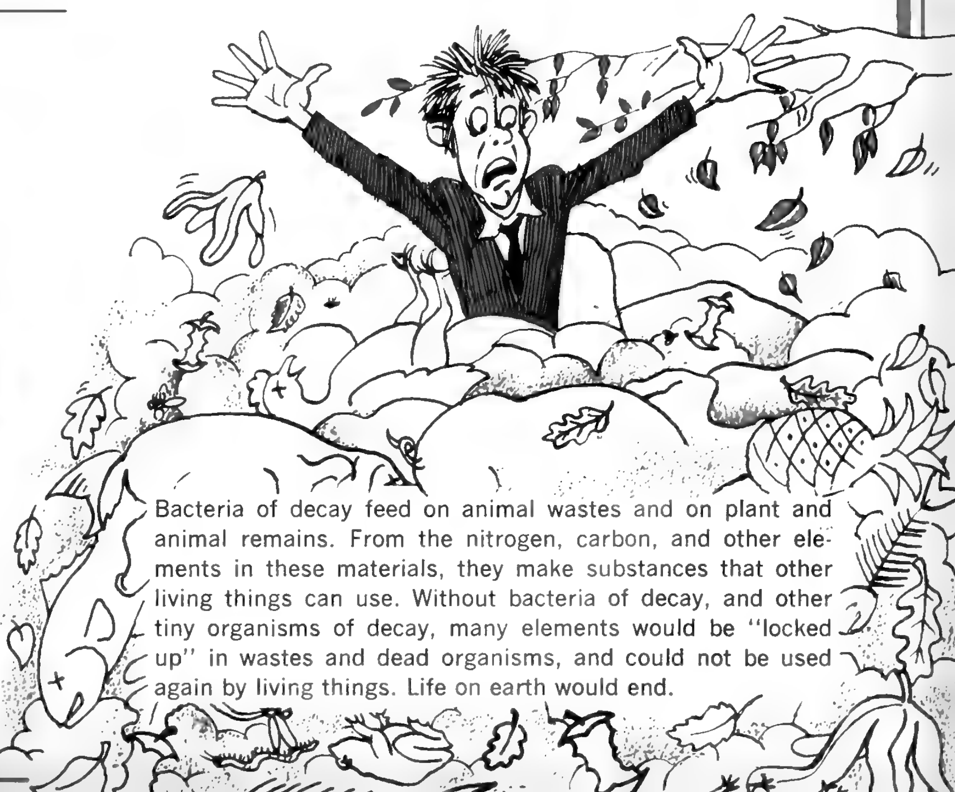
Some bacteria feed on sewage in rivers and streams. As they digest this food, they give off carbon dioxide, nitrates, and other substances that plants can use. But they need oxygen to do this. If a great deal of sewage is dumped in the water, the bacteria may use up so much oxygen that fish and other animals cannot live in the water. In sewage treatment plants (*see photo*), bacteria on the surface of rocks help purify sewage *before* the waste water enters a stream. The "arm" shown in the center of the photo is spraying water over some bacteria-covered rocks.



Scientists and engineers have been investigating new uses for bacteria. For example, bacteria could supply some of our food in the future. Certain kinds of bacteria can digest gasoline-like fuels, and from them make proteins that man and other animals could eat.

This photo shows a "biological battery." In the glass container at the bottom*(1)*, bacteria digest sugar and produce an acid that is pumped through tubes into the square cell at the top*(2)*. There, electricity is produced when air is let in. Three of these cells can power a transistor radio. They could be used to supply electricity on space flights or at sea.

Farmers have recently begun to use certain bacteria to kill Japanese beetles (*see photo*) and other insect pests. The bacteria can be grown in large quantities, dried to a powder, and then dusted on the fields. Although the bacteria are no longer active, the substances in them can still harm the insects. The bacterial powders affect only insects, and some powders kill only one pest species, leaving useful insects unharmed.



Bacteria of decay feed on animal wastes and on plant and animal remains. From the nitrogen, carbon, and other elements in these materials, they make substances that other living things can use. Without bacteria of decay, and other tiny organisms of decay, many elements would be "locked up" in wastes and dead organisms, and could not be used again by living things. Life on earth would end.

INVESTIGATIONS

- Are bacteria in the air around you? Leave some sterile potato slices uncovered, so that they are exposed to the air. Put them in different places, such as in a kitchen, on a windowsill, and on a sidewalk. Cover them after about 15 minutes, and leave them covered. Check them daily for bacteria colonies.
- Does washing your hands wash away bacteria? Touch a few sterile potato slices with an unwashed finger. Touch a finger you have rinsed to other sterile potato slices, and a thoroughly-scrubbed finger to still others. Cover the slices and check them daily to see on which ones bacteria grow.
- Do soaps and antiseptics keep bacteria from growing? Scrape the inside of your cheek with a sterile toothpick, and put some cheek scrapings on six sterile potato slices. Then put some liquid detergent on two, some antiseptic solution on two others, and nothing on a third pair. Carefully pour off the liquid that is not soaked up by the potato slices, cover the slices, and check them daily.
- What does cold do to bacteria? Put some cheek scrapings on six sterile potato slices and cover them. Leave two at room temperature, put a second pair in the refrigerator, and a third pair in the freezer. Check them daily. If no bacteria show on the "cold" potato slices in the refrigerator or freezer, move them to a warmer place, and check them in a day or two.
- Do bacteria need moisture? Instead of potato slices, use dry soda crackers for growing your bacteria. Add two tablespoons of water to two jar lids containing crackers, and leave two others dry. Sterilize all four in the oven, and then add cheek scrapings to each. After several days, can you see any differences in bacteria growth?

Grow Your Own Bacteria (continued from page 7)

may have been on the toothpicks, jar lids, and potato slices. They should now be *sterile,* or free of living things.

Finding Bacteria To Grow

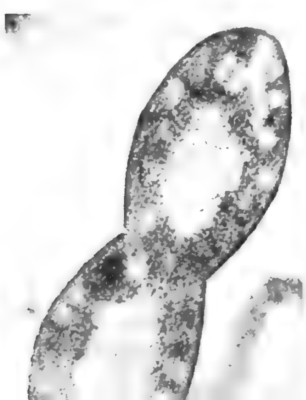
To find bacteria, you might begin with yourself. Use tears from your eyes, a short piece of hair, or dirt from under your fingernails. From your home or school, try a piece of cheese, used dishwater, a bit of soil, or anything else you can think of.

To collect the bacteria, rub an end of a sterile toothpick over each substance you have chosen. (Use a different sterile toothpick for each substance.) Then touch that end of the toothpick to several parts of a sterile potato slice. As soon as you do this, cover the slice with a large jar lid so that no bacteria in the air will settle on it.

Leave *at least* one potato slice untouched (but cover it with a jar lid). This will be your *control.* If no bacteria grow on it, you can be quite sure that all slices were sterile before you touched them with the toothpicks. (If some bacteria *do* grow on the potato slice, does that mean that it definitely *wasn't* sterile?)

After you cover the slices with the large lids, tape a label to each lid, writing down the date and the substance you put on the potato slice. Put the slices in a warm place (such as on top of a refrigerator), where they will not be knocked over or touched.

Every day, look at the potato slices for signs of growing bacteria. A colony of bacteria will show up as a spot on the potato slice. Cover the slice quickly each time you look at it, so that other bacteria will not get onto it. In which jar lid do you first see bacteria? ■



This is a cutaway view of a pneumonia-causing bacterium, photographed through a powerful electron microscope. The bacterium was dividing in two when it was prepared for the microscope. Bacteria are made of only one cell.

Jeffrey Hurtt, 12, is one of 18 boys and girls who studied the life in a pond in New York City's Central Park *(see "Operation Pond Probe,"* N&S, *October 13, 1969).* Jeffrey has identified some of the bacteria in the pond, using a microscope that magnifies objects 1,000 to 2,000 times. To identify them, he first looks at their basic shape *(see photos on page 7),* then looks for characteristics such as length and the shape of the colony the bacteria form. Some of the pond's common bacteria, Jeffrey reports, are disease-causing ones such as *Streptococcus.*

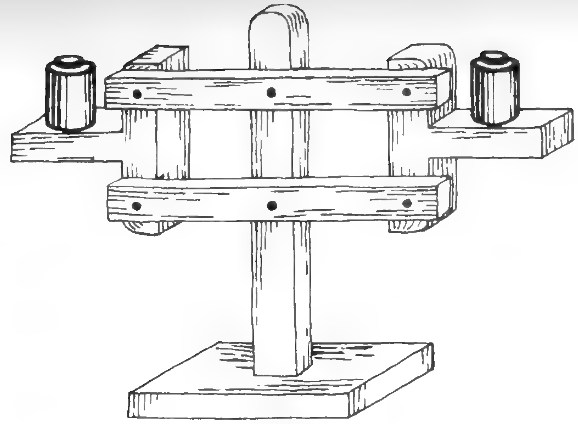
For more information about bacteria, look in a library or bookstore for this book: **Microbes in Your Life,** by Leon Schneider, Harcourt, Brace & World, New York, 1966, $3.75.

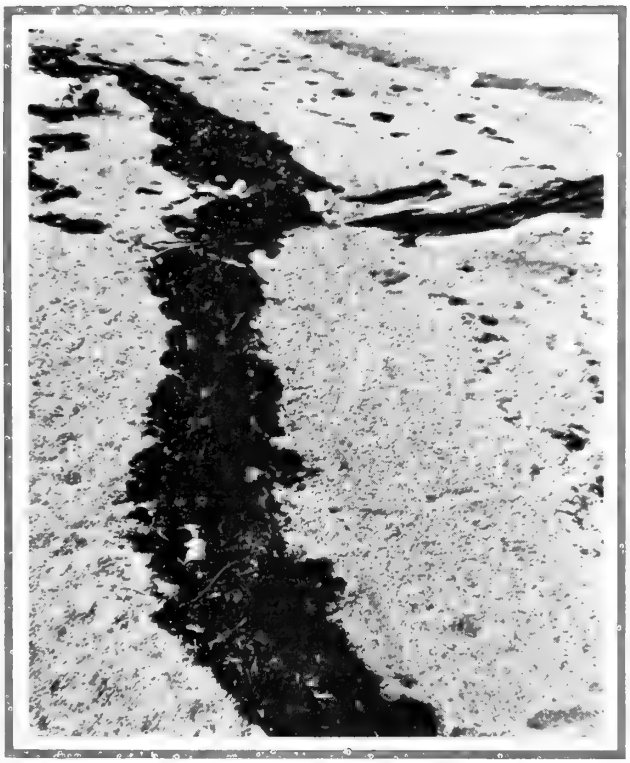
WARNING!

Don't touch the bacteria colonies that grow on your potato slices. Some of the bacteria may be able to cause disease. When your investigations are finished, you can throw the potato slices and jar lids into a garbage pail. If you want to save the jar lids, just throw away the contents (being careful not to touch them) and wash the lids in *hot* soapy water.

Brain Boosters

prepared by
DAVID WEBSTER

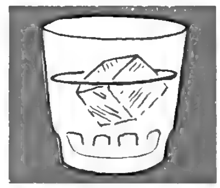




MYSTERY PHOTO
What caused this long mound of seaweed to form on a beach?

WHAT WOULD HAPPEN IF?
The balance is pivoted so the platforms on either side can move up and down. If equal weights were placed at the center of each platform as shown, the platforms would balance. What would happen if the weight on the right were pushed all the way to the outside end of the platform?

CAN YOU DO IT?
Can you float an ice cube in a glass of water for a minute so that the cube does not touch the sides of the glass?



FUN WITH NUMBERS AND SHAPES
What number can be added to 7 or multiplied by 7 to give the same answer?

Submitted by John Hoebing, Grant's Pass, Oregon

FOR SCIENCE EXPERTS ONLY
Veins in your body appear blue through your skin, because the blood in them is blue. When you cut a vein, however, the blood comes out red. Why?

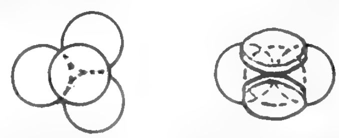
JUST FOR FUN
Make a mold garden in an old aquarium tank, a plastic box, or a glass jar. Put in bread, vegetables, meat, wood, leather, metal, string, paper, plastic, or cloth for molds to grow on. Then add a little water and cover the top of the container with a plastic bag to keep the moisture inside. How long does it take for molds to begin to grow? Do all the molds look the same, or do they have different colors and shapes? How many different kinds of molds can you find in your garden? Keep your mold garden for a year and look at it again. You may be surprised at what you see and smell.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The man on the strange-looking trailer is spraying trees to control insects.

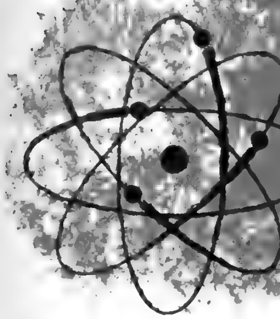
What would happen if? The weight of the sealed jar and food will not change as the food decays and becomes moldy. What would happen if the jar had been left uncovered?

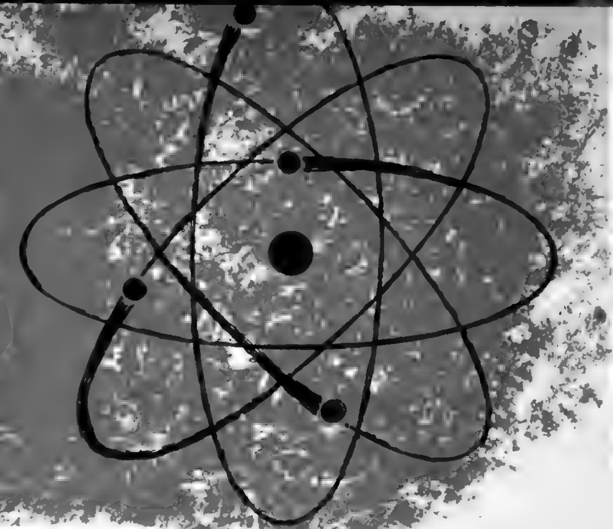
Can you do it? Here is how to arrange the pennies.



Fun with numbers and shapes: It takes 65 minutes and 27 seconds for the minute and hour hands of a clock to meet again after meeting. (Since the hands pass one another 11 times in 12 hours, you can divide the number of seconds in 12 hours by 11 to get the answer.)

For science experts only: As the weather gets cold, soil cools off faster than water. Lake water near the cooler land then gets cold faster than water in the middle of the lake. Also, the shallow water near the edge of the lake does not move around and become mixed with warmer water underneath as much as deeper water does. In the spring, the soil heats up faster than the ice, so the ice melts first around the edge of the lake.





Man's First Look inside the Atom

by Roy A. Gallant

In Part 1 of this series of seven articles (N&S, January 5, 1970), the author told how scientists became convinced that all matter is made of tiny particles called atoms. In Part 2, he tells the fascinating story of how the tinier particles that make up atoms were discovered.

■ Only 100 years ago, the popular scientific view of atoms was that they were hard, solid spheres that could not be broken apart. But that view was soon to be changed. When it was, the atom began to "open up" and—like a flower—it revealed many hidden parts.

The Puzzling Green Glow

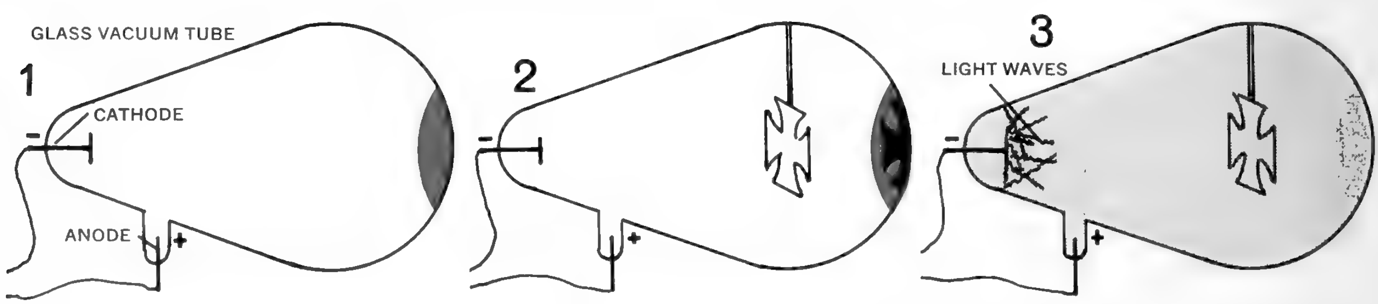
In 1896, the English physicist J. J. Thomson, who lived from 1856 to 1940, had been experimenting with electricity for many years. One of the things he was trying to find out was what happens to electricity when it passes through a glass tube that has had most of its air pumped out. He could see that *something* was happening, but he could not explain it. As electricity passed through the vacuum tube, the tube glowed with a green light *(see Diagram 1)*. Although scientists had known about this glow since Thomson was three years old, no one knew what it was.

Something was moving from one end of the tube to the other. But what? Just saying that it was "electricity" didn't explain anything. You could then ask, "Well, what is *electricity*?" The "something" seemed to be "rays" of some sort that traveled in straight lines. Thomson could see that they traveled in straight lines, because an object put inside the tube in the path of the rays would cast a sharp shadow *(see Diagram 2)*. If the rays, or whatever they were, traveled in a helter-skelter way, then they would not cause an object to cast such a sharp shadow *(see Diagram 3)*.

Thomson also used a magnet to try to find out more about the mysterious rays, or whatever they were. When he held one end of a bar magnet near the tube, the rays were bent away from their straight-line path and followed a curved path *(see Diagram 4)*. While this did not tell Thomson what the rays *were*, it told him one thing they were *not*. They could not be rays of light, because light cannot be bent by a magnet.

Discovering Electrons

As Thomson experimented and puzzled over the problem, he was led to two thoughts: 1) Perhaps whatever was passing through the tube was not rays at all, but instead was a stream of solid particles. 2) If so, then each of the particles must have an electrical charge, because their path is bent by a magnet.



A glow of green light appears at the end of a glass vacuum tube when an electric current is passing through the tube between the *cathode*, or negative plate, and the *anode*, or positive plate.

Thomson thought the glow must be caused by some kind of "rays" traveling straight out from the cathode, because an object placed in their path cast a sharp shadow on the end of the tube.

He knew that the "rays" could not be light waves from the heated cathode, because such waves would spread out in all directions, making most of the tube glow and producing only a blurry shadow behind the object in the tube.

If he were right, then the mysterious stream would also be bent away from its straight-line path by electricity. When Thomson did an experiment like the one shown in Diagram 5, the same thing happened that had happened when he had used the magnet. When the mysterious stream passed between two metal plates with electricity on them, the stream was bent. This showed that the stream was made up of solid particles, and that the particles were "charged." In other words, in some way the particles were being pushed away by the electricity, somewhat as the north poles of two bar magnets push each other apart. A stream of particles that were not charged would not be bent off course.

Thomson also managed to get at least some idea of the *mass,* or "weight," of these charged particles. Meanwhile, other scientists had also managed to learn something about the masses of different kinds of atoms. For instance, they knew that hydrogen atoms were the lightest (least massive) of all known atoms, that oxygen atoms were heavier (more massive) than those of hydrogen, those of lead more massive than those of oxygen, and so on.

Thomson was able to say that his "corpuscles" of matter, as he called the particles, were much smaller than any known atom. He also said that these charged particles were a part of all atoms. He even made a guess about how these particles might be arranged in an atom. He imagined each one to travel in a circular path, much as the planets circle the sun. Today, we call these particles *electrons.* The electricity (mysterious rays) Thomson had been experimenting with in the vacuum tube was a stream of electrons.

Thomson had broken the not-so-solid atom apart and had shown that it had tiny particles of negative electricity. But what was the rest of the atom like?

An atom could not be made up *only* of electrons, Thomson reasoned. If it were, the electrons would scatter all over in an instant, because they would *repel,* or push, each other apart just as the like poles of two bar magnets do. Also, the atoms making up a footstool, or a piece of chalk, or your skin, usually do not have an electric charge. They are electrically *neutral,* which means that some other part of the atom must have a positive charge that "balances" each electron's negative charge *(see Diagram 6).*

But in what part of the atom were these other charges to be found? Was there one positively charged particle to balance each electron? If so, were the positive particles scattered around inside the circular paths of the individual electrons? Or were they lumped together at the center of the atom? Thomson didn't know, but he guessed that they were scattered around. As it turned out, his guess was wrong. It was left to one of his brightest students to find the correct answer to that question.

Rutherford Finds a Nucleus

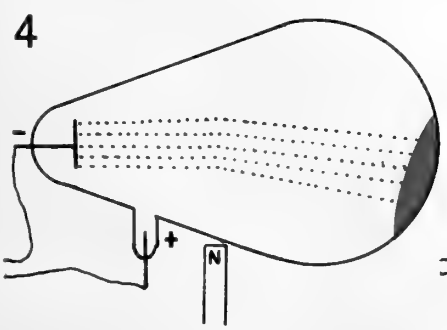
In the early 1900s, Ernest Rutherford was experimenting with an element called thorium. Like uranium, thorium has atoms that are big, and not very stable; bits and pieces of these atoms fly off from time to time. Rutherford knew that the tiny "bullets" that are shot out of a lump of thorium have a positive charge.

He used thorium to explore the inside of atoms. As Diagram 7 *(page 14)* shows, Rutherford aimed a stream of thorium bullets from the window-opening of a container with thorium in it at a thin sheet of gold foil. By finding out what the atoms of gold did to the tiny thorium bullets, he hoped to find out something about the part of the atom inside the "rim" of electrons. He could tell what happened to most of the thorium bullets by watching where they hit a special screen placed behind the gold foil.

Most of the thorium bullets followed a straight-line path through the barrier of gold atoms, just as if nothing were in the way at all. But some of the bullets seemed to *ricochet,* or hit something and bounce away at an angle. If

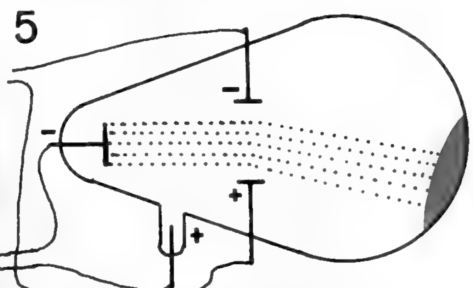
(Continued on the next page)

4



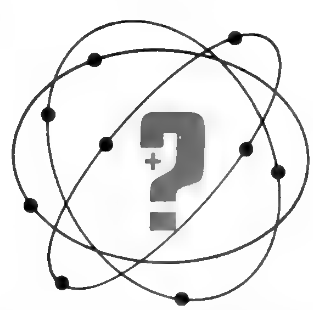
When the "rays" were pulled toward the end of a bar magnet held near the tube, Thomson decided that they must be made up of a stream of particles, with each particle carrying an electrical charge.

5



When Thomson passed the stream of particles between two electrically charged plates, the stream was bent away from the plate with the negative charge, so he knew that each of the particles must carry a negative charge.

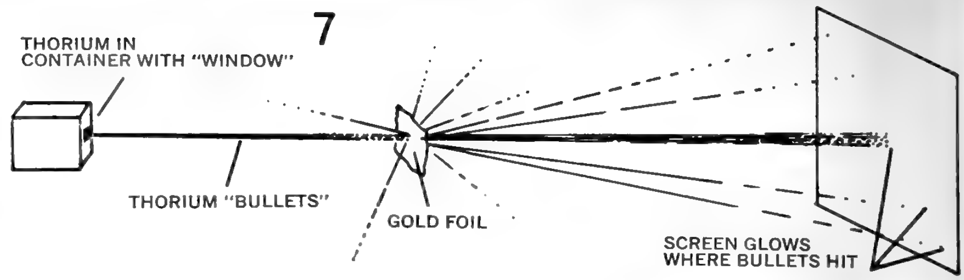
6



Thomson said these negatively charged particles *(electrons)* are part of all atoms, but that some part of an atom must carry a positive electrical charge to balance the negative charges and hold the electrons together.

To explore the inside of atoms of gold, Rutherford aimed a stream of "bullets" from the element thorium at a thin piece of gold foil. A screen that glowed where a bullet struck it showed that only a few of the bullets had changed course as they passed through the atoms of gold.

7



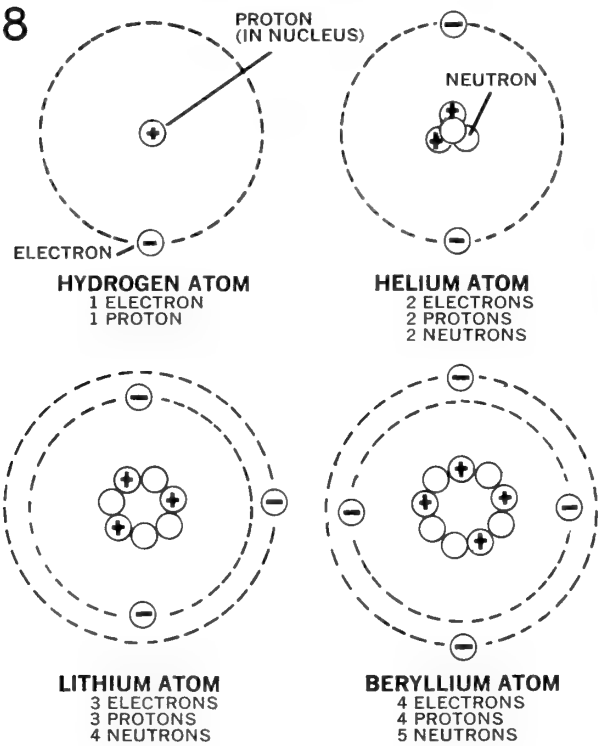
Exploring the Atom (continued)

you did this experiment in a laboratory today, you would find that about one out of every 10,000 thorium bullets is knocked off course a bit when it passes through a sheet of gold foil. And once in an even greater while, one is knocked off course at nearly a right angle.

Since most of the thorium bullets went right through the sheet of gold without changing direction at all, Rutherford decided that the atoms of gold must be mostly empty space. If they were solid, or mostly solid, even the thinnest sheet of gold would stop the bullets or change the path of most of them. Also, since some of the thorium bullets shot off at sharp angles when they passed through the gold foil, he thought that the central core of an atom of gold must be very massive. Otherwise, the thorium bullets would simply push the core to one side and plow straight on through.

With such information, Rutherford could now picture an atom: If the central core, called the *nucleus,* were made as large as a pea, then its nearest electron would be about 50 yards away! Think about that for a minute, and you will understand how an atom can be mostly "empty space."

8



These diagrams show one atom of each of the four simplest elements. An atom normally has equal numbers of electrons and protons, so their negative (—) and positive (+) electrical charges are "canceled out" and the atom itself carries no electrical charge. Neutrons have no charge. They are packed tightly together with protons in the atom's *nucleus*, which makes up nearly all of the atom's mass (weight). Atoms with more electrons, protons, and neutrons make up the remainder of the 103 known elements.

Protons, Electrons, and Neutrons

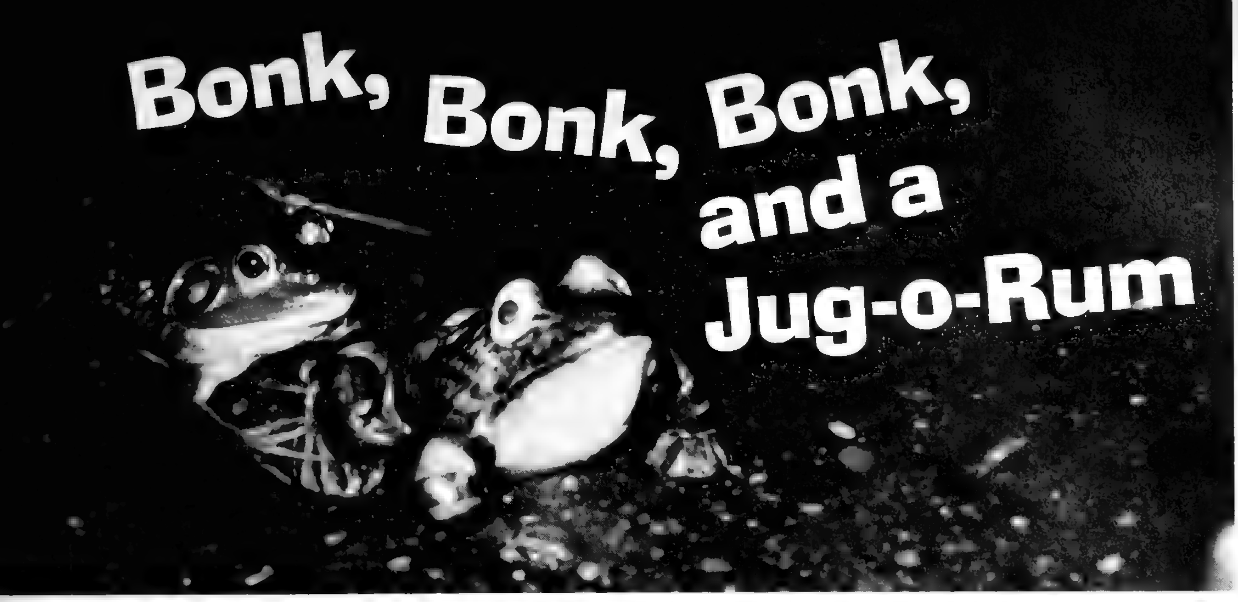
Since the time of Thomson and Rutherford we have found out a lot more about atoms, and we do not picture them in quite the same way that Rutherford did. For instance, experiments show us that the nucleus of the simplest atom we know about is made of one particle (called a *proton*) that has a positive charge. One moving electron forms a "shell" of electricity around that proton. At one time the electron may be closer to the proton-nucleus than at another time.

Other atoms, such as helium and lithium *(see Diagram 8),* have other particles in their nuclei. In addition to having protons, they have particles called *neutrons.* Neutrons do not have any electric charge, but they add mass to the atom. Atoms ordinarily have the same number of protons as electrons, so usually they do not have an electric charge.

The work of Thomson and Rutherford took us a long way toward understanding how an atom is made up of protons, electrons, and neutrons. It also opened the door to our understanding of what happens to atoms when we say that they give off "radiation," or that they are *radioactive* ■

Part 3 of this series, in the next issue, will describe some of the early experiments with radioactivity, which led men to begin to discover some of the deadly dangers of the atom.

Bonk, Bonk, Bonk, and a Jug-o-Rum



A real male bullfrog (far left) attacks a model frog about a foot from where the loudspeaker gave out frog calls.

■ *Jug-o-rum. . . Jug-o-rum. . . Jug-o-rum. . . .*

In a bullfrog's world, these sounds have special meaning. The series of deep croaks that sound to some people like "jug-o-rum" is the mating call of male bullfrogs. "Jug-o-rum" also seems to be a sort of advertising call that announces to other male bullfrogs that a male "owns" its home area, or *territory.*

Recently, a biologist used a tape recording of frog mating calls to investigate the territories and behavior of bullfrogs. During the summers of 1965 and 1966, Thomas Wiewandt observed bullfrogs living in some ponds on Long Island, New York, near the Kalbfleisch Field Research Station of The American Museum of Natural History.

Most of his studies were made at one pond where there were seven bullfrogs, including five adult males. Mr. Wiewandt made a tape recording of a male frog's "jug-o-rum." Then he set a loudspeaker on shore (usually within about 15 feet of a calling male frog), played the tape, and watched the frog.

Hearing the call, the frog would turn toward the loudspeaker, give one or two short calls of a different kind ("bonks"), then swim toward the loudspeaker, giving more "bonks" and mating calls ("jug-o-rums") along the way. Once near the loudspeaker, the frog eventually lost interest and swam back to the center of his territory. In 1966, however, Mr. Wiewandt set a model bullfrog made of pottery about a foot from the loudspeaker.

When a male frog swam within about three feet of the loudspeaker, Mr. Wiewandt turned off the sound of the mating call. At this distance the frog could see the model in the water *(see photo)* and would attack it by jumping at or on it, sometimes tipping the model over. If the mating call was played again, the frog would leave the model, jump onto shore, and hop to the loudspeaker. The sound of the mating call seemed to interest the frogs more than the sight of the model.

By playing the "jug-o-rum" mating sound at different places around the pond, Mr. Wiewandt was able to get some idea of the sizes of the frogs' territories. He began by placing the loudspeaker about 30 to 50 feet from a calling male frog. Then the "jug-o-rum" sound was played for several minutes. If the frog didn't come toward the loudspeaker, Mr. Wiewandt moved the speaker a few feet closer to the frog. This was done until the frog came "bonking" toward the speaker, ready to defend the edge of its territory.

In this way, Mr. Wiewandt was able to get a rough idea of the size of the territories of three male frogs. One frog defended about 30 feet of shoreline, another about 65 feet, and a third male defended about 80 feet, though the area defended varied from time to time.

Male bullfrogs rarely fight each other. When they do, they wrestle around in the water until one male "feels" defeated. Neither male is hurt physically.

Beware of the Bonks

Mr. Wiewandt wondered what effect the "bonk" call would have on male bullfrogs. To find out, he first attracted frogs by playing the "jug-o-rum" sound. Then, when a male had come close to the loudspeaker, Mr. Wiewandt switched to the "bonk" sound. Usually, this caused the frog to swim away. Once, however, a male frog stayed by the speaker, no matter how many "bonks" were played. Later, when the speaker was moved farther from the center of this frog's territory, the frog swam away when the "bonk" sound was played.

From this, Mr. Wiewandt decided that "bonk" is a threatening sound, given by bullfrogs when they are defending their territory. "Bonks" from a male near the edge of another frog's territory will send the "owner" of the territory back to its center. Nevertheless, the "owner" is unwilling to give up the center of his territory. He will fight to keep it, even if an intruder "bonks" threateningly.

—Laurence Pringle

WHAT'S NEW

by
B. J. Menges

Surfing in the desert may sound impossible. But in the sunbaked city of Tempe, Arizona, 350 miles from the ocean, the surf is always up. Man-made waves up to five feet high give surfers a 300-foot ride in an artificial pond.

To make natural five-foot-high waves in the ocean, it takes a 17-mile-an-hour wind blowing all day long across a 400-mile stretch of water. To make them in the pond at Tempe, half a million gallons of water are pumped into a reservoir at one end. Once each minute, 15 underwater gates open and close, releasing 50,000 gallons of water into the pond each time. This sends a wave five feet high through the pond. A construction engineer named Phillip Dexter developed the wave-making device after experimenting with a small model in his back yard.

Rocking on the beach doesn't always mean a party. It's what many clams do to bury themselves in sand. The clams burrow into the ocean bottom by standing their shells on edge and rocking from side to side.

The ridges on the shells of these clams are arranged in a wavy pattern, instead of in circles like the ridges on other clam shells. Watching these clams burrow in the sand of an aquarium, Dr. Steven M. Stanley of Johns Hopkins University, in Baltimore, Maryland, discovered that the pattern and shape of the ridges make burrowing easier. As the clam rocks back and forth, one side of the shell moves down through the sand while the other side moves up. The ridges are shaped somewhat like the barbs on a fishhook, so they slide down through the sand easily. But when they are pushed upward, they catch in the sand and push the clam downward.

Has Noah's ark been found? Some scientists think so. The Bible says the ark came to rest on top of Mount Ararat, in eastern Turkey, after a great flood. Fourteen years ago, some wood that seemed to have been worked by hand was found in the ice of a lake near the top of the 17,000-foot-high mountain. Pieces of the wood were studied by European and American scientists, who estimated that they were at least 4,000 years old—probably old enough to have been used in the ark.

Last summer, two more pieces of what appears to be the same wood were found frozen in the lake ice. Next year machinery will be hauled up to the lake to remove much of the 20- to 30-foot-thick ice. If more of the wood is found, scientists should get a better idea of whether the remains of Noah's ark have indeed been discovered.

Eating wooden houses isn't the only way termites get food. Some termites have gardens in their underground nests. In these gardens the insects raise a single kind of fungus that they eat. Nothing else grows in the gardens. But if the termites are removed from their nest, many other kinds of fungi soon appear in the gardens. Dr. A. Sannasi, a scientist at the University of Georgia, in Athens, had guessed that the termites must do something to prevent these fungus "weeds" from growing. But what?

After careful study, Dr. Sannasi found the answer. The queen termite produces a substance that the worker termites apparently mix with the "soil" of the garden. This substance acts as a "weed killer," keeping unwanted fungi from growing. Why the termites raise only one particular kind of fungus is not yet known.

Ten-mile-an-hour moonmobiles will carry astronauts over the lunar surface, beginning with the Apollo 17 mission about two years from now. The 10-foot-long "Lunar Rovers" will be driven by separate battery-powered motors at each of the four wheels. The vehicles will fold up, so they will take up little room aboard a lunar spacecraft.

The moonmobiles will allow astronauts to travel farther and carry more equipment than they could on foot. Eventually, it may be possible to control the vehicles by radio signals from the earth. After a team of astronauts had returned to earth, the vehicle they left behind could be commanded by radio to go to the landing site of the next team. Then, when the astronauts arrived on the moon, their car would be waiting.

The world's largest solar furnace, built on a hillside in France, has over 20,000 mirrors that bring so much sunlight together at a small spot that its heat can melt a hole in a half-inch-thick steel plate in less than a minute. The flat mirrors on the hillside reflect sunlight to the huge, concave wall of mirrors in the background, which focuses the light on a small area in the tower. Objects can be placed in the tower to see how various materials are affected by high heat—as high as 7,000 degrees Fahrenheit when all the mirrors have been properly adjusted.

nature and science
TEACHER'S EDITION

VOL. 7 NO. 11 / FEBRUARY 16, 1970 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Blood Color

Hemoglobin usually contains iron, and it is the iron that "carries" oxygen. All animals with backbones (except icefishes) have hemoglobin with iron.

Within a species, the amount of hemoglobin in the blood sometimes varies. A person living at a high altitude usually has extra hemoglobin, for his body has responded to the shortage of oxygen at high altitudes by making more hemoglobin and more red blood cells. Some people have too little hemoglobin, cannot carry all the oxygen they need, and feel tired most of the time. A shortage of a vitamin or of iron can cause this *anemia*. The proper diet can usually cure both of these kinds of anemia.

Another kind of anemia is caused by a tiny *inherited* abnormality that makes a person produce a kind of hemoglobin that cannot carry much oxygen. The disease is called *sickle-cell anemia*, because of the shape of red blood cells with the diseased hemoglobin. People who inherit this abnormality from both parents usually die during childhood.

Man could not survive without hemoglobin. Unlike "cold-blooded" icefishes, we have body temperatures that are always high. We need too much oxygen to get along carrying oxygen only in the blood plasma, as icefishes do.

Saguaro Cactus

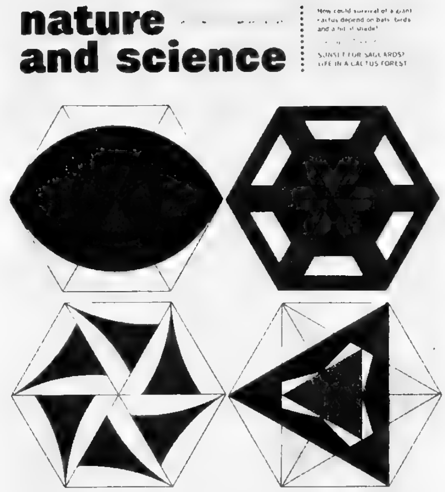
The survival of a species of cactus in part of southwestern North America may not seem very relevant to your pupils' lives, but some important biological ideas are brought out in the article and WALL CHART. The central concept is: *Organisms are adapted for survival in their environment.* An adaptation is any aspect of an organism that promotes its welfare, or the welfare of the species to which it belongs, in the organism's natural environment. There are three main categories of adaptations: 1) *behavioral,* 2) *morphological* (shape, size, structure, color), and 3) *physiological* (processes within the body). Adaptations usually come about through thousands or millions of years of evolution, although some take less than a century.

Topics for Class Discussion

• *What adaptations help the saguaro cactus to survive in its desert environment?* Its spines protect it somewhat from plant-eaters; its waxy outer surface reduces loss of water; its cells are especially adapted for storing water; its roots (shallow, far-reaching) are adapted to collect as much as possible of the scant rainfall; its abundant seeds enable it to reproduce despite heavy losses. *(For further examples of desert plant adaptations, see "Making the Water Last,"* N&S, *Oct. 30, 1967.)*

• *In what ways is the saguaro dependent on its environment?* Its survival depends on the animals that pollinate its flowers, on the climate,

(Continued on page 2T)



Fold a strip of paper into a hexahexaflexagon, color its six surfaces in patterns like these, then watch for surprises as you discover—HOW TO FLEX A HEXAGON—see page 4

IN THIS ISSUE

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

IN THE NEXT ISSUE

Investigating your community's environment: a WALL CHART and two articles to help children assess, and perhaps change, the "sight blight" around them . . . Testing muscle strength . . . Early experiments with radioactive elements.

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

and on the plants that provide shade for saguaro seedlings.

Its success or failure in reproducing may even depend on the *color* of the soil on which its seeds fall. In one series of tests, biologists raised thousands of saguaros from seeds, then planted the seedlings in the desert. All those planted in the open died quickly. Among those planted under shady bushes, the seedlings growing in light-colored soils survived better than those in dark soil. Dark soil is warmer than light soil because it absorbs more heat from sunlight (*see "Water From Glaciers,"* N&S, *Feb. 2, 1970, p. 1T*).

- *Has climatic change affected the survival of other organisms?* The fossil record reveals great climate changes in the past. Antarctica once had a warm, moist climate (*see "What's New?", page 16*). The change in climate there resulted in the extinction of life that is still mostly unknown to man. Climatic change is one of several factors that probably contributed to the extinction of the dinosaurs. A more recent and subtle change is the warming trend in North America; one result is that animals such as opossums, cardinals, and mockingbirds have extended their ranges northward.

Even though humans are able to "create" a favorable climate about themselves (by heating, air-conditioning), man's survival on earth is also affected by climatic changes. How would the lives of your pupils be affected if another glacial age began, or if the world's glaciers melted? *(See "Is 'Pop Gas' Warming the Atmosphere?",* N&S, *Sept. 29, 1969.)*

- *Compare the reproduction of saguaros with that of other organisms, including humans.* A species can't survive without reproducing, and plants and animals have evolved an amazing variety of ways in which to reproduce successfully.

The saguaro has succeeded so far by producing many young. Even though only about half of a saguaro's flowers are pollinated, the plant may produce 10,000 embryos (seeds) a year. Some other kinds of plants produce fewer seeds, but the seeds are adapted to survive better. For example, some seeds have "wings" that aid their dispersal to favorable growing places. Some kinds of mammals and birds reproduce often; mice and rabbits have several litters each year.

Humans produce many sex cells (eggs and sperm), but few eggs are fertilized. Human young cannot survive without several years of parental care. If a cactus could care for its young as humans and many other mammals do, it wouldn't need to produce thousands of seeds. But, as one biologist put it, "Nature's way is any way that works."

Exploring the Atom—Part 3

Roentgen's discovery of X rays and Becquerel's discovery of radioactivity both resulted from their investigations of *fluorescence*—the glow of light given off by certain substances when they are exposed to light or to a source of energy such as a stream of moving electrons.

How this glow is produced is explained under "Exploring the Atom—Part 2," *N&S,* Feb. 2, 1970, p. 3T, and would be worth reviewing with your pupils before discussing fluorescence further. Fluorescence in a TV picture tube is explained in the above reference. Your pupils have also seen fluorescent lamps—narrow, gas-filled, glass tubes with fluorescent powder coating their inside wall. Electricity passing through the tube excites electrons in atoms of the gas, making them give off ultraviolet waves, whose energy excites electrons in the atoms of the fluorescent powder and makes them give off visible light.

Topics for Class Discussion

- *From what you know about fluorescence, can you guess what X rays are, and why they come from the fluorescing glass of a cathode tube?* X rays are electromagnetic waves that are even shorter than waves of ultraviolet light (which cannot be detected by the human eye). They are part of the energy given off by excited electrons in the fluorescing glass. Shorter waves carry more energy than longer waves, which is what enables X rays to pass through soft substances that block light of longer wavelengths.

- *Do you think Roentgen discovered X rays mostly by accident?* The coated sheet of paper that he noticed glowing was one he had prepared for use in investigating fluorescence (though he did not expect it to be affected by the covered cathode-ray tube).

Historians report that before Roentgen's discovery, an English scientist had already noticed that photographic plates kept in a box near his cathode ray tube somehow got exposed to light. But that was not what he was investigating, so he just told his assistant to move the plates, and forgot about it. (Your pupils will probably agree that while Roentgen had "a little bit of luck," his discovery was mainly due to his curiosity and willingness to investigate an unexpected result of his experiments.)

- *What, exactly, did Becquerel discover as a result of his investigations described in this article?* He discovered that the element uranium (which is not fluorescent) is constantly giving off some kind of invisible "rays" that can pass through soft substances and expose photographic film as X rays do. (Becquerel later discovered that what uranium gives off is not waves of electromagnetic energy, but streams of moving electrons like those inside a cathode ray tube. The Curies called this phenomenon *radioactivity*; their investigations will be described in the next issue.) *(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.

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

• *Publishing the results of their investigations helps scientists get the proper credit for their discoveries.* (Becquerel later shared a Nobel prize with the Curies for his part in the discovery of radioactivity.) *Can you think of other ways that publishing their findings helps scientists?* It gives scientists a chance to learn from each other's discoveries (as Becquerel did from Roentgen's); to test each other's experiments and compare results; and to either point out mistakes in another scientist's work or support his findings with additional information or ideas.

Brain-Boosters

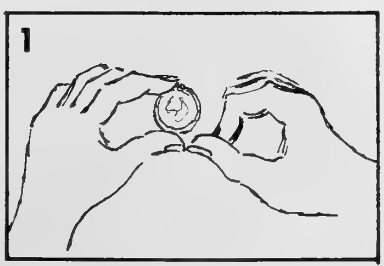
Mystery Photo. The frozen spray on the ship's railings shows that salt water does freeze, contrary to what many people think. Your pupils could mix up a salt solution with the same salt concentration as sea water (about 3 per cent) and put it in the freezer with a thermometer to see at what temperature it freezes (about 29° F.).

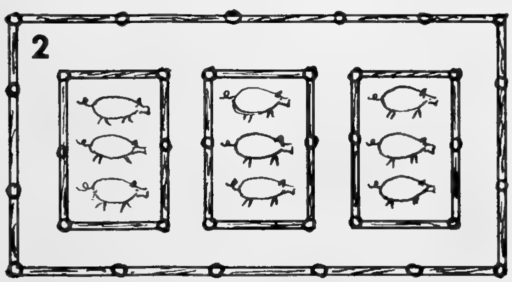
What will happen if? Milk, too, will freeze, though it never becomes as hard as ice. When thawed, it tastes like normal milk. Your pupils could try freezing other liquids – vinegar, syrup, orange juice, liquid detergent, and so on—and see which can be frozen in a refrigerator freezer compartment and which cannot. If a liquid will not freeze, can they make it freeze by diluting it with water? How much water must be added to the various liquids to make them freeze?

Can you do it? To drop a coin so that it stays on its edge, you must make it spin. Hold the coin loosely between thumb and forefinger a few inches above a table, and snap its edge with your other forefinger *(see Diagram 1)*. The coin should drop to the table and spin on its edge for a few seconds.

Fun with numbers and shapes. Diagram 2 shows how nine pigs can be placed into four pens having an odd number of pigs in each pen.

For science experts only. The towers that support the Verrazano Bridge stick "straight up" from the earth; but because the earth is round, "straight up" is not the same direction at different points on the globe. Thus, the towers are not exactly parallel to one another, and get farther and farther apart as they rise above the water. You can demonstrate this by sticking two toothpicks into an orange so that the "bottom" end of each toothpick points toward the center of the orange. (For a tower to stick "straight up" from the earth's surface, its "bottom" end must point toward the center of the earth.)





Recent Life Science Books For Your Pupils

By Barbara Neill

■ Children today live in a time of rapid scientific advances, shifting values, and environmental changes. The following new books will help give them the knowledge they need to understand the earth and variations in its climate, soil, and water. They will help them understand themselves and the life around them better, and point out the many ways in which all life is interdependent.

The Only Earth We Have by Laurence Pringle (Macmillan, 86 pp., $4.50) tells how our environment is being altered by technology and our careless management of natural resources. The author spells out the expense and inconvenience involved in changing things; but he makes clear that to maintain our present quality of life, we must start to work now, and he gives concrete examples of ways we can all help. The book is written in a readable style suitable for fifth-graders through adults and is illustrated by many excellent photographs.

Clues to the Riddle of Life by Malcolm E. Weiss (Hawthorn, 107 pp., $3.95) is a simple, non-technical book for children 10 years and older. Its subject is the origin of life and its many adaptations. The book ranges from primitive life such as anaerobic bacteria to the adaptations of desert animals. The author's explanation of DNA is surely one of the clearest in print. The book's theme is the unity of all life and the importance of man's understanding the needs and interdependencies of all living things.

Another book dealing with the interdependence of living things is **The Tale of Whitefoot** by Carl T. Brandhorst and Robert Sylvester (Simon and Schuster, 78 pp., $3.50). The title and the delicate drawings seem to indicate a charming story about a mouse. But the mouse is dead by page 26. The rest of the book explains how the mouse's body is changed by natural processes. Children learn that the molecules that made up the mouse are not destroyed, but merely changed in form. The authors' explanations of the functions of bacteria and enzymes are excellent and best suited to fifth- and sixth-graders.

Within the interdependent web of life there are many special relationships. **Unusual Partners** by Alvin and Virginia B. Silverstein (McGraw-Hill, 64 pp., $4.50) introduces the subject of symbiosis to children aged nine to twelve. An attractive, easy-to-read book, it tells of such odd partners as the Portuguese man-of-war and the brightly-colored fish,

(Continued on page 4T)

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

N&S REVIEWS...

(continued from page 3T)

Nomeus. Crocodiles of the Nile River open their mouths wide for the Egyptian plover to search inside for leeches. The role of various microscopic organisms within larger animals and plants is described also.

Two New "Firsts"

One of two new entries in the "First Book" series is concerned with a vital part of our environment, the wetlands. Bogs and soggy ground are still considered waste places by some, but their value has long been recognized by ecologists. **Swamps and Marshes** by Frances C. Smith (Watts, 64 pp., $2.95) presents these areas to children as homes for wildlife, as natural reservoirs that maintain the underground water level, and as tidelands that provide nutrients and become nurseries for ocean life. A short book on a complex subject, it is best suited to sixth grade and up.

The other "First Book" answers most questions fifth- and sixth-graders might ask about eagles. **Eagles** by Robert Whitehead (Watts, 84 pp., $2.95) tells where eagles live, what they eat, how high they fly, what an eagle's eye is like, and how many kinds of eagles there are.

Like the eagle, the tiger is often a subject of myths and legends. **The Tiger: Its Life in the Wild** by George B. Schaller and Millicent E. Selsam (Harper, 71 pp., $4.95) tells of a ghostly tiger that was supposed to guard a sacred shrine in India. However, most of this book is about real tigers and contains first-hand information Dr. Schaller has gathered by studying tigers in Kanha Park, a reserve in central India. A fine book with many black-and-white photographs for junior-high age and older.

The survival of eagles, tigers, or other animals that need both space and a wilderness habitat is uncertain in this increasingly urbanized world. **Animals at Bay** by Adrien Stoutenburg (Doubleday, 159 pp., $3.50) dramatizes the plight of a number of North American mammals. For children in the fifth grade and up, this book tells the familiar story of the once-thundering herds of buffalo and why they disappeared; what prairie-dog towns were like; and why the grizzlies are gone from the West. They will be brought up-to-date on efforts to save wild animals. There are fine black-and-white illustrations by John Schoenherr.

The relationship between plants and animals is usually a simple one—plants are food for animals. But in **Plants that Eat Animals** by Linna Bentley (McGraw-Hill, 32 pp., $3.50) we find plants that can close their spiny-edged leaves fast enough to trap a fly and then proceed to digest it. One meat-eating plant from Borneo can even capture a shrew. This book describes carnivorous plants from all over the world and includes the American pitcher plant and the well-known Venus fly-trap. The illustrations are unusually decorative and accurate, and eight- to twelve-year-olds will enjoy the book.

Insects Reviewed

Of three new books about insects, one describes insects that use camouflage, warning colors, or mimicry to confuse their enemies. **Insect Masquerades** by Hilde Simon (Viking, 95 pp., $4.75) tells of mantids in the Malaysian jungle that resemble blossoms, and four-inch leaf insects that seem to disappear in the tropical foliage. But not all the insects are exotic. The praying mantis is hard to see on green plants; the walking-stick resembles a twig; while the odd-shaped ambush bug lies concealed in goldenrod flowers to wait for its prey. The book's detailed drawings are clear and colorful, and the text, suitable for fifth grade and up, reflects painstaking research.

Hunting Big Game in the City Parks by Howard G. Smith (Abingdon Press, 240 pp., $4.95) is a fun book about insects. Lacewings are called "vampires of the grasslands," ground beetles are "armored flesheaters," and ants are "pirates, kidnappers and slave-hunters." Stalking and trapping methods are given, as well as directions for keeping an insect zoo. Classification is covered in an appendix, and there are a glossary and a bibliography. Despite the light-hearted approach, this big, well-illustrated book is full of information and activities for children aged 10 and older.

Mosquitoes by Charles L. Ripper (Morrow, 64 pp., $3.25) is a model of clarity. The well-known author-illustrator has written a fine introduction to the insect he says has probably been investigated more than any other. The large print and attractive drawings help make it a good choice for the fourth grade and up. Readers will learn such things as how an adult mosquito uses its six stylets when it bites, and how a larva breathes air with its spiracle.

Although two insects are included in the next book, the rest of the animals it deals with are much smaller. **Some Animals Are Very Small** by Edward Lindemann (Crowell-Collier, unpaged, $4.50) is a colorfully illustrated book about planaria, hydra, copepods, and other animals best seen with a microscope. Just enough information is given about each one to stimulate further investigation by children eight to ten.

Animals with a Mysterious Past

Probably more children are familiar with the word "Tyrannosaurus" than with "planaria." But it is safe to say that few know "Uintatherium." These strange mammals lived on earth for about twenty million years, long after dinosaurs disappeared. They stood seven feet high, had three pairs of horns, and nine-inch fangs. They left no descendants.

Other early mammals are equally strange but have yet to be popularized. **After the Dinosaurs** by Carla Greene (Bobbs-Merrill, 72 pp., $3.50) and **The Age of Giant Mammals** by Daniel Cohen (Dodd, Mead, 160 pp., $4) are about these prehistoric mammals. The first is an introductory book for children aged seven to eleven. The illustrations are good and it is well-written, but it contains some inaccuracies and is flawed by over-simplification. **The Age of Giant Mammals** is written for children 12 and up, and is far more substantial. Besides information on such mammals as Coryphodon, the wooly rhinoceros, and Alticamelus, it gives the early speculations concerning their huge, fossilized bones. The final chapters speculate upon the fate of today's large mammals. It is a good source-book for students.

Dodos and Dinosaurs by Dorothy E. Shuttlesworth (Hastings House, 64 pp., $3.25) tells the stories of some of the extinct animals in the exhibits at The American Museum of Natural History in New York City. So slim a volume can no more than touch upon a few highlights of fossil-hunting and fossil exhibits, and this readable account for 10- to 16-year-olds ranges from how the Brontosaurus bones were put together to why the great auk disappeared.

In a class by itself is **Why You Look Like You Whereas I Tend To Look Like Me** by Charlotte Pomerantz (Scott, 64 pp., $3.95). In lilting verse, it tells about Mendel's theory of heredity and explains why children usually resemble their parents. The illustrations, gay and imaginative, are a perfect match. The end of the book has a short biography of Gregor Mendel, and diagrams of natural and artificial pollination of the pea. It can be read by a nine-year-old, but is for all ages ■

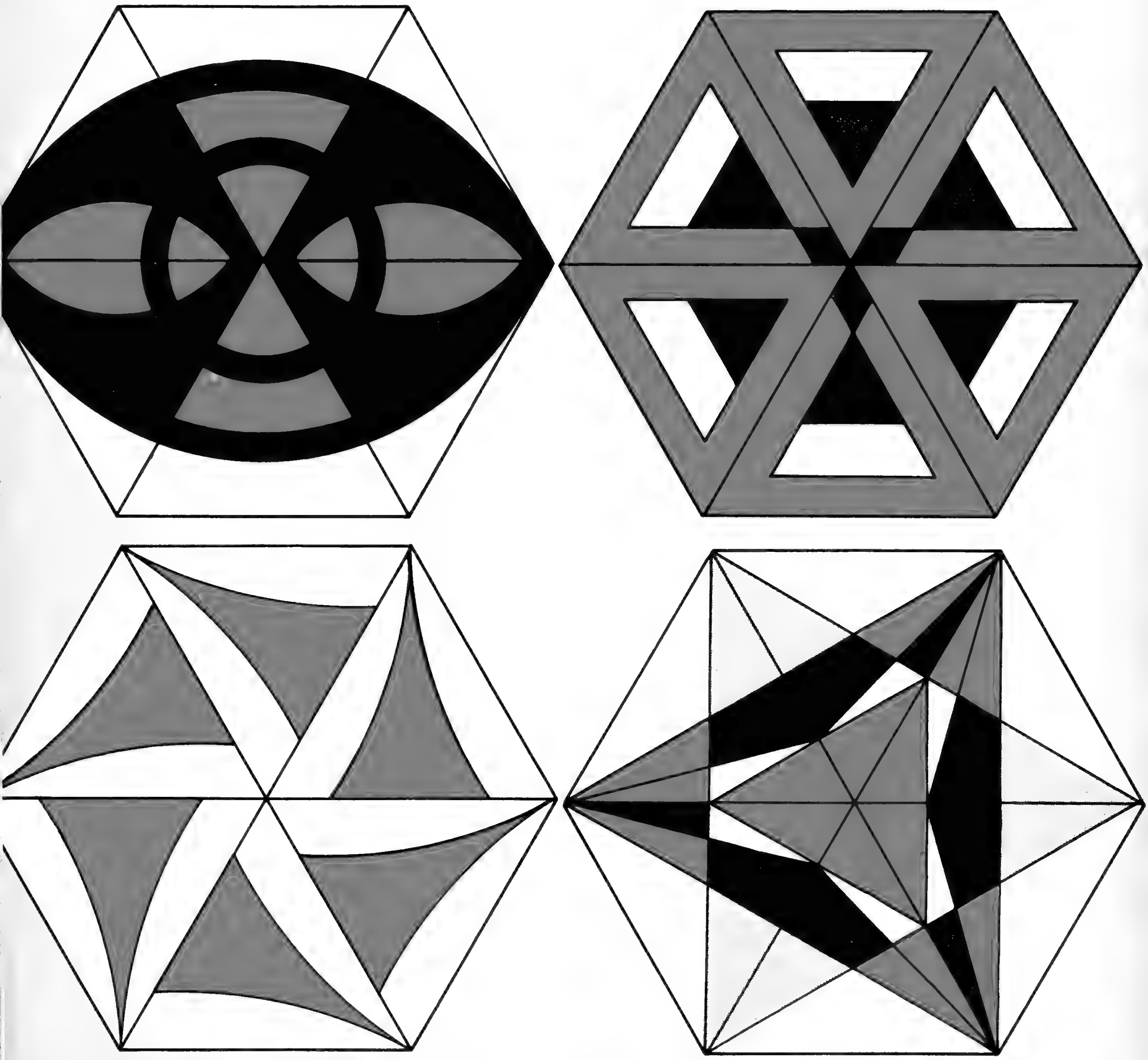
nature and science

VOL. 7 NO. 11 / FEBRUARY 16, 1970

How could survival of a giant cactus depend on bats, birds, and a bit of shade?

see pages 7 and 8

SUNSET FOR SAGUAROS? LIFE IN A CACTUS FOREST



Fold a strip of paper into a hexahexaflexagon, color its six surfaces in patterns like these, then watch for surprises as you discover—HOW TO FLEX A HEXAGON—see page 4

VOL. 7 NO. 11 / FEBRUARY 16, 1970

CONTENTS

PICTURE CREDITS: Cover, designs by Harriet Cole; pp. 2-3, E. A. Hemmingsen; pp. 4-5, 14 (top), 15, Science Photo/Graphics; p. 6, photo by David Webster; pp. 6-11, 13, drawings by Graphic Arts Department, The American Museum of Natural History; p. 7, photo by Ray Manley; pp. 8-9, (hawks and woodrat) Karl H. Maslowski, (cactus flowers and woodpecker) Allan D. Cruickshank, (owl) Lewis W. Walker, (coyote) Joe Van Wormer, all from National Audubon Society; p. 10, photos by Laurence Pringle; p. 14 (bottom) Theodore K. Himelstein; p. 16, Thomas Eisner.

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; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

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.

Blood in many animals is red. But deep in Antarctic waters live pale-colored, nearly-transparent fishes with . . .

■ Years ago, whalers returning from long voyages in the Antarctic told of catching fishes that were so pale they were almost transparent. These fishes were known as icefishes, and people thought that they looked as pale as ice because they had no blood.

The seas are full of unusual fishes. There are pencil-thin ones, fishes that look like brightly-colored ribbons or like rocks, and fishes with both eyes on the same side of the head. But as different as they are on the outside, all of these fishes have similar blood. Could the icefishes have no blood at all?

Red Blood, White Blood

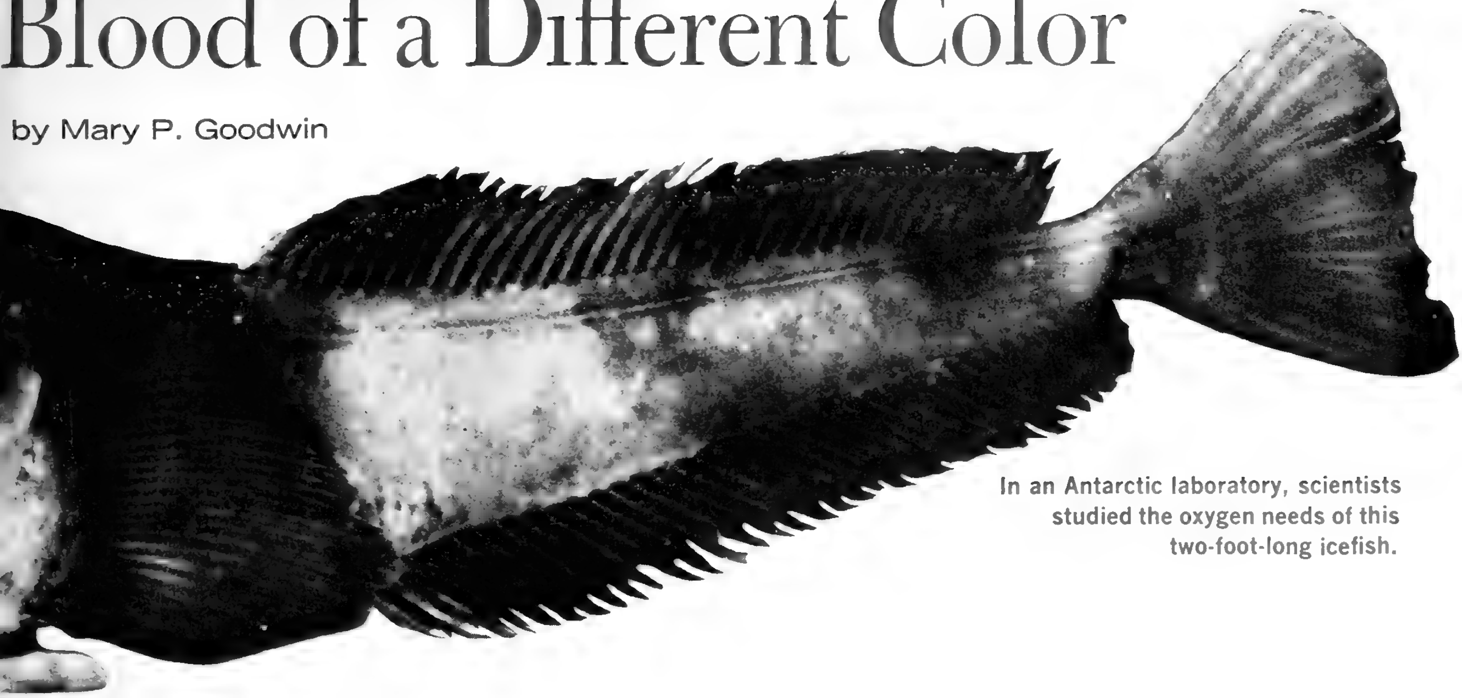
Blood has two parts—the fluid called *plasma,* and cells of two kinds. The white blood cells help prevent disease, and the red blood cells hold oxygen, which is carried by the blood to all parts of the body. Red blood cells can hold oxygen because they have a substance called *hemoglobin.*

Today, biologists know that icefishes are not bloodless; they have plasma and white blood cells. But the kinds, or *species,* of icefishes that have been investigated have few red blood cells, and little or no hemoglobin. This is why their blood is almost white; hemoglobin gives blood its red color.

Without hemoglobin, icefish blood can still carry some oxygen. It is dissolved in the plasma, as it is in the blood of other animals. But the amount of oxygen that icefish blood can hold is about one-tenth the amount of oxygen that blood in fishes with hemoglobin can hold. How icefishes can live with so little oxygen in their blood has puzzled biologists.

Blood of a Different Color

by Mary P. Goodwin



In an Antarctic laboratory, scientists studied the oxygen needs of this two-foot-long icefish.

All of the 16 species of icefishes live at the bottom of coastal waters near Antarctica, in places where the water temperature is about 32° Fahrenheit throughout the year. Fishes are "cold-blooded" animals; their body temperature is usually close to that of their surroundings. When their body temperature is low, living things use less oxygen than at a higher temperature. Because of the cold, icefishes may be able to live without the oxygen that is carried by hemoglobin in fishes of warmer waters.

Animals that are very active use more oxygen than those that are inactive. The bottom-dwelling icefishes probably don't move around too much. Perhaps icefishes need less oxygen than more active kinds of fishes.

To find out whether cold surroundings are the key to survival for icefishes, biologists tested the effects of cold water on other kinds of fishes. They put them in jars with water of different temperatures. The biologists found a way to keep the hemoglobin of the fishes from carrying oxygen. Then they watched to see how well the fish survived. The fish in water near 32° F. all lived, even though their hemoglobin couldn't carry oxygen. Fish in warmer water died. From these tests, the biologists decided that at low temperatures, even fishes *with* hemoglobin do not seem to need the hemoglobin to stay alive.

How Did Icefishes Lose Their Hemoglobin?

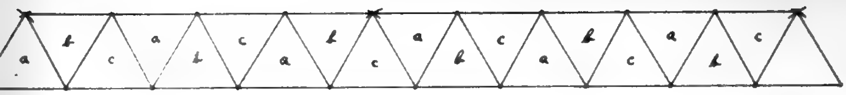
The cold surroundings of the icefishes seem to be the key to survival without hemoglobin. But icefishes are the only fishes without this substance in their blood. How did their lack of hemoglobin come about?

Biologists have looked at the blood and the blood-forming organs of several species of icefishes through microscopes. Some species have a few red blood cells and a little hemoglobin. Scientists think that icefishes slowly changed (*evolved*) from ancestors that had many red blood cells with oxygen-carrying hemoglobin. Some fish were probably born without the ability to make much hemoglobin. Because of the cold environment, these fish were still able to survive and reproduce. Their offspring also could not make much hemoglobin. The fish that did not make much hemoglobin or many red blood cells might have saved some energy. (Making hemoglobin and red blood cells requires energy.) So the earliest icefish might have had a slightly better chance of surviving and reproducing than their relatives with hemoglobin.

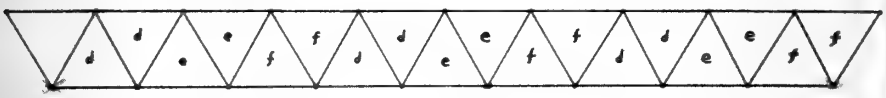
Living in the Antarctic with icefishes are other kinds of fishes that do make and use hemoglobin. Some biologists wonder how icefishes have survived in spite of this competition from fishes that might be able to move around more because they have hemoglobin.

One possible explanation is that icefishes take in more oxygen through their skin than other fishes do. (In most fishes, nearly all of the oxygen is taken in through the gills.) Icefishes have few scales to block the movement of oxygen through the skin. The skin of some icefish species has a network of many tiny blood vessels, which probably take up oxygen from the water.

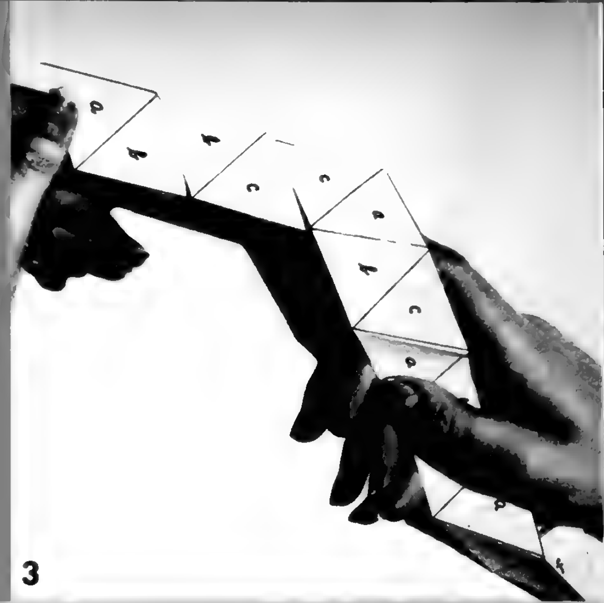
Scientists know that the surroundings of icefishes have a lot to do with their survival. What is still a mystery is whether these fishes have special body parts, or special body processes, that also help them survive without hemoglobin ■



1



2



3

HOW TO FLEX A HEXAGON

by Roy A. Gallant

■ One of the most fascinating paper puzzles ever to come out of a paste pot is one called *flexagons.* They were invented, quite by accident, by a young math student named Arthur H. Stone, about 30 years ago. Martin Gardner, the well-known mathematical puzzle expert, described how Stone stumbled onto flexagons, and how to make them, in the December 1956 issue of *Scientific American* magazine.

It all started when Stone began folding some long, thin scraps of paper in different ways. One pattern of folding in particular interested him. He kept working at it until he had developed a group of folded figures called flexagons.

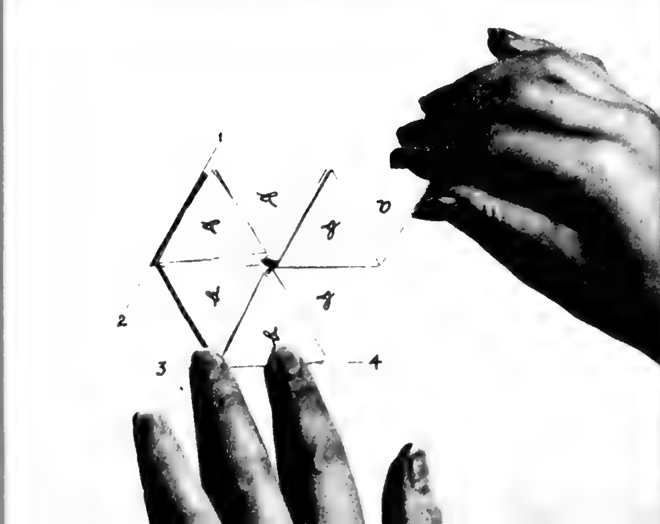
The particular flexagon described in this article is called a *hexahexaflexagon* (double-six flexagon, if you like)One reason for calling it a double six is that the completed figure has six edges and it folds open to reveal six different surfaces on which you can paint different patterns. As you begin to flex your flexagon, however, you will discover that more than six patterns turn up!

Making Your Hexahexaflexagon

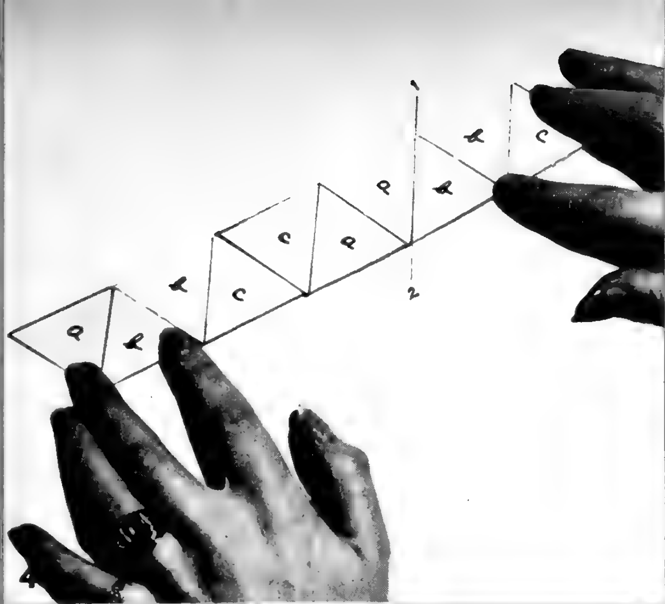
A sheet of heavy construction paper or thin cardboard (such as a file folder) is best to work with. The first thing you have to do is decide how large you want your flexagon to be. For example, if the triangles you draw are two inches along each side, your completed flexagon will be about four inches across. There are 10 triangles along the longer of the two edges of the strip, so to make a flexagon of that size, you must use a piece of cardboard or paper at least 20 inches long.

Start by drawing a line 20 inches long. Next, make a dot every two inches, *exactly,* along the line. It is *very* important that you measure and fold as accurately as you can.

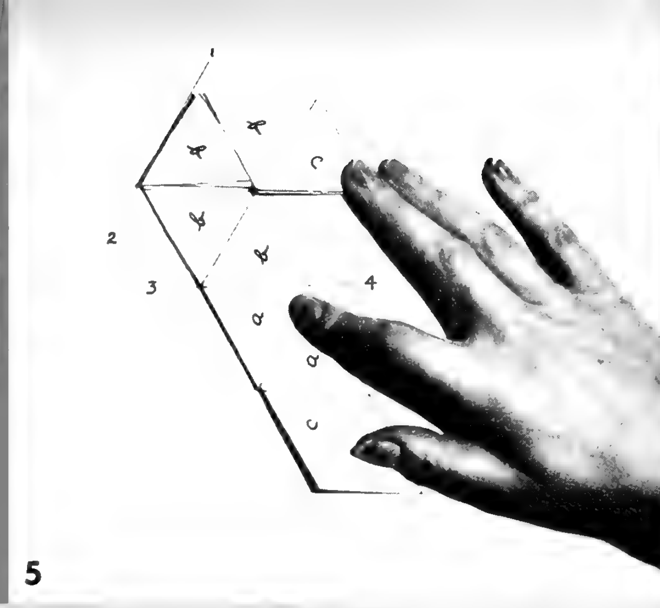
6



7



4



5

With a drawing compass or dividers set to a space of two inches, or with some such device, you can mark and cut out the strip of 19 triangles. Draw each line as shown. In pencil, lightly letter in each triangle, as shown in Photo 1. Make sure that your *abc, abc,* and-so-on side of the strip has one triangle left blank at the right-hand end.

Now flip the strip over so that it is in the next position, shown in Photo 2. This time lightly letter the triangles *dd, ee, ff, dd, ee, ff,* and so on, as shown, leaving a blank upside-down triangle at the far left.

Next comes the tricky job of folding the strip *(see Photo 3).* Fold it over and over so that you end up with the letter sequence *ab, bc, ca, ab, bc (see Photo 4).* Notice that the letters are now sideways. Now fold the shortened strip under along line 1-2, so that you end up with the folded-over strip *(see Photo 5).* Make sure the blank triangle is positioned as shown. You make the final fold by another underhand fold, this time along line 3-4 *(see Photo 6).*

Now you should have the nearly completed flexagon with six *b*'s showing on one side and with an *a* triangle left sticking out. Fold the *a* triangle over and glue its blank side to the blank triangle on the reverse side of the flexagon. When you have done that, there should be six letter *a*'s on the opposite side.

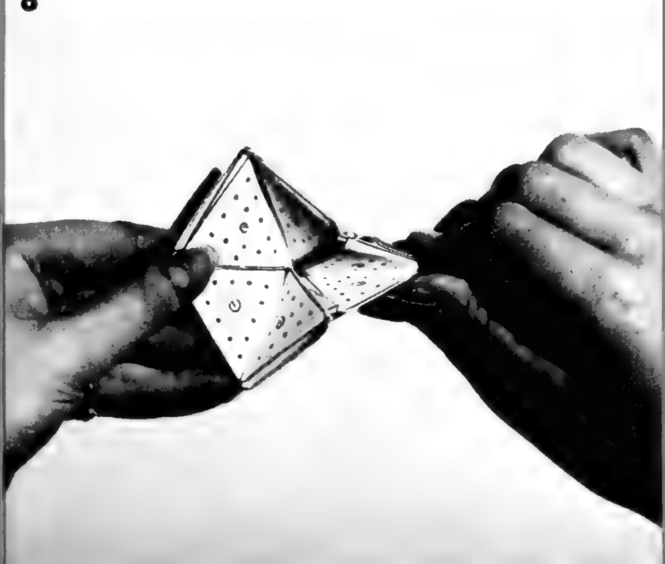
Now you are ready to decorate your hexahexaflexagon. Our cover illustration shows some patterns we made up, but you may want to make patterns of your own, using many different colors. Begin by decorating surface *a* and surface *b*.

When you have finished, you will be ready to flex your hexagon. Pinch two triangles together *(see Photo 7),* and with the other hand ease the flexagon open *(see Photo 8)* so that a new (blank) surface is exposed *(see Photo 9).* If the flexagon won't flex on the first try, it may be because you happened to pinch the wrong triangles together. Try two others. If you select the right ones, and if you have followed all instructions carefully, your flexagon flower will open and there will be surprises in store for you ■

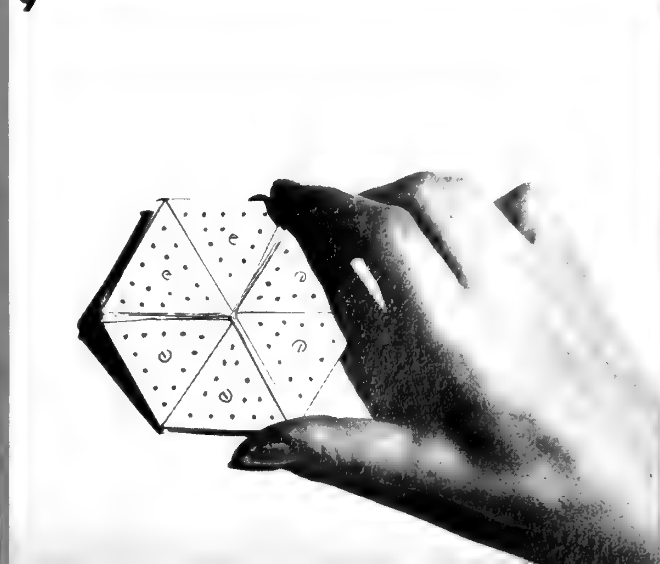
PROJECT

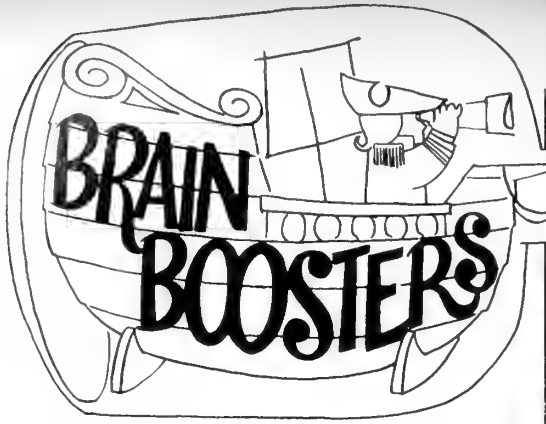
Once your flexagon is "broken in," you will find that surfaces a, b, and c turn up more often than surfaces d, e, and f. See if you can work out a system in which all six surfaces turn up in only 12 flexes. (There is a foolproof way.)

8



9





prepared by **DAVID WEBSTER**

MYSTERY PHOTO What is it?

WHAT WILL HAPPEN IF . . .

. . . you freeze a pan of milk? Will the milk become solid like ice? What does the milk taste like when it is thawed out?

CAN YOU DO IT?

Can you drop a coin onto a flat surface so it stays on its edge for a few seconds?

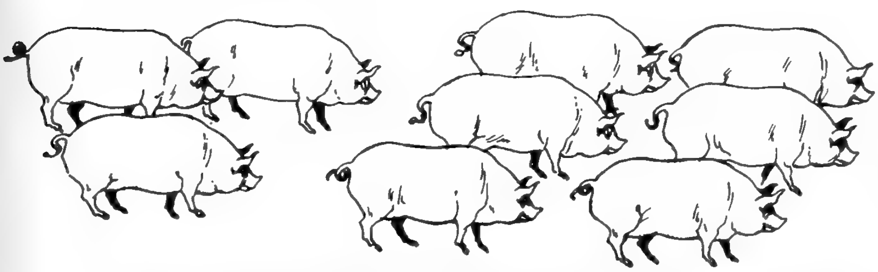
Submitted by J. S. Kessler, South Orange, New Jersey

FOR SCIENCE EXPERTS ONLY

The main span of the Verrazano Bridge, connecting Brooklyn and Staten Island, New York, is about 4/5 of a mile long. Why are the two 800-foot-tall towers that support the span 1⅝ inches farther apart at the top than at the bottom?

FUN WITH NUMBERS AND SHAPES

Put these nine pigs into four pig pens with an odd number of pigs in each pen.



JUST FOR FUN

Here is how to write invisible messages. Stir a teaspoon of cornstarch into a glass half full of water. Dip a matchstick into the mixture, and use it to write some words on a piece of paper. (You must dip the match into the starch mixture after each letter.) Allow the letters to dry for about 20 minutes. While you are waiting, add five drops of tincture of iodine to a small glass of water. To make the writing appear, wet the paper with the iodine solution.

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: As the tide came in, waves carried floating seaweed farther and farther up on the beach. When the tide began to go out, the seaweed was left on the beach at the high-tide mark.

What would happen if? The platforms will always balance if they carry equal weights, no matter how the weights are moved. What would happen if the two weights were unequal?

Can you do it? If the ice cube is large, it almost always drifts slowly from the center of the glass and touches the sides. You can make it stay longer in the center by adding some soap to the water. Why does the soap help to keep the ice from moving to the side of the glass?

Fun with numbers and shapes: 1-1/6 is a number that can be added to 7 or multiplied by 7 to give the same answer.

For science experts only: Blood in a vein is blue because it does not contain much oxygen. When you bleed from a vein, the oxygen in the air mixes with the blue blood and changes its color to red.

Sunset for Saguaros?

■ A giant looms above you in the twilight gloom of a desert. Its great arms stretch out, seeming to clutch at you. You turn and run, but then see another giant, and another. You're surrounded.

In better light, you would see that the giants are big cacti called *saguaros* (pronounced suh-WAR-ros). These cacti are a symbol of the Southwest, though few grow outside of Arizona and Mexico.

The saguaro is a giant in trouble. In some parts of its range, there are no young saguaros growing to replace the giants that die. Biologists are trying to discover the cause of this problem, and determine whether anything can be done about it.

Seeds and Shade

Saguaros live as long as 250 years, and are at least 25 years old before they begin to produce seeds. Each red fruit contains about 2,000 tiny seeds, and a big saguaro may produce 60 fruits each year. With all these seeds, you might suppose that saguaros would have no trouble reproducing.

A biologist working for the National Park Service wanted to find out what happens to the seeds. In one test, he carefully counted out a thousand seeds and scattered them in a small area he had marked off in the desert. He wanted to see how many would sprout and how many would be eaten or lost in other ways.

His answer came quickly. Large red ants swarmed from a nearby underground nest and began carrying the seeds away for food. In about an hour not one seed was left.

Biologists are not surprised to learn that few saguaro seeds sprout, and that few seedlings live to be big cacti *(see page 8)*. In nature, those plants and animals that *produce* many young also *lose* many young. There isn't enough room in the desert for all saguaro seeds to grow into big plants. Also, there isn't enough water for more than, say, 60 big saguaros per acre of land.

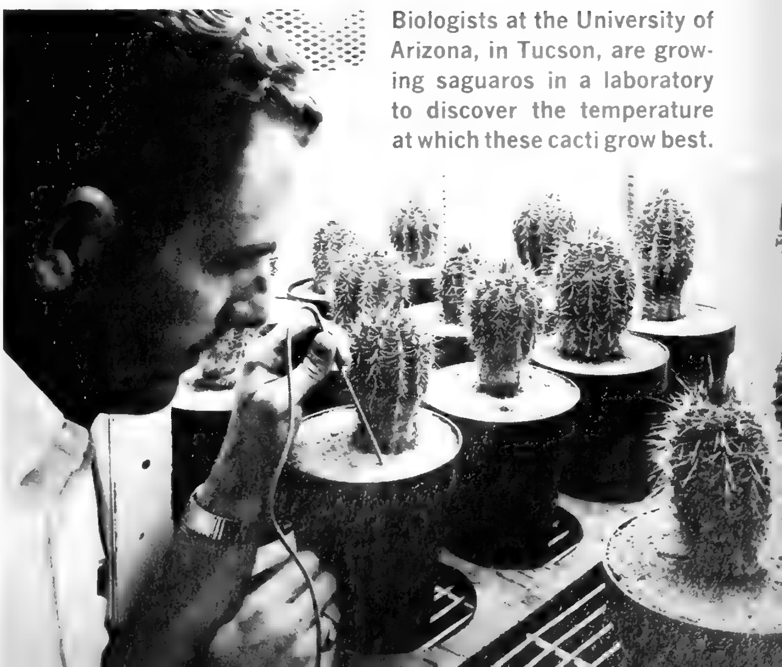
For the saguaros to survive, a new seed-producing plant must replace each seed-producer that dies. In some areas this is not happening.

There seems to be no single reason for the lack of young cacti. In some areas, too many cattle are allowed to graze on the land, and they trample young plants, including saguaros. Also, the numbers of woodrats and other animals that eat young cacti may have increased *(see page 8)*.

If these were the only reasons for the lack of young cacti, something could be done. The numbers of cattle and other plant-eating animals could be reduced. But saguaros may be getting scarce for another reason, one that man cannot change.

Over the world, the amount of rain and snow that falls each year is slowly decreasing. So far, this change in climate doesn't seem to bother the saguaros directly. In some areas, however, desert plants such as acacia and paloverde seem to be dying out because of a lack of water. It is in the shade of plants like these that young saguaros grow.

Could the loss of a bit of shade here and there in the desert lead to the death of all saguaros? Only time and more study of the desert giants will tell ■



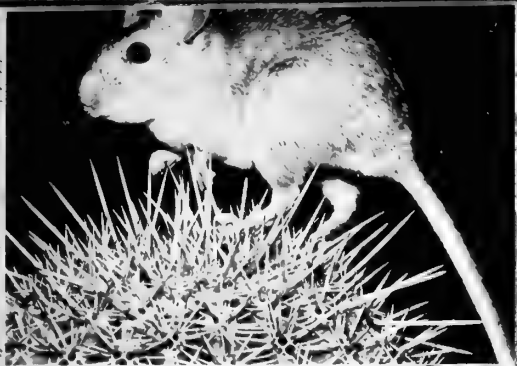
Biologists at the University of Arizona, in Tucson, are growing saguaros in a laboratory to discover the temperature at which these cacti grow best.

The tallest plants in the desert community, saguaros provide a safe nesting place for wary birds such as red-tailed hawks. The hawks catch plant-eating mammals such as rodents and rabbits to feed themselves and their young.

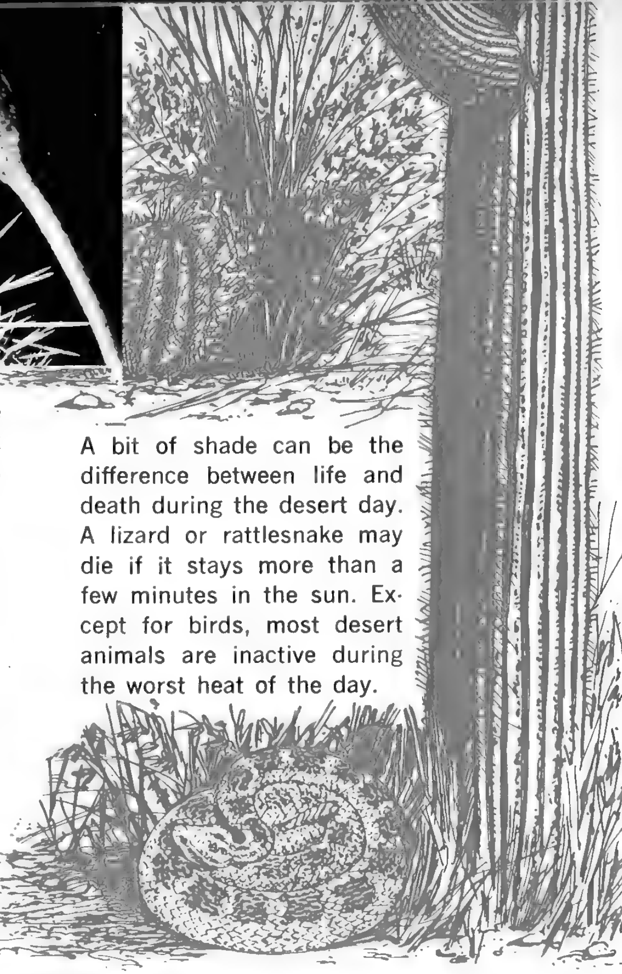
Saguaro flowers bloom for only a day or two, in the spring. If seeds are to develop from a flower, the pollen from another flower must somehow reach it. The pollen is accidentally carried from one flower to another on the bodies of bees, bats, and birds as they drink the sugary nectar in the flowers.

Woodpeckers chip out nesting holes high up the green trunk. The nest is abandoned after the young woodpeckers leave. From then on, the hole is home for many different animals. Insects find shelter there, and birds such as elf owls, purple martins, and sparrow hawks raise young in the holes.

Some kinds of insects cannot survive without the saguaro cactus. The saguaro moth lays its eggs only on this cactus. The moth also carries a bacterial disease that infects saguaros.



Each year a saguaro may produce more than 100,000 tiny black seeds. Most are eaten by rodents and birds. Some pass through an animal's body without being digested, and are spread about the desert in this way. Only those seeds that fall in a shady place have a chance to grow, and nearly all young saguaros are eaten by insects and rodents such as woodrats. One biologist estimates that just one out of every 275,000 saguaro seeds results in a mature plant that can produce seeds of its own.



A bit of shade can be the difference between life and death during the desert day. A lizard or rattlesnake may die if it stays more than a few minutes in the sun. Except for birds, most desert animals are inactive during the worst heat of the day.

desert winter by storing water during the brief summer rainy season. As its cells store water, the plant gets thicker and the "pleats" on its trunk spread apart. The cactus then gets thinner as the water is used. A waxy outer covering helps prevent the loss of water to the air.

Coyotes, hawks, and other *predators* (animals that kill others for food) help control the numbers of rodents and other mammals that eat young saguaros. If rodents become too plentiful, they may kill all the young saguaros, leaving none to replace the ones that die. This seems to be happening in parts of Arizona, and biologists suspect that the numbers of rodents have increased because coyotes and other predators have become scarce.

Life in a Cactus Forest

The king of cacti in the United States is the *saguaro* (pronounced suh-WAR-ro). It may grow 50 feet high and weigh 10 tons. In some places there may be 60 of these giants to an acre, creating a cactus forest.

This forest is like no other on earth. In a cactus forest there is no *canopy*, or top layer of leaves and branches. The ground is exposed to the full light and heat of the sun, then cools quickly at night.

Biologists are studying the *ecology* of the saguaro forest, trying to learn more about how living things there affect each other and their environment. They have discovered that many animals depend on the cacti for life, and that the saguaros themselves couldn't survive without certain plants and animals. The illustrations on this WALL CHART show some of the ways saguaro cacti affect, and are affected by, other living things in the desert community.

Unless you live in Arizona, you probably can't study the ecology of saguaros. But you can pick another kind of plant—a tree, or even a weed—and watch to see how other living things affect it and are affected by it. —LAURENCE PRINGLE

MEALWORM WATCHING

You and a mealworm respond to things around you. But do mealworms use the same senses, and respond to the same things?

■ From mushrooms to mackerel to man, all living things *must* respond to what is around them in order to survive. Hundreds of scientists around the world watch and investigate the responses of living things. What they learn can be used in many ways—to control insect pests, to keep animals thriving in captivity, to understand the human brain.

In this Science Workshop, you will be watching mealworms—caterpillar-like creatures that you may have used as fishing bait. You can find mealworms under a rotting log, but at this time of year, your best bet is a pet store. It probably has mealworms on hand because they are used as food for toads, chameleons, and birds.

Breakfast cereals such as corn flakes and wheat flakes make good food for mealworms. Put about half an inch of cereal into a glass jar, and add some mealworms. Keep the jar loosely covered. The mealworms live in the cereal.

Every few days, put in a piece of banana peel and some lettuce; this keeps the cereal moist. Don't let the cereal get too wet or it will get moldy.

Backing Up a Mealworm

Put a mealworm into the center of an empty shoe box or cigar box. The box should have smooth plastic tape around the rim, so that the rim is too slippery for the mealworm to climb over. Once the mealworm has started to move, try to make it respond to something in its path by backing up. There are several things that might make it do this: putting another mealworm in its path; holding a hot light bulb in front of it; blowing on its head; putting some cereal soaked in perfume in front of it; ringing a small bell in front of it.

Does a mealworm respond in the same way more than once? Do others respond in the same way? Keep a record of your observations on a chart like this one.

WHAT WAS DONE	TIMES TRIED	MEALWORM CONTINUED FORWARD	MEALWORM CHANGED DIRECTION
HOT BULB IN FRONT OF MEALWORM	5	1	4

Each method should be tried many times. When you have finished, see which method was most effective in making the mealworm back up.

Do Mealworms See?

Flash a beam of light at a mealworm in the test box. How does the light affect the behavior of the mealworm? Try flashing the beam on several more mealworms.

Place at least five mealworms in the test box, and cover the center with dark paper *(see Diagram A)*. After an hour, take off the paper. Are the mealworms in the parts that were open, or in the part that was covered?

Put a wooden block that is several inches thick in the center of the box. What does a mealworm do? Lay three pieces of cardboard in the box, with spaces between them *(see Diagram B)*. Does a mealworm avoid the obstacles, or bump into them?

Block a mealworm's forward motion by holding a mirror across its path. What does the mealworm do? Do the same thing with a piece of cardboard, instead of the mirror. Does the mealworm respond in the same way? Repeat the investigation several times. Do you think that mealworms respond to light? Do they see objects? Does a mealworm have eyes?

Feeling Their Way

Tap gently on the head of a mealworm with the tip of a pencil. How does the mealworm respond? With a straw, carefully touch a mealworm. What does it do? Touch different parts of the mealworm's body, and see whether the same thing happens. Blow through the straw, and see how the mealworm responds.

Watch a mealworm move in the empty box. Does it seem to know where the "walls" are? Scatter a little powder over the bottom of the box, and put the box in a dark place for about 30 minutes. Take it out, and look at the trails. Does a mealworm follow the walls? Does it need to see the walls in order to respond to them?

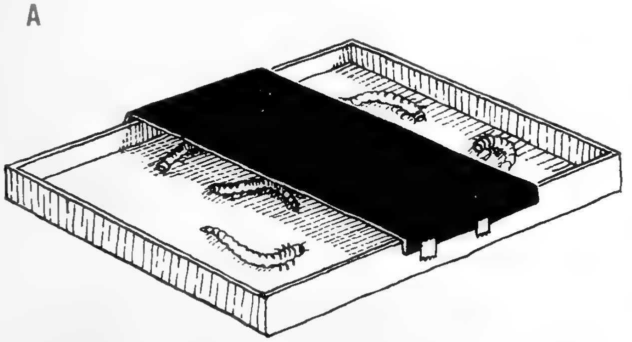
What Is a Mealworm?

The caterpillar-like creatures called mealworms look very different when they are adults. Mealworms, which hatch from eggs laid by darkling beetles *(see drawing)*, are the young form of this insect, called *larvae*. After weeks of nearly constant eating, the mealworms begin a period of little movement, called the *pupa* stage. During this time, they gradually develop into *adult* beetles. At a temperature slightly warmer than room temperature, the eggs develop into adults in four to six months. Many other insects have life cycles with these four stages. Do the adult darkling beetles respond to touch and light in the same way as the larvae did?

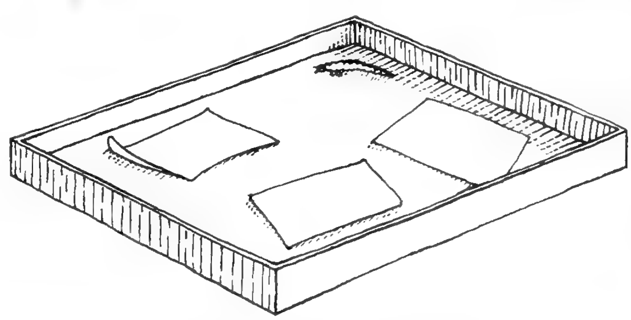
Look at the body of a mealworm through a magnifying glass. Does it have anything that might help it sense walls in the dark? You should be able to find a pair of pointed antennae on its head, hooks at the end of each leg, and "hairs" on the legs and the underside of the body. One or more of these structures could sense touch. Through the magnifying glass, watch several mealworms move. How do they sense where the wall is?

Cover half the bottom of the test box with about an inch of cereal, and put some mealworms in the empty part, near the cereal. Leave the box in the light. After 30 minutes, where are the mealworms? Can you figure out why they move where they do? Some possible reasons might be the darkness, the odor, the weight of the flakes on the mealworms, and the food around them. What other investigations could help you decide? ■

A



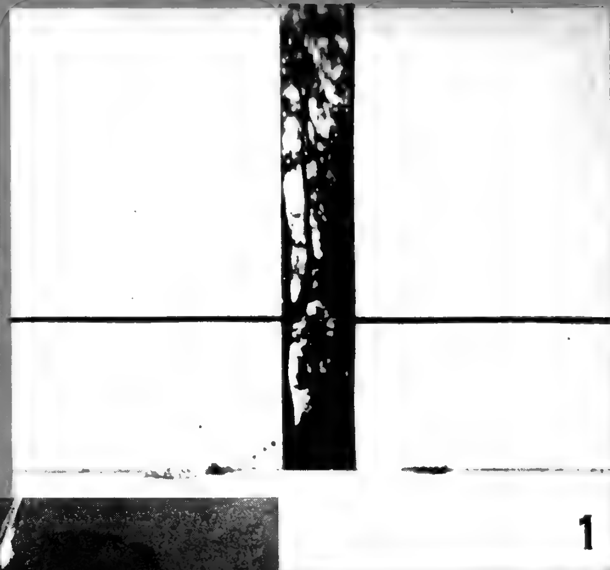
B

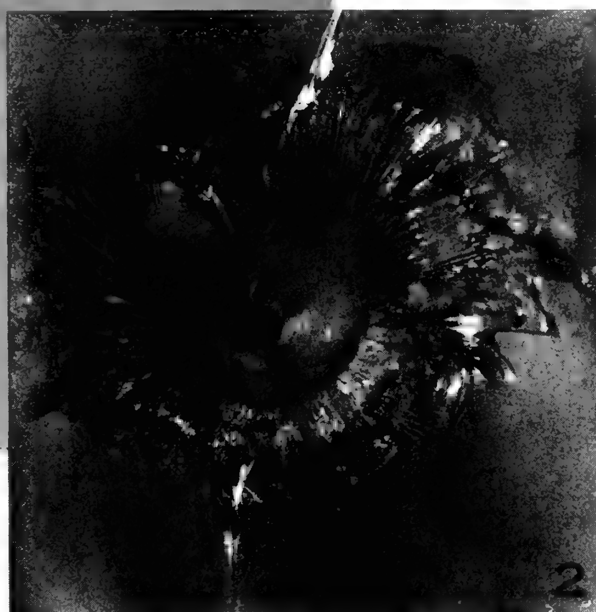


MYSTERY PHOTO

CONTEST WINNERS

Here are some of the winning photos that were sent in for the Mystery Photo Contest announced in the October 13, 1969 issue of *Nature and Science*. Each of the winners received a $10 prize. Can you guess what the photos show?


1


2


3


4

Here is what the mystery photos show:

1. Two squash courts (*from Roy Mittelman, New York, New York*).

2. BB hole in a pane of glass (*from Kurt Henize, Houston, Texas*).

3. Front view of a tobacco pipe (*from Karl Franzen, Burlington, Massachusetts*).

4. Magnified view of an adhesive bandage (*from Dirk Iwema, Grand Rapids, Michigan*).

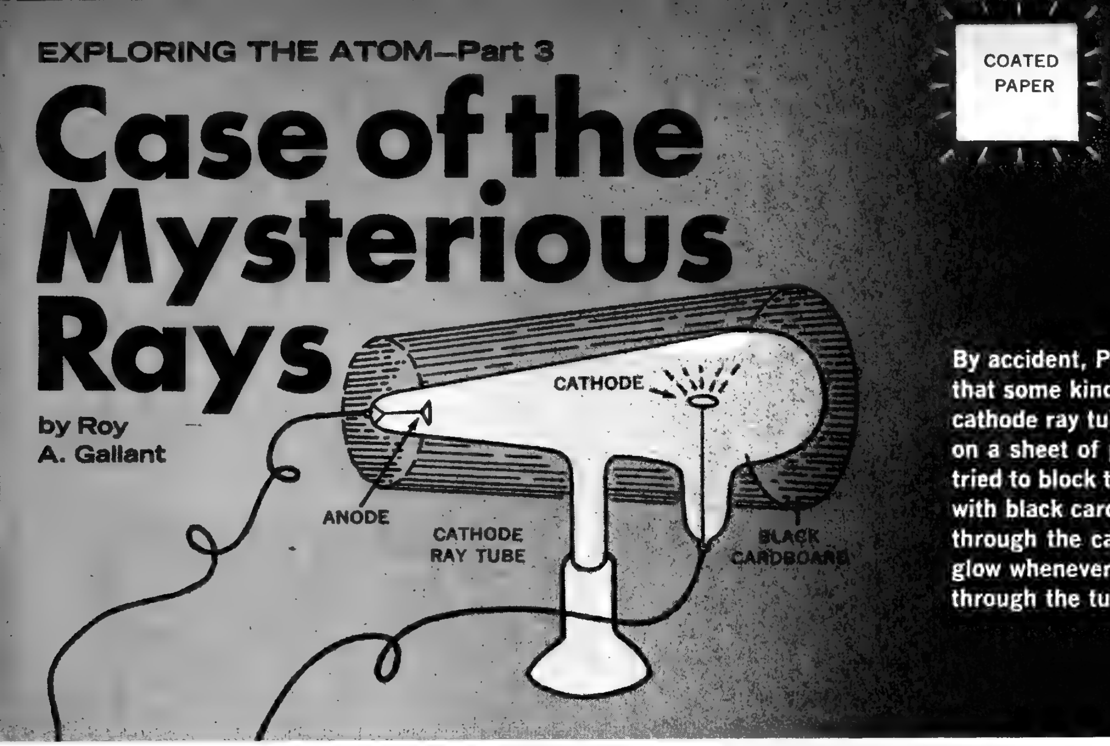
5. Magnified view of a soda cracker (*from Richard Iwema, Grand Rapids, Michigan*).

Other contest winners whose photos could not be shown are: Nick Bauer, Kirkwood, Missouri; Elizabeth Doucett, Olean, New York; Cary Gore, Lincoln, Nebraska; Marie Guinto, Brooklyn, New York; Nicholas Ritter, Union, Missouri.

EXPLORING THE ATOM—Part 3

Case of the Mysterious Rays

by Roy A. Gallant



By accident, Professor Roentgen discovered that some kind of invisible rays from a cathode ray tube made the chemical coating on a sheet of paper glow with light. He tried to block the rays by covering the tube with black cardboard, but the rays passed through the cardboard and made the paper glow whenever electricity was flowing through the tube.

In Part 2 of this series of seven articles, the author told how J. J. Thomson and Ernest Rutherford discovered that atoms are made up of electrons circling about a central core. In this article, he tells how another scientist discovered that atoms of uranium are powerful sources of energy, a form of energy that later was to be called radioactivity.

■ The time was 1896. The place, Vienna, the capital of Austria. A newspaper story, which soon found its way onto front pages of other newspapers the world over, startled many readers.

According to the report, a German professor had found a way of making photographs of hidden things. Even the bones inside living animals could be photographed. Surgeons, in particular, were interested in the new discovery. They now had an important new way of "seeing" a patient.

The German scientist was Wilhelm Conrad Roentgen, a professor at the University of Würzburg. Roentgen had been experimenting with cathode ray tubes much like the ones that the British scientist J. J. Thomson had been using in his investigations at the same time *(see "Exploring the Atom—Part 2,"* N&S, *February 2, 1970).*

These tubes *(see diagram)* were glass globes with most of the air pumped out. When electricity flowed through the tube from the *cathode,* or negative plate, to the *anode,* or positive plate, a stream of invisible "rays" from the cathode made the glass glow wherever the "rays" struck the tube wall. (It was not until 1897 that Thomson discovered that these invisible "rays" were not rays at all, but instead were tiny particles—*electrons*—moving away from the cathode at high speed.)

Thomson used tubes made of English lime glass, which glowed with a green light. Roentgen used tubes made of German lead glass, which glowed with a blue light.

Discovering a New Kind of Rays

Roentgen's main interest was in the *glow.* No matter what part of a tube lit up with the bluish glow, some kind of rays were given off from the area that glowed. Roentgen discovered these rays almost by accident. To get a better look at the glowing tube, he turned out the room lights and fixed a thin, black cardboard shield around the tube to keep out any stray light *(see diagram).* Off in another part of the room, there happened to be a sheet of paper coated with certain chemicals. Roentgen noticed that the paper sheet glowed each time the tube was turned on; but it did not glow when the tube was turned off.

He was surprised to find that the sheet of paper could be made to glow when it was moved into the next room. He decided that the electricity flowing through the tube gave off rays of some sort that passed through the glass and even through the thin wall of the room, and so caused the sheet of paper in the next room to glow. Roentgen did not know what these rays were. He called them *X rays.*

During all of November and December of 1895, Roentgen experimented day and night with the new rays. He found that they passed easily through thin and lightweight materials, but that thick and heavy materials could stop the rays.

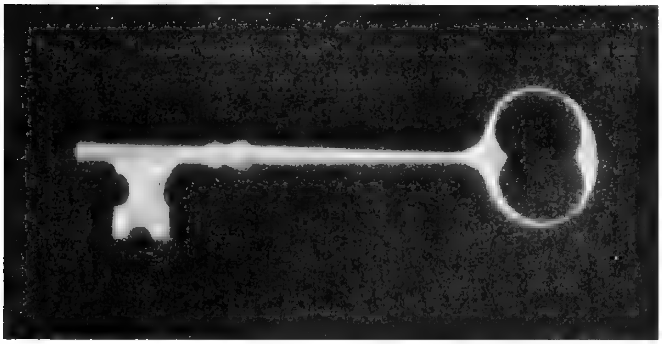
For example, in a darkened room he placed certain soft materials on a piece of photographic film and then aimed X rays at the film. He did the same thing with hard objects, such as metal keys and pieces of bone. In every case, the rays passed through the lightweight objects and exposed the film beneath them. But when he developed the film that was exposed with a key resting on it, he found an un-

(Continued on the next page)

exposed area the shape of the key where the key had blocked the X rays from reaching the film.

Announcing a Discovery

By Christmas 1895, Roentgen felt sure enough about his discovery of X rays to announce it to the world. When a scientist makes a discovery, he usually writes a complete report of his experiments, including any new ideas suggested by the measurements and other observations he made. He then has the report published in a scientific magazine, or he reads the report at an official meeting of some scientific organization. In that way, the scientist can feel pretty sure of being given the credit he deserves for making the discovery.



Roentgen placed a metal key on a photographic film in a dark room and aimed a beam of X rays at the film. The developed film showed an unexposed area the shape of the key where the X rays had been blocked from the film.

This X-ray photo of a human foot shows where a bone is broken. (X rays pass through flesh, but not through bone.)

There have been many times when a scientist made an important discovery but did not publish his report soon enough. A scientist in some other part of the world, who was doing the same kind of experimenting, published his report and got the credit for making the discovery, even though the other scientist made it first. There have been many bitter arguments in science over who was the "first" to make a discovery.

Roentgen did not waste any time. The Saturday after Christmas he had his report printed, then on New Year's Day he mailed copies to many of the leading scientists in Europe. With each copy, he sent X-ray photographs he had made. The copy that was sent to Vienna reached a newspaper editor. The newspaper stories that followed made Roentgen's name and discovery known the world over.

Act 2: The Scientist Who Reported Too Soon

The next act in this science drama takes place in Paris only 19 days after Roentgen had mailed his report. One of the scientists in the audience listening to a report about Roentgen's X rays was a French physicist named Henri Becquerel. The more he thought about the exciting discovery, the more he began to wonder about it.

What interested him most was that the X rays came from that part of the glass cathode ray tube that glowed. Such a glow is called *fluorescence*. Becquerel had known about other substances that were *fluorescent,* or glowed when exposed to ordinary light. Could it be, Becquerel asked himself, that other substances that are fluorescent also give off X rays?

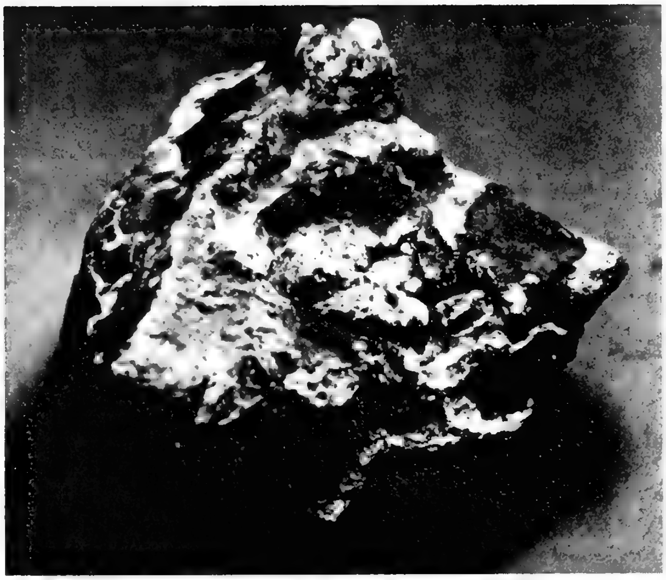
Here is an excellent example of how the work of one scientist can give someone else a new idea to investigate. Becquerel had asked an important question. His next task was to experiment and try to find an answer.

One day he was experimenting with some crystals of a substance made of potassium, uranium, oxygen, and sulfur. For some time, Becquerel had known that such crystals glowed when they were bathed in ultraviolet light. (Ultraviolet light is the part of sunlight that causes sunburn; its waves are too short to be detected by human eyes.) To find out if the crystals gave off X rays when they were made to glow, here is what Becquerel did:

First, he wrapped a sheet of unexposed photographic film in heavy black paper to protect it from the light. Next, he scattered several of the crystals on top of the paper and put the film package outside his window in the sunlight. The ultraviolet light from the sun made the crystals *fluoresce,* or glow. After several hours, Becquerel brought the package inside and developed the film. On it, he saw gray smudges in the exact places where the crystals had been resting above the film!

Finally, it seemed, he was getting somewhere. He tried the same thing several times more. One time he would place a coin beneath one of the crystals. Another time he would place beneath the crystals a piece of metal with holes punched through it. Each time, he found a grayish patch on the developed film in the shape of the object the crystals had been resting on. On February 24, Becquerel read a report of his discovery to the French Academy of Sciences. In it, he said that he had discovered an X-ray-like ray that was produced by light.

The experiments seemed foolproof. He had started with the idea, or *hypothesis,* that X rays are a regular part of fluorescence. His experiments then turned up exactly what he had predicted would happen. A beautiful piece of scientific thinking and experimenting—but completely wrong!



Ultraviolet light (which you can't see) made certain minerals in this rock *fluoresce,* or glow, with a blue light that appears white in this photo. When Becquerel detected X rays coming from a fluorescing rock, he mistakenly thought the X rays were caused by the ultraviolet light that was making the rock fluoresce.

X rays without Light

Three days later, Becquerel discovered that he had been wrong. He was carrying out more of the same experiments, but the weather turned cloudy and dark. Annoyed, Becquerel put one of the film packages he had carefully prepared into a drawer and tossed some of the crystals containing uranium on top of the wrapping. Then he closed the drawer. Surely, the film would be safe from all light there, Becquerel thought. And the crystals could not possibly glow since ultraviolet light could not get to them in the drawer. When it turned sunny again, he would then take the film package out into the light, as before.

But Becquerel grew impatient. During those few cloudy days he decided to develop the film anyway. Imagine his surprise when he found patches on the film that were much sharper and darker than before.

Somehow, even without light, the crystals were giving off rays of their own. Becquerel repeated the experiment many more times. Each time, the same thing happened. No matter how long the crystals were kept in pitch dark—hours, days, or weeks—they still gave off the mysterious rays.

Becquerel tested different kinds of fluorescent substances, one after another. Those that were made of calcium or zinc, for instance, did not give off the rays. But every substance he tested that contained uranium did give off the rays. Uranium seemed to be the key substance. To make sure, Becquerel next used the film test on substances that contained uranium but were not fluorescent. Each of these substances gave off rays that exposed the photographic film.

Becquerel now knew that neither visible light nor ultraviolet light was needed to make the uranium give off rays. Somehow, the uranium was giving off rays all the time. Becquerel heated and melted his uranium substances, wondering if that would destroy the rays. It didn't. The melted substances, in liquid form, still gave off rays.

Becquerel was anxious to find out whether pure uranium would give off stronger rays than a substance that was only part uranium, but no one had yet managed to separate pure uranium from the rocks that contained it. A few months later, in May 1896, a chemist Becquerel knew succeeded in separating uranium from its ore.

When Becquerel placed a lump of the pure uranium metal on a piece of film wrapped in heavy black paper as before, the results were the same. But this time the rays were the strongest ever. There could be no doubt now. Uranium was a storehouse of energy and gave off rays, in the dark as well as in the light.

Becquerel, given an idea by Roentgen, an unknown scientist in another country, had made an important discovery about matter. It was a discovery that was to help other scientists come still closer to an understanding of what atoms are, how they "work," and some of their hidden dangers ■

Part 4, in the next issue, tells how the French physicist Marie Curie and her husband contributed to the discovery of energy in atoms.

WHAT'S NEW

by
B. J. Menges

To tame a hurricane, try flying into the storm and "seeding" it with silver iodide crystals, suggest some scientists. Water droplets should form around the crystals, and freeze. In freezing, water releases heat. If enough heat is released from a hurricane, the storm will lose much of its energy. The weakened storm will then do less damage and take fewer lives.

Weather scientists have been trying to test this theory since 1956. They managed to seed two storms on a small scale in 1961 and 1963, but the results were unclear. Last August the scientists tried again. After one seeding, a storm's winds dropped in speed from 113 to 78 miles an hour, a decrease of 31 per cent. After a second seeding, wind speed slowed by 15 per cent. This year scientists hope to seed at least two more hurricanes to test the theory further.

Noisy cars and trucks are the targets of a new noise detection system being tested in Connecticut. The system provides evidence that could be used against a noisemaker in cities or states where there are laws against noise above a certain level. Here's how the system works:

Microphones along a highway detect the noise made by each car as it passes, and send signals to a recorder. If the noise is above the legal level, a camera snaps the car's picture. Also in the picture is a graph showing the car's noise level. A signal then goes out to a trooper down the highway. Result: a ticket—or at least a warning—for the noisemaker.

The coldest place in the world was once warm. Near the South Pole in Antarctica, where temperatures as low as about 127 degrees below zero Fahrenheit have been recorded, scientists have found the fossil remains of plants and two animals. One of the animals was a salamander-like creature, the other was a reptile; both were about three feet long. These plants and animals lived a few hundred million years ago, and could have survived only in a mild climate. In fact, they were similar to plants and animals that lived about the same time in Australia, South Africa, India, and South America.

It's not likely that similar plants and animals would have developed separately on continents far apart from one another. So the fossil finds strongly support the idea that Antarctica, Australia, Africa, India and South America were joined together as a supercontinent until about 250 million years ago, when they split up and slowly drifted apart to their present positions.

Have moon rocks fallen onto the earth? Scientists thought that glassy rocks called *tektites* had been formed and hurled to the earth 700,000 years ago, when a huge meteor crashed into the moon and created the 56-mile wide and 9-mile deep crater called Tycho. They had even figured out the paths that tektites might have followed in their 240,000-mile flight from the moon to the earth. And some tektites seemed to be similar to rock tested by the Surveyor VII space probe on Tycho's rim in 1968.

But now scientists are doubtful about the tektites' origin again, because glassy beads that the Apollo 11 astronauts brought back from the moon do not have a mineral makeup very similar to that of tektites. While the "moon beads" contain minerals found on earth, tektites are much like granite, which has not been found on the moon. So scientists are not so sure how or where the tektites may have been formed. One other theory is that heat from great explosions on earth ages ago may have formed the round, glassy objects.—RJL

London's famous fogs are becoming less of a problem. The thick "pea-soupers" that covered the city regularly for six centuries now appear only three or four times a year. The turning point came in 1952, when a smoke-laden fog blanketed the city for four days and killed about 12,000 people, most of whom had diseases that made it hard for them to breathe even under normal conditions.

This shook Londoners into taking action they had put off for years. They banned the burning of soft coal in fireplaces and stoves, thus cutting down the smoke and soot that were a major cause of the fogs. They also forced industry to reduce smoke from its factories. As a result, Londoners are seeing more sun this winter, and even hearing more birds. Songbird species last seen in London a hundred years ago are returning to the city—apparently because they find the air more "liveable" now.

These photos of the same marsh marigolds were made with ordinary film *(left)* and with film that is especially sensitive to ultraviolet light *(right)*. Ultraviolet light is a part of sunlight that is invisible to humans and many other animals *(see "How Light Affects Life,"* N&S, *January 19, 1970)*. Scientists believe that honeybees and some other insects are able to see the ultraviolet light that is reflected by some objects. So the photo at right shows how the marsh marigolds might appear to a honeybee. This "hidden" pattern may be important to the reproduction of the marigolds. The dark centers of the flowers might be "targets" for bees that can pollinate the flowers while gathering nectar from them.

nature and science

TEACHER'S EDITION

VOL. 7 NO. 12 / MARCH 2, 1970 / SECTION 1 OF TWO SECTIONS

Involving Children with Their Environment

by Susan C. Stone and Frances D. Quinn

Open space . . . visual pollution . . . a dirty little stream . . . all this and much more is the concern of the articles on pages 6-10, a sort of "environmental primer" for your pupils. Here, in pages 1T-3T, the authors explain why better planning of our communities is needed, and how to awaken your pupils to the processes that now shape the places where they live.

■ "Youth Finds New Cause: End World Pollution," announces a newspaper headline. And every day more articles describe more ways in which we have been poisoning our planet and ourselves. Public concern grows, at least about the pollution problems that are in the news. But there are other kinds of pollution affecting us every day, about which we hear far less.

Scientists can measure the point at which carbon monoxide from automobile exhausts becomes harmful to human health. Audiologists can measure the point at which prolonged noise causes loss of hearing. We cannot yet, and may never, accurately assess the damage to human beings caused by living in congestion, confusion, chaos, or just dull drabness. But the toll of *visual* pollution, or "sight blight," is as real as that of monoxide poisoning.

In his book *The Human Zoo,* Desmond Morris writes: "Our monkey house is one of our own making, defined as today's urban sprawl. Man has demonstrated that he can survive under these conditions, but only at the cost of desolating loneliness, blocked social instincts, boredom alternating with over-stimulation, and constant encounters with high stress situations. Hence, urban man exhibits the zoo syndrome."

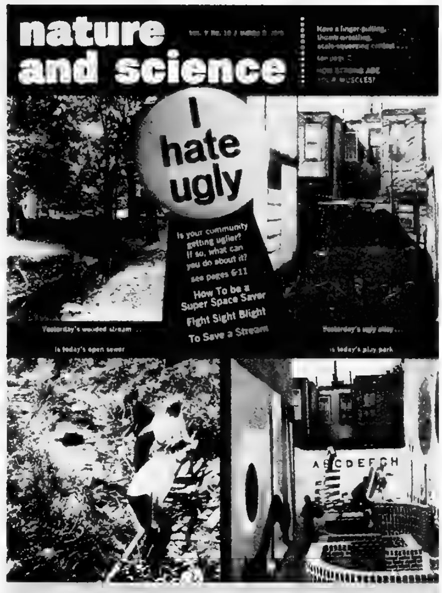
We have words to describe the visual characteristics that we recognize and dislike about urban and suburban America: "ticky-tacky," "slurb," "sprawl." They suggest an absence of form and definition, a lack of character; a shapeless, depersonalized, and dehumanized growth.

The 1968 report of the President's Council on Recreation and Natural Beauty states: "Much of the Nation's environmental deterioration can be attributed to the fact that most Americans are ill-equipped by their education [and by the examples they have at hand] to understand and influence the forces acting on the immediate world around them . . . The Council recommends that . . . local school systems establish environmental education programs."

Although more people are going to museums and art galleries than ever before, most Americans suffer in their daily lives from "esthetic anemia." As a result, they are lulled into a non-seeing state, or they just accept the ugliness they see.

(Continued on the next page)

Susan C. Stone is a founder and past chairman of the Champaign County Development Council Foundation, and former consultant on school-park planning for the Urbana (Illinois) School District. Frances D. Quinn has taught at all levels of elementary school and is a member of the board of directors, currently in charge of public information, Champaign County Development Council Foundation. Together, the authors are preparing a book on environmental awareness, tentatively titled Where I Live Is Important to Me, *for use in the upper elementary grades.*



IN THIS ISSUE

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

IN THE NEXT ISSUE

How biologists study the strange relationships of birds, butterflies, and milkweed . . . Investigating color pigments by chromatography . . . Ideas about what reverses the earth's magnetic poles . . . Are all forest fires "bad"? . . . How scientists use radioactive atoms.

Involving Children . . .
(continued from page 1T)

But what about the children? How can we nurture, sharpen, and shape their environmental awareness? How can we get them to look outside museums for qualities found in works of art: form, scale, balance, harmony, variety, rhythm, color, texture? How can we show them that communities can be shaped by design instead of by default? *(See page 3T.)*

A Different Kind of Beauty Contest

Where a child lives is the most important place in the world to him. Because of this, it is the best place to begin to teach him environmental awareness—to help him learn about the parts that make up the vital whole of a city or neighborhood that is a good place to live; to establish standards by which he can judge his environment; and to help him to know the conditions, laws, professions, and processes that shape it.

In one community, Champaign-Urbana, Ill., a citizens' group became concerned with improving the quality of the community's environment. The Champaign County Development Council Foundation took a first step toward an environmental education program by sponsoring an "environment contest" for upper elementary school children. The purpose was to stimulate an awareness of the children's surroundings—the "good," the "bad," and possible alternatives. Pupils were asked to make a picture of a favorite place that they thought added beauty to the community, and they were asked to explain their choice. They were also given the option of drawing and describing a place they particularly disliked. The "environment contest" was voluntary, not an assignment.

The range and depth of responses suggest that this is one approach to developing environmental literacy among children of *any* community. When asked to observe, the children really did get out and look, and they knew *what* they liked and disliked, although their analytical abilities varied:

PHOTO BY R. KATZ

The wide sidewalk, trees, and sitting places provide a pleasant approach to this landmark, Park Street Church in Boston. Notice that utility poles and wires, and big signs and billboards are missing. This approach was planned to meet the needs of people more than the needs of automobiles or private businesses.

"You can call this place anything you like *except 'good'!*"

"This park is the only place where there are things to *do*."

"This place is on the beam. It gives our town a certain gleam."

"Help, help. Please! This summer. Please, somebody help this park!"

Because they combine loyalty and affection for their home communities with a sense of discrimination, children can learn to become what John Gardner has called "loving critics and critical lovers." With some guidance now, as adults they may be able to do a better job of city-building and rebuilding than we have done.

Teaching environmental awareness is both a challenge and an opportunity, because it cuts across so many curriculum boundaries—science, social studies, history, art, and others.

Get Help from Experts

The books listed at the end of this article will give you background information on the planning (and non-planning) of cities, the choices available, and the values of well-planned open spaces in communities. You can also get information (and perhaps classroom visits) from city planners, architects, park naturalists, and many others who work with or who help shape your community and its open space.

Depending on the makeup of your class, perhaps you should not assume that all of your pupils value open space and trees. You might assess their attitudes with an "environment contest" like the one held in Champaign-Urbana. You might also draw them out by discussing quotes like these:

"When we try to pick out something by itself we find it hitched to everything else in the universe." (John Muir)

"Ugly towns breed ugly tempers." (Russell Kirk)

"For us to love our country, our country should be lovely." (Edmund Burke)

Eventually, a list of the values of open space might evolve, along with another list of the open spaces—real or potential—that exist in your community (see list on page 3T).

For Your Reading

- *Design with Nature,* by Ian McHarg, Natural History Press, Garden City, New York, 1969.
- *The Last Landscape,* by William Whyte, Doubleday & Company, Inc., Garden City, New York, 1968.
- *Small Urban Spaces,* edited by Whitney North Seymour, Jr., New York University Press, New York, 1969.
- *Open Space for Urban America,* by Louise Strong, available for $1.50 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
- *God's Own Junkyard,* by Peter Blake, Holt, Rinehart and Winston, New York, 1964. *(Continued on page 3T)*

What Do They Do?

Have your pupils investigate the role each of the professions listed here might have in planning and preserving the environment of a community.

architect	hydrologist
biologist	landscape architect
builder	lawyer
civil engineer	psychologist
ecologist	sanitary engineer
economist	sociologist
geologist	urban planner

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.

Involving Children . . . *(continued from page 2T)*

- *Cities,* by Lawrence Halprin, Reinhold Publishing Corp., New York, 1963.
- *Urban Design: The Architecture of Towns and Cities,* by Paul Spreiregen, McGraw-Hill Book Company, New York, 1965.

Films and Film Sources

- *No Time for Ugliness,* produced by the American Institute of Architects, 1965, 16mm. color, sound, 28 minutes. Available from Sterling Educational Films, Inc., 241 E. 34th Street, New York, New York 10016.
- *Films, Filmstrips, Slides and Audio Tapes on Housing, Community Development,* a list available from the United States Department of Housing and Urban Development, Washington, D.C. 20410 ■

Cities by Design or by Default

Cities are, and always have been, settlements of and for *people*. They provide places for people's living, working, and leisure needs. And people have changed very little in the last 2,500 years. The contemporary Greek architect-planner, Constantinos Doxiadis, points out that today's man is like his counterpart in ancient Athens in at least one important way. Today's man prefers to walk to places not more than 10 minutes away from his starting point, and, when he looks around, he can only understand the size of things in relation to himself within one mile of where he stands. Thus, *man's* scale has not changed. This basic fact has been overlooked in most city-building.

Many of today's cities and buildings leave us feeling uncomfortable, overwhelmed, and helpless. The ancient Romans *intentionally* built large buildings and monuments in their cities to impress and frighten people with the might of imperial Rome.

PHOTO BY SUSAN C. STONE AND FRANCES D. QUINN

In this architect's office, the silhouette of a man on the wall is a reminder that man is the main "client" for whom buildings and cities are designed.

The cities that people love, feel at home in, and go to visit with anticipation are essentially cities that can be *understood*. They may be vast in their totality, but they are divided into distinct districts or neighborhoods of comfortable size and scale, and they are cities to be *walked* in. They are, as architect Kevin Lynch says, "legible." What gives legibility and form to a city, says Lynch, is the arrangement of its structure or skeleton, which is composed of the following five parts:

1. *Pathways*—the major and minor roads and other ways of getting to and from places.
2. *Districts*—the sections of a city. These include residential, shopping, business, manufacturing, and other areas.
3. *Edges*—the ends of districts and their separations from other districts. Edges are often the weakest parts of the skeleton of a community, except where they are made by a natural boundary such as a river or ridge.
4. *Landmarks* — prominent visual features that are important not only of themselves but also to help let people know where they are, and in what direction they are going.
5. *Nodes*—concentrated centers of activity. They may also be landmarks. Rockefeller Center in New York is an example of a node.

Another checklist of community components might read: entryways, highways and streets, landmarks, homes and neighborhoods, parks, playgrounds and open space, water, places to gather together, places to be by yourself, places to shop, factories, farms, trees, and surprises (such as a hidden courtyard).

Getting Ready for "Second America"

The idea of a town as a *planned* and *designed* unit is as old in our country as the early colonists. William Penn planned his "greene countrie towne" of Philadelphia to ensure the maximum in beauty, health, safety, and convenience for all its citizens. When the new Federal City on the Potomac was proposed, George Washington hired an engineer-planner, Pierre L'Enfant, to design a city worthy of the new nation.

If, nearly two centuries ago, some leaders thought it necessary to control and shape the ways their communities grew, how much more we need today to plan, control, and even limit growth. The population of the United States is expected to double in the next 60 years. A "second America"—of houses, highways, schools, factories—must be built for this population. Today's children need to know more about how communities are planned—or unplanned—so that they can help bring "order, usefulness, and delight" to the places where they will live tomorrow.—SUSAN C. STONE and FRANCES D. QUINN

Some Kinds of Urban-Area Open Space

As your pupils assess the open space in their community, have them list areas now in use and potential ones—such as vacant lots—that could be made more useful. Some examples:

1. City parks and playing fields
2. School playgrounds
3. Town squares, city plazas, village greens and commons
4. Tree-lined streets, trails, and bike paths
5. Abandoned railroad, canal, and other rights-of-way
6. Vacant lots and alleys
7. Forest preserves and conservation areas
8. Nature centers and wildlife sanctuaries
9. Water and its edges (from drainage ditches to oceans)
10. Flood plains and wetlands (discuss why such areas are unsuited for urban development)
11. Agricultural land

Changing Poles

Place a bar magnet at the center of a small ball of clay, and have your pupils find the "North Magnetic Pole" of this "model earth" (where the north-seeking end of a compass needle points straight toward the center of the ball). Mark that point "N", cut the ball in half, turn the magnet end-for-end, and put the "earth" back together. Where is its "North Magnetic Pole" now?

If your pupils are not yet familiar with magnets and compasses, have them: 1) find the north-seeking end of a bar magnet *(see "Three Kinds of 'Poles'," page 4)* and mark it with crayon or sticky tape; 2) manipulate two bar magnets to see how their "like" poles repel each other and their "unlike" poles attract each other; 3) move a compass around a bar magnet to see how its needle lines up with the lines of magnetic attraction surrounding the magnet *(see photo, page 5)*.

Exploring the Atom

Once your pupils understand "How a Uranium Atom Changes into an Atom of Thorium" *(see page 14)*, you can help them work out most of the rest of the steps in which radioactive uranium^{238} gradually *decays*, or changes, into an atom of stable (non-radioactive) lead^{206} *(see table below)*.

Have them copy on a chalkboard or lined pad the headings and the first two lines of the table on page 14. Point out that the "new"atom of thorium^{234} decays by giving off a beta particle. A beta particle is an electron, and since electrons weigh hardly anything at all, the resulting atom will have the same *weight* (234) as the atom of thorium^{234}. However, when the thorium atom gives up an electron, one of its neutrons changes into a proton, so the resulting atom has one less neutron but one more proton than the old atom of thorium^{234}. This new atom is an atom of protactinium^{234}.

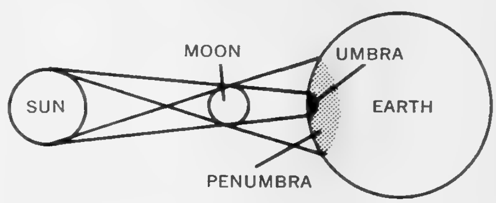
Now, tell your pupils that an atom of protactinium^{234} decays by giving off a beta particle. Have them try to figure out the weight and numbers of neutrons and protons of the resulting atom. Then give them its name: uranium^{234}. (They will find other atoms in this series that have the same names but different weights. Uranium^{238} and uranium^{234}, for example, are called *isotopes* of the element uranium. Some uses of isotopes will be described in Part 5 of "Exploring the Atom.")

From the kind of particle each atom gives off when it decays, your pupils should be able to figure out the weight and numbers of neutrons and protons of the resulting atom, and you can then supply its name from this table.

kind of atom	weight (mass)	neu-trons	pro-tons	particle lost
uranium ↓	238	146	92	α
thorium ↓	234	144	90	β
protactinium ↓	234	143	91	β
uranium ↓	234	142	92	α
thorium ↓	230	140	90	α
radium ↓	226	138	88	α
radon ↓	222	136	86	α
polonium ↓	218	134	84	α
lead ↓	214	132	82	β
bismuth ↓	214	131	83	β
polonium ↓	214	130	84	α
lead ↓	210	128	82	β
bismuth ↓	210	127	83	β
polonium ↓	210	126	84	α
lead	206	124	82	—

ECLIPSE OF THE SUN MARCH 7

On Saturday, March 7, the moon will pass between the sun and the earth, producing a brief partial eclipse of the sun where the *penumbra* of the moon's shadow passes over most of North America, and a total eclipse where the *umbra* of the shadow moves over a narrow strip of the East Coast *(see diagram). Caution your pupils not to look directly at the eclipse, as the sun's rays can cause blindness.* They can follow the eclipse along its *path of totality* by watching a telecast from 1 to 2 p.m. EST on stations of the CBS television network. (Check your local TV listings for station and time.)



Brain-Boosters

Mystery Photo. The photo is a closeup view of dry, cracked mud. The tiny "craters" were made by raindrops.

What will happen if? Your pupils will be surprised to see that when the hands are drawn apart, one hand will remain under the middle of the yardstick while the other travels all the way to the end.

When you begin to draw your hands together, one hand moves first because there is less friction between it and the yardstick than between the other hand and the yardstick. As the hand moves, however, it approaches the yardstick's *center of mass,* where all of the yardstick's weight seems to be concentrated. So the friction increases as the hand moves along, until there is *more* friction between that hand and the yardstick than between the stationary hand and the yardstick. Then the moving hand stops, and the other begins to move. The hands continue moving in this way, alternately stopping and starting, until they meet under the center of the yardstick.

When you then begin to spread your hands *apart,* one hand moves first, as before. But as that hand gets farther from the yardstick's center of mass, the friction between it and the yardstick keeps *de*creasing. So that hand keeps on moving to the end of the yardstick, while the other hand never "gets a chance" to move out from under the center.

Can you do it? A quick, jerking motion should make the bottom string break.

Fun with numbers and shapes. Line 4 is the continuation of the line below it, as your pupils can see by laying a ruler down on the page.

For science experts only. When a candle burns, it warms up the air around it, which then rises. Cooler air moves in to take its place, and this results in convection currents that keep a constant supply of fresh air moving around the flame. In the "weightless" environment of an orbiting spacecraft, however, the hot air would not rise. So the flame would go out as soon as the oxygen in the air immediately surrounding it became used up.

VOL. 7 NO. 12 / MARCH 2, 1970

nature and science

Have a finger-pulling, thumb-wrestling, scale-squeezing contest . . .

see page 2

HOW STRONG ARE YOUR MUSCLES?

I hate ugly

Is your community getting uglier? If so, what can you do about it?

see pages 6-11

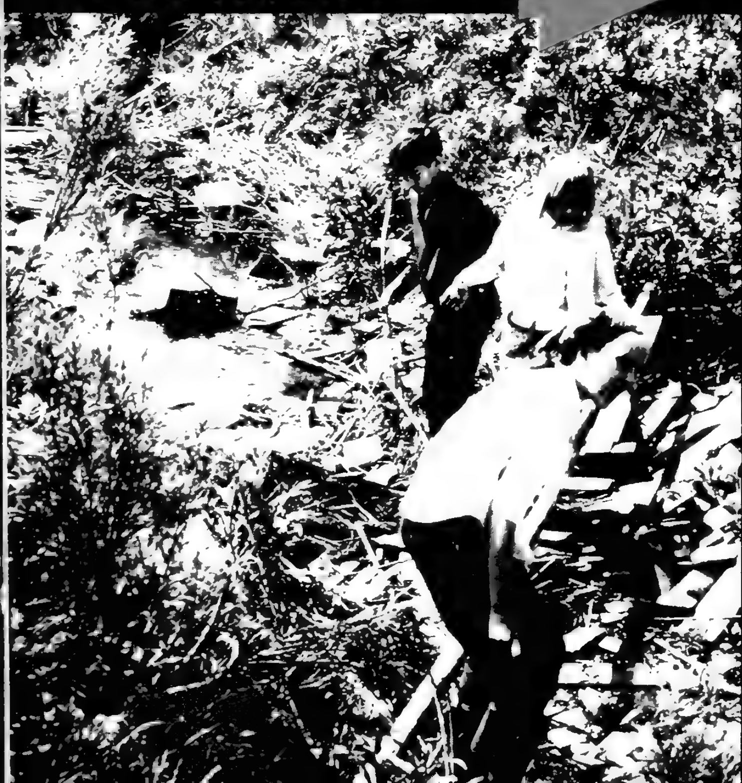
How To be a Super Space Saver

Fight Sight Blight

To Save a Stream

Yesterday's wooded stream . . .

is today's open sewer



Yesterday's ugly alley . . .

is today's play park

nature and science

VOL. 7 NO. 12 / MARCH 2, 1970

CONTENTS

PICTURE CREDITS: Cover, top left courtesy of University of Illinois Archives, bottom left by D. Walker, right courtesy of City of Philadelphia; pp. 2-5, 13, 14, 16, drawings by Graphic Arts Department, The American Museum of Natural History; p. 5, Fundamental Photographs; p. 6, courtesy of City of Philadelphia; p. 7, top by C. Rusch, bottom by D. Wolken; p. 8, top left by D. Wolken, right by L. Pringle; p. 9, left by United Press International, C. Rusch, D. Wolken, right by A. Rutledge, R. Katz, D. Wolken; p. 10, top by D. Walker, bottom courtesy of Champaign-Urbana *News-Gazette;* p. 11, courtesy of Atomic Energy Commission; p. 12, Bettmann Archive; p. 15, top courtesy of Federal Water Pollution Control Administration, bottom left courtesy of Tennessee Valley Authority, right courtesy of Vitro Corporation of America; p. 16, David Webster.

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

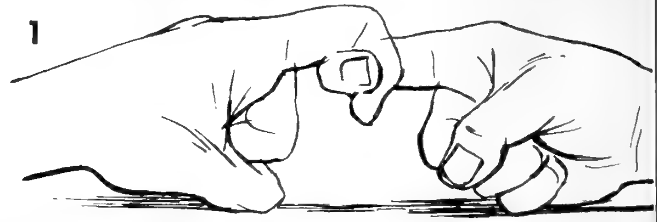
EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

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.

SCIENCE WORKSHOP

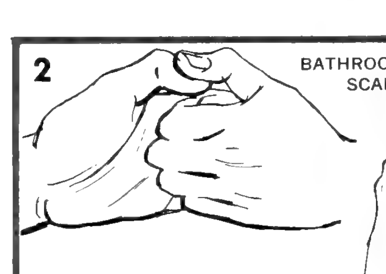


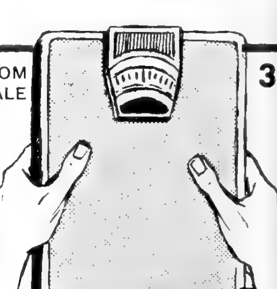
■ There are over 600 muscles in your body that mov parts of your skeleton. You use certain muscles or combinations of muscles for different jobs, such as bending you knee, blinking your eyes, or smiling. Which muscles ar you most aware of? Do you think they are your stronges muscles? Here are some ways to find out how strong som of your muscles are.

You can test the strength of your finger muscles b challenging a friend to a finger-pulling contest. Make fist and place your hands firmly on a table, as shown in Diagram 1. Lock forefingers and pull. The one who can forc the other person's finger to uncurl and let go has th stronger finger muscles. Another game you can play i thumb-wrestling. Lock fingers with your opponent a shown in the diagram, and then try to pin his thum beneath your own thumb *(see Diagram 2).*

Scale Your Strength

These games only tell you whether certain of your muscles are stronger than those of your friend. You can use bathroom scale to actually measure the squeezing strengt of your finger, hand, and lower-arm muscles in pounds o





force. Grip the scale with one hand on either side, an squeeze as hard as you can *(see Diagram 3).* How high ca you make the scale read? Let your friends try, too. Ar heavier people always stronger than lighter people? Ar boys always stronger than girls?

When you exercise a muscle steadily for a while, i becomes temporarily weaker. To see how much strengt your finger muscles lose after you exercise them, open an close your fingers as fast and as hard as you can for minute. Then immediately squeeze the scale again. Is th

How Strong are your Muscles?

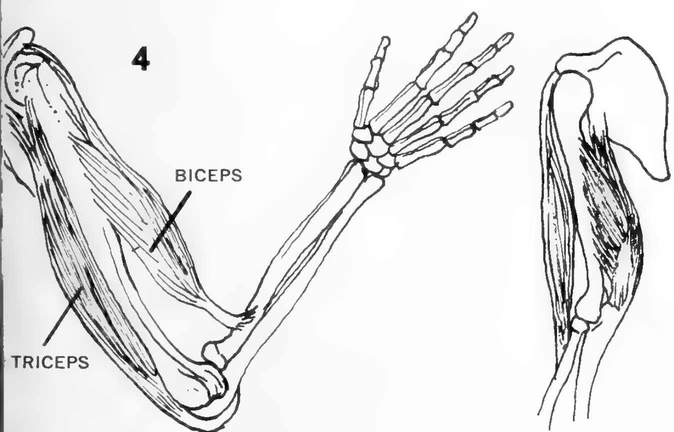
by David Webster

reading now as high as it was before the exercise?

Rest your fingers for a few minutes, and then take another scale reading. Keep taking readings every few minutes until you can make the scale reach its original highest reading. How long did it take your fingers to regain their strength after exercising?

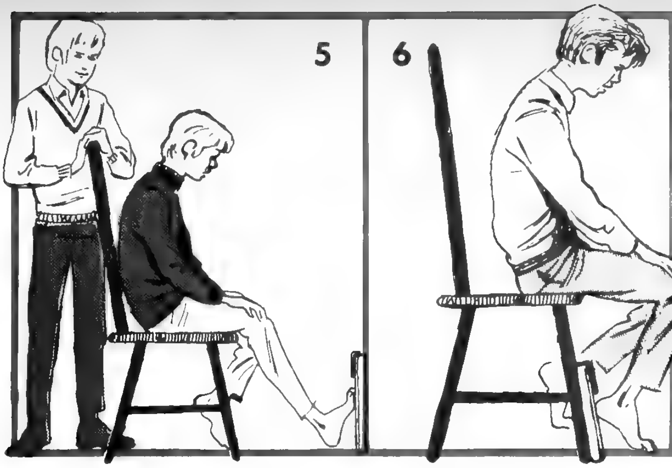
Muscle tissue is made of cells that can *contract,* or become temporarily shorter. When the cells contract, the muscle becomes shorter and pulls on the bone to which it is connected. The muscle moves the bone in this way. But each muscle can pull in only one direction. For example, two muscles are needed to bend and unbend your arm—the biceps contracts to pull your forearm toward your shoulder, and the triceps contracts to pull your arm straight again *(see Diagram 4).*

4



All the muscles that move the skeleton work in pairs. Usually one muscle in a pair is stronger than the other. One of the strongest pairs of muscles in your body is the set that controls your lower leg. Which muscle of the pair is stronger—the one that extends your leg, or the one that pulls it back?

While sitting on a chair, push your foot forward against a scale that is propped up against a wall, as shown in Diagram 5. (Have a friend stand behind you to keep the chair from tipping or sliding back.) How hard can your leg muscle push forward, according to the scale? Stand the scale on end against one of the front legs of the chair. Then pull your leg back, with your heel pressing on the



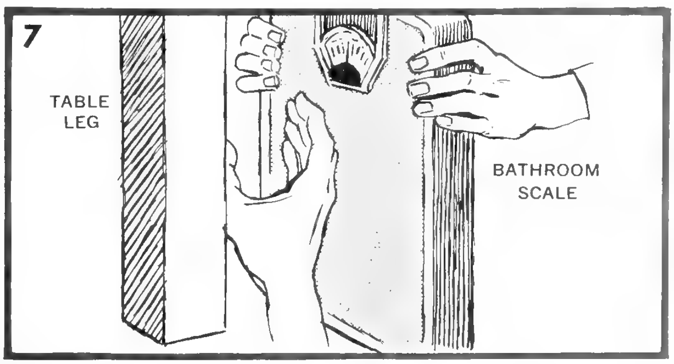
scale *(see Diagram 6).* How strong is the muscle that pulls your leg backward? (Have a friend read the scale for you, or else set up a mirror in front of your chair.)

Now measure the strengths of other muscle pairs. In each test you will have to figure out how the scale should be placed. For example, to test some of your finger muscles, you could first try squeezing the scale between thumb and forefinger, then standing the scale up and stretching your thumb and forefinger apart between the scale and a table leg *(see Diagram 7).* Record your results in a table like the one shown.

Is one muscle in each pair always much stronger than the other? Which muscle of each pair do you use more to perform various tasks? Can you guess which muscle in a pair that you haven't tested will be the stronger? Test the pair to find out.

Which muscle in your body is the strongest of all? Would you want all your muscles to be that strong? ■

7

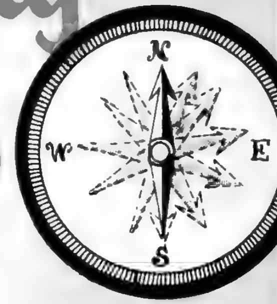


STRENGTH OF MUSCLE PAIRS

LOCATION	MOVEMENT	POUNDS
FINGERS	SQUEEZING TOGETHER	
	PUSHING APART	
LOWER LEG	PUSHING FORWARD	
	PUSHING BACKWARD	
BIG TOE	PUSHING DOWN	
	LIFTING UP	
LOWER ARM	PUSHING DOWN	
	LIFTING UP	
HEAD	MOVING FORWARD	
	MOVING BACKWARD	

Many times in the earth's past, a compass needle that now points northward would have pointed to the south. Scientists know when these times were, but they are still trying to solve—

The Mystery of the Changing Poles



Part I

by Diane Sherman

■ Suppose you invented a "time machine" that could take you back into the past at a "speed" of, say, *one million years per hour,* without moving from the place where it was standing. When you got out of the machine some time in the distant past, the land around it would appear quite different, so you would probably take a compass along to keep from getting lost if you left the machine.

As you sped back through time, after about 42 minutes you might be surprised to see the north-seeking end of your compass needle swing around to point southward!

That would be when you were about 700,000 years into the past. And by the time you were four million years into the past (a four-hour trip by time machine), your compass needle would have swung back northward, then southward, then northward, and so on, nine times.

We know this would happen because scientists have discovered that the earth's North and South *Magnetic* Poles *(see "Three kinds of 'poles'")* have "switched positions" with each other at least 171 times in the past 76 million years. We even know when these switches took place, but what caused them is still a mystery.

The Wandering Magnetic Poles

As you may know, a compass needle and the earth are both magnets *(see photo and diagram).* Because of this, the north-seeking pole, or end, of the compass needle is attracted to the earth's North Magnetic Pole, and the south-seeking pole of the needle is attracted to the earth's South Magnetic Pole. The earth's magnetic poles, however, do not stay in the same places. They move from day to day—sometimes as far as 30 miles in a day. The magnetic poles also seem to move around the geographic poles over long periods of time.

Every few years the U.S. Navy sends a team of men to find out exactly where the magnetic poles are. Flying in a large plane over thousands of miles of territory, the men watch an instrument called a magnetometer, which measures the magnetic "pull" of the earth below. When the instrument reads zero, the magnetic pole is directly below.

In 1965, the North Magnetic Pole was near Bathurst Island in northern Canada, over 900 miles away from the geographic pole. The South Magnetic Pole was almost twice as far from *its* geographical pole, and is apparently moving northwest about 8 miles a year. From the evidence we have so far, the magnetic poles seem to be moving in an oval-shaped pattern around the geographic poles. Yet no one is sure this is really happening or, if it is, why.

For the earth's North and South Magnetic Poles to "switch positions," however, is different from their "wandering" around the geographical poles. It is as if an imaginary bar magnet inside the earth reversed its poles, or turned around end-for-end. The evidence that such reversals did take place in the past comes from the study of magnetism in certain kinds of rock.

Patterns in the Ocean Floor

Many rocks have tiny bits of iron in them. When hot melted rock wells up out of the earth, these bits of iron are lined up in the rock so they point to the earth's magnetic poles just as a compass needle does. When the rock hardens, the north-seeking poles of the iron particles point to wherever the North Magnetic Pole is *at that time.*

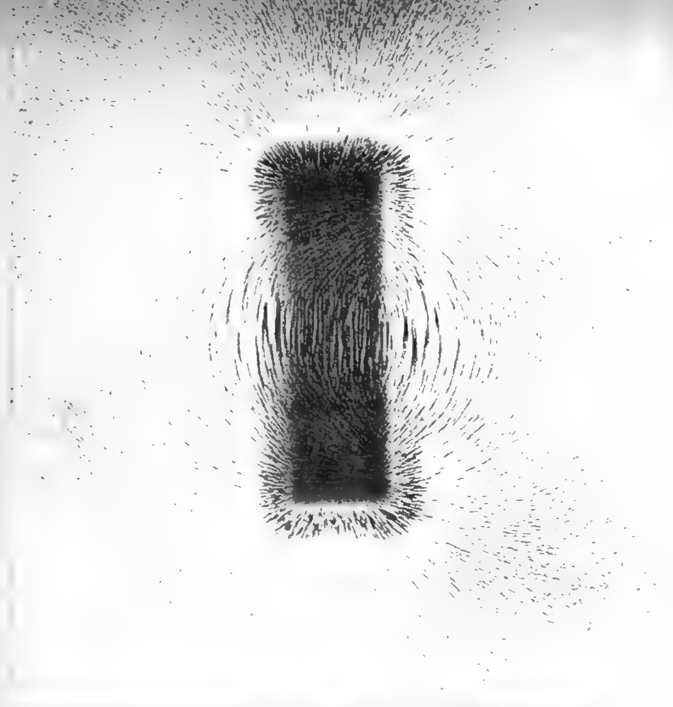
Many scientists suspected that this might be happening in the huge undersea mountain range that winds through the oceans of the world. This mountain chain, called the

THREE KINDS OF "POLES"

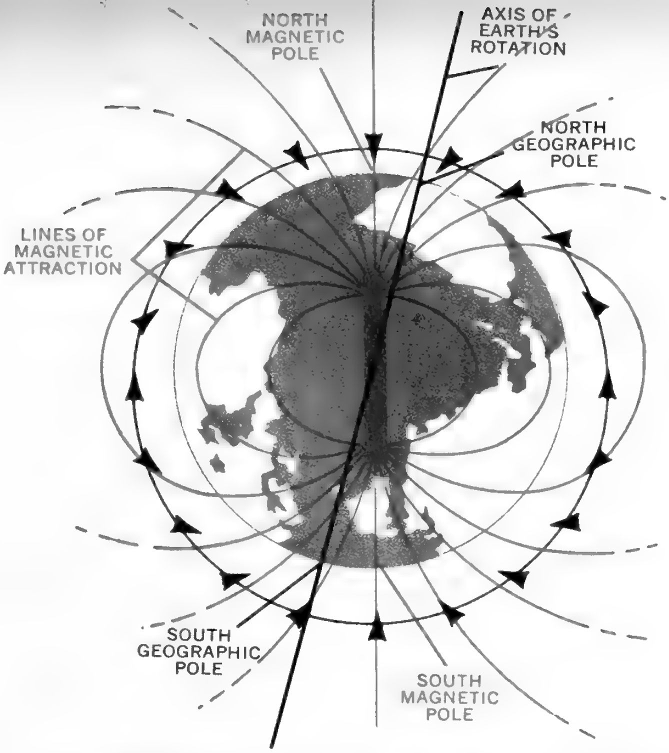
1. The earth's North and South *Geographic* Poles are points on its surface at opposite ends of the earth's *axis*—the imaginary "axle" around which it rotates *(see diagram on next page).*

2. The earth's North and South *Magnetic* Poles are points on the earth where a magnetic compass needle points straight down toward the center of the earth *(see diagram).* The magnetic poles move around near the geographic poles.

3. The *poles of a magnet* are its two ends. Hang a magnet by a thread so it can swing freely. When it stops turning, its two poles will be lined up in a roughly north-south direction, the same as a compass needle. The pole that points northward is called the *north-seeking pole.* It is usually marked "N" or some other way to distinguish it from the magnet's south-seeking pole.



Tiny bits of iron sprinkled over a plastic sheet resting on a bar magnet form a "map" of the *lines of magnetic attraction* in one slice of the space around the magnet. The north-seeking pole of each particle points along a line of attraction in the direction of the magnet's south-seeking pole. What would happen if the magnet were suddenly turned end-for-end, reversing the position of its poles?



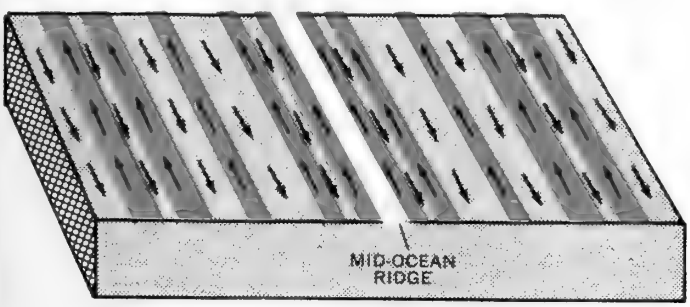
The earth behaves as if a giant bar magnet were at its center. Its lines of magnetic attraction point the north-seeking end of a compass needle different ways at different places around the earth (*see arrows*). Iron particles in rocks formed at different times in the earth's history point in opposite directions, showing that the earth's magnetic poles have been reversed many times in the past.

mid-ocean ridge, has a deep crack in its center. The crack, or *rift,* is up to 30 miles wide, and the scientists thought hot, melted rock was slowly oozing up through the rift.

Around 1963, scientists began to notice a pattern of magnetic "stripes" in the ocean floor on both sides of the mid-ocean ridge. The "stripes" are wide bands of rock with the iron particles in one band pointing in one direction and the iron particles in the bands next to it pointing in the opposite directions *(see diagram).*

Dr. Frederick J. Vine, who was then a 24-year-old graduate student at Cambridge University, in England, had an idea. Along with Dr. Drummond H. Matthews, (also at Cambridge) Vine made a startling proposal.

He knew that the sun reverses its North and South Magnetic Poles regularly. He also knew that *geophysicists* (scientists who study what goes on inside the earth) had found evidence of similar reversals on earth.



Bands of rock with their iron particles pointing in opposite directions make up the sea floor at both sides of the mid-ocean ridge.

Vine reasoned that as molten rock came up through the mid-ocean rift, the iron particles in it would line up with the earth's magnetic field. As more rock came up, it would push the already hardened rock away from both sides of the ridge. If a magnetic reversal took place, then the new rock would have different magnetic markings. Gradually, as rock continued to rise, and the magnetic poles continued to flip, a pattern of magnetic "stripes" would appear in the rock on both sides of the ridge.

Scientists from many fields examined the evidence more closely, and by 1966 most were convinced that the earth's magnetic poles have reversed many times in the past. The times when these reversals took place were figured out by measuring the ages of rock samples from the edges of the magnetic "bands" on the sea floor. The age of such a rock sample can be figured roughly from the amounts of different *radioactive* elements in the sample *(see page 14).*

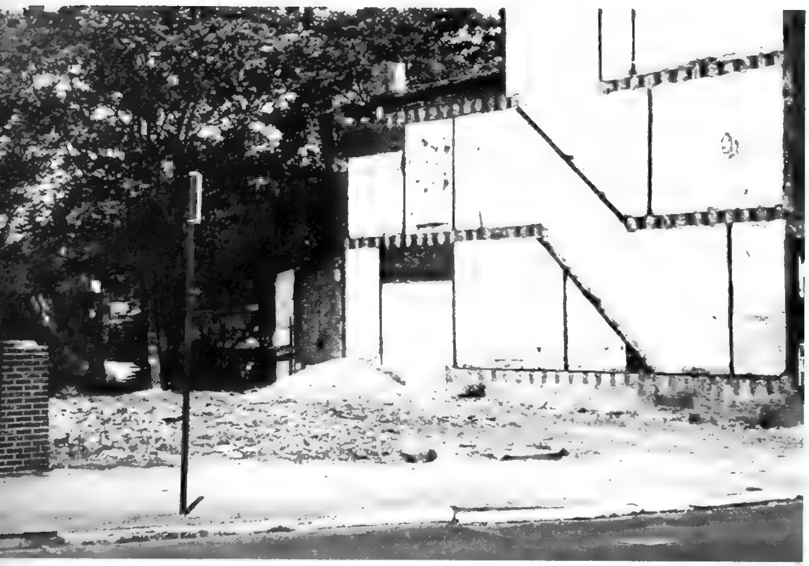
The scientists found that the magnetic poles do not reverse themselves regularly. As much as three million years have passed without this happening, but at other times the poles have reversed at 10,000-year intervals.

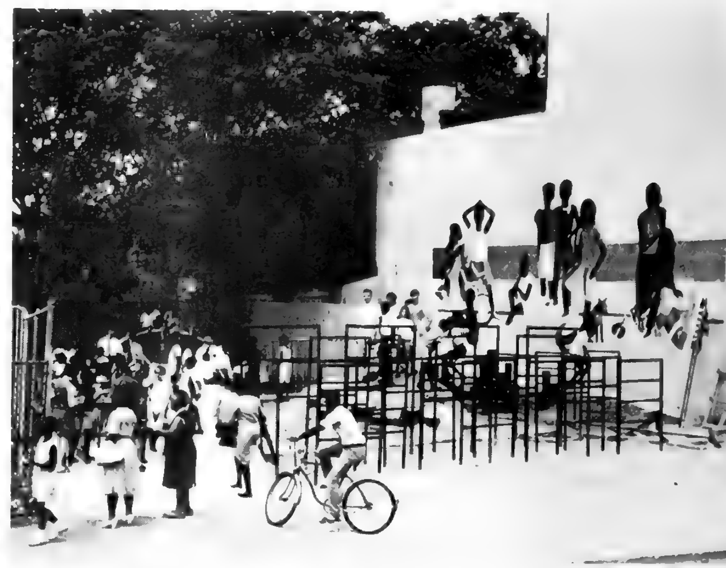
No one knows for sure what causes these reversals, but some ideas scientists have suggested will be described in Part 2 of this article, in the next issue ■

Is your community well supplied with parks, playgrounds, and other open areas? Are there places that could be changed into new "mini-parks"? Here's how you can begin to answer these questions.

How To Be a Super Space Save

by Susan C. Stone and Frances D. Quinn





This ugly lot in Philadelphia was changed into a place for fun. Could the same be done in your community?

■ Parks and all kinds of open space are the outdoor rooms in our lives. Humans seem to need both the shelter of enclosed space in buildings and the balancing open space of the outdoors. Someone once said, "A good park is like an open window in a stuffy room." But what kinds of "open windows" have we kept or designed for our communities?

Too often, we have built hastily on land at the edges of cities, usually not allowing much open space close by, where the people are. The space close at hand has often been neglected or destroyed. Within the older parts of cities, people sometimes make room for more cars by turning parks into parking lots and by cutting down trees to widen streets. (Take the TREE out of STREET and what's left?)

There are lots of opportunities to do better. One of the secrets of good city-building is to discover ways to keep or create "open windows" in our cities. All open spaces do not have to be big to be useful and beautiful. The narrowest alleyway or smallest vacant lot can be turned into a "mini-park" *(see photo)*.

Where Is the Nearest "Window"?

How is the supply of "open windows" in your neighborhood or community? Is there enough open space to suit you? (The National Recreation Association recommends that there be 15 acres of parks and playgrounds in a city for every 1,000 people.) Can you think of some ways to improve the open spaces you see?

If you want to be a "super space saver," explore your community and take notes on what you see. Try to answer as many of the following questions as you can. Add some questions of your own. You'll be doing what city planners do as they try to find ways to make a community a better place to live.

Begin by drawing a simple map of your community or neighborhood, showing the park or playground nearest your home. Color it green. You might do the same with other open spaces you find.

1. Describe the park or playground. What can people *do* there? Do you like to look at it? You might draw a picture of it.

Who Cares?

In the most beautiful cities of the world, people think that the streets and other outdoor public areas "belong" to them. These are their "outdoor homes" and everyone appreciates them and takes care of them. In America, people often think that streets and public areas "belong" to someone else. They do little to plan for or take care of these areas. How could this attitude be changed?

In some communities, people in cars, on bikes, and on foot are kept apart for their safety and convenience.

2. What might be changed or added? Is there space for more trees?

3. Can you walk to the park? Are there sidewalks all the way? How many street crossings? How many traffic lights?

4. Where is the nearest place you can swim or ice skate? Can you put it on your map? Can you get there by bike?

5. Where is the nearest place to see wild animals and explore nature? What can you find there?

6. Where can you see a woods and go for a hike (maybe with a picnic)?

7. Where is the nearest river, lake, stream, or seashore? Can you walk along the banks or shore? Who owns the land at the water's edge? Can you use a boat there? Do fish live in the water?

8. Where can you go in or near your community to camp overnight? Have you ever done it?

9. Can you find space to put rows of shade trees on the streets of your community or neighborhood? (In one city in Illinois, students sold buttons that said "Love Trees" in order to raise money to plant new street trees.)

10. Can you find bits and pieces of land near your home or school that could be used for gardens or playgrounds or places for people to sit and relax? What would you have to do to change these areas?

11. Are there parking lots that could be turned into parks? Where else could the cars be parked? If you left the cars in the lots, are there some ways in which the lots could be made more attractive?

12. Can you think of ways to connect all or some of the open spaces in your community so that people would have a "network of green" for walking throughout the city? ■

Could more shade trees be planted along streets in your city? Which street would you prefer to walk along on a hot day?

Fight Sight Blight

AN ENTRYWAY TO A CITY can be inviting and beautiful, or cluttered, ugly, and dangerous. What do people see when they enter your community by car, train, or from an airport? How do the entryways to your community compare with the entryway to your home?

A VIEW OF THE SKY doesn't have to include utility poles and wires. Some communities now have laws that require electric and telephone wires to be put underground.

■ It's easy to detect pollution when your eyes water from smoke or smog, or when the water tastes awful and has detergent foam on top. "Ugh, that's pollution!", everyone would agree.

It's not as easy to agree on *visual pollution*—ugliness in our surroundings. Something that you find ugly may not even be noticed by someone else. But most of us would agree with experts on design, such as architects, who say that there is a lot of ugliness being built into our communities.

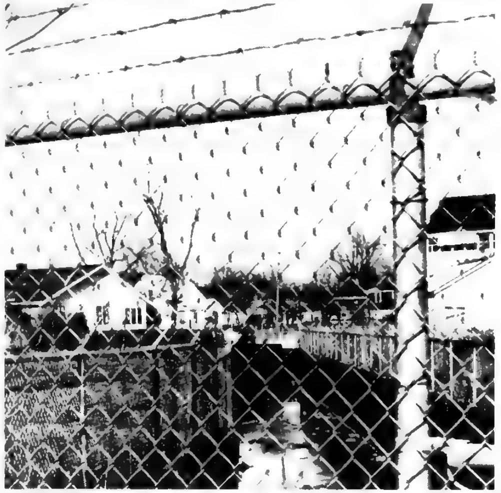
One trouble with visual pollution is that it lasts so long. A river, if given a chance, will clean itself of pollution. So will air. But ugly roadsides, buildings, shopping centers, signs, and electric wires and poles stay on and on and on. That's why it is important to take more care and *plan* the changes made in the places where we live.

Some of the photos on these pages show examples of "sight blight," or visual pollution. Explore your own neighborhood or community and look for more examples. Then find out what laws—if any—control the design and location of man-made structures in your community. Can anything be done to halt the spread of "sight blight?"

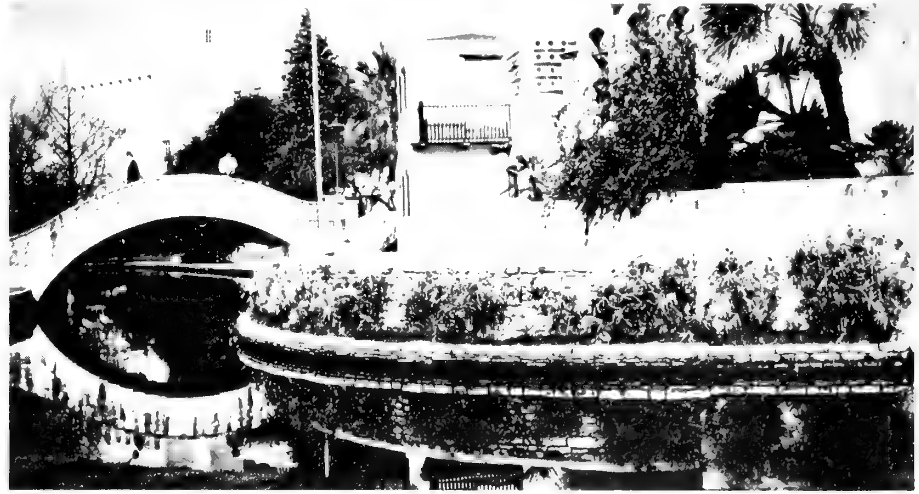
Why ask these questions in *Nature and Science?* Because people are a part of nature. Cities, suburbs, and towns are the places where most Americans now live, and where more and more will live in the future. How *well* they live will depend a great deal on how they build and change their communities.

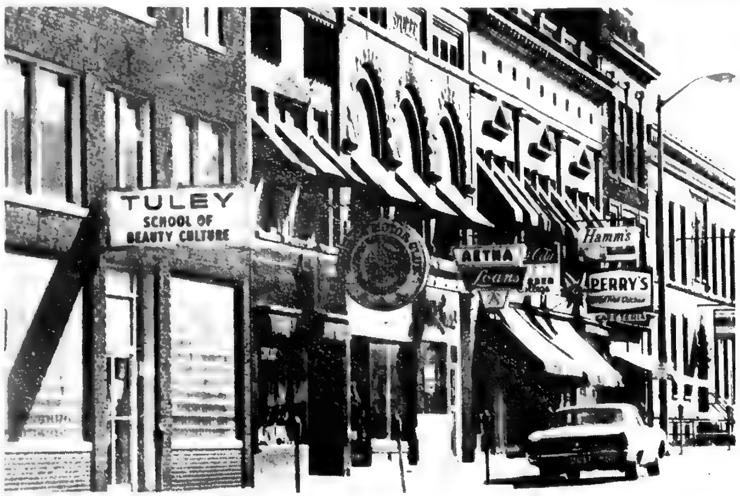
—Susan C. Stone and Frances D. Quinn

shown in an aerial photo (*left*). In a closer view you could see that the streets, houses, and yards are nearly all alike. The right photo shows another way of arranging houses. Fewer streets are needed. Wooded areas that remain are shared by everyone. Who decides the arrangement of new groups of houses in your community?



A STREAM THROUGH A CITY is often badly polluted and ugly, a kind of water slum that people can't even reach—if they want to. About 40 years ago, a small river flowing through San Antonio, Texas, looked like the Illinois stream in the left photo. Some people wanted to cover the river with a street. Others thought they could do something better with the river. Today the river in San Antonio has walkways, gardens, outdoor restaurants, and shops along its banks (*right photo*). How does the river or stream in your community compare with these two views?





DOWNTOWN IS THE CORE of a community. It is usually the oldest part and often has interesting buildings. But they may be neglected and shabby. These buildings (*left photo*) are going to be torn down for a parking lot. Do you care? You might if you looked closely, above the clutter of signs, for pleasant surprises in the construction of the old buildings (*right photo*). Perhaps some old buildings are worth saving. Who decides if they are saved in your community?

To Save a Stream

■ One day last spring, two men led a fifth grade class on an expedition along a dirty little stream that runs the entire length of an Illinois city. One man was a *landscape architect* (a "designer of the outdoors"); the other was an *aquatic biologist* (a scientist who studies the plants and animals that live in water).

The stream that the class explored was very much like the streams and rivers found in most towns and cities all over the country. For a long time after people first settled in the area, most of the land close to the stream was left alone. Grass and trees grew along the banks. When it rained a lot, the soil and the living and dead plants along the stream soaked up most of the water, so floods were not a problem.

The stream meandered along through the center of town, mostly undisturbed. It was a favorite swimming and fishing spot. And on warm spring days, children going home from school didn't mind falling in, "accidentally on purpose."

As the years went by, land in the city became scarcer and people built closer and closer to the edge of the stream. Apartments, stores, office buildings, and parking lots were built and alleys were paved. More and more of the land was covered with concrete and asphalt. Now, when it rains, there is no spongy grassland to soak up the water. It runs off into the stream channel, and the stream floods.

Pipes from some of the buildings dump wastes into the stream, even though it is against the law. Do you suppose anyone fishes or swims in the stream these days?

On their trip, the boys and girls put on boots and waded in the stream behind dry-cleaning shops, hamburger drive-ins, a used-car lot, and a motel. They wanted to see exactly what the stream and its banks looked like, and what plant and animal life could survive in the water. They found sludge worms in some places and midgefly larvae in others. They also found most of a car, some tires, chairs, tin cans, and a shopping cart covered with algae.

Later a school bus took them out into the country to visit the same stream before it reached the city. There they found a few fish, mayflies, and caddisflies, which showed that the water was cleaner.

When they returned to school, the pupils decided that the people of their city needed to take better care of the stream. As it turned out, the boys and girls weren't the only ones concerned about it. The stream flows past a university, and some students there had a big "wade-in," collecting many truckloads of junk from the stream *(see photo)*. News of this was reported on television and in newspapers. People began to realize how bad things were. Then, under a new state law, many of the polluters were identified. They were warned to stop pouring wastes into the stream. If they didn't, they could be fined heavily—not just once, but every day they kept on polluting.

A group of citizens, including landscape architects, planners, lawyers, and engineers, are now working with city officials to find ways to solve the flooding problem and to end the dumping. Then they hope to make the banks of the stream a pleasant green path along which people can walk, or sit and relax, and someday fish again.

The job will take plenty of imagination, planning, time, and money. Many people think that the stream is worth the effort.

What about the stream that flows near your neighborhood? Are there any changes you'd like to make?—SUSAN C. STONE and FRANCES D. QUINN

The stream became a dumping ground for all sorts of junk *(see top photo)*, and many truckloads of litter were cleared from the stream by university students.

WHAT'S NEW

by
B. J. Menges

The roars of elephant seals echo across islands near California and Mexico from December to March. This is the mating season, and the adult males (bulls) are bellowing warnings to one another. Occasionally a fight breaks out between bulls, but usually one backs down. Only the "winning" bulls mate with the female seals.

In studying the roars of elephant seal bulls, two California scientists discovered that bulls on different islands have slightly different calls. Songs of birds of the same species have also been found to be slightly different in different places. But man is the only mammal other than the elephant seal that is definitely known to have "languages" that differ from place to place.

Like tiny submarines, freshwater turtles float on the water's surface one moment and lie on the bottom the next. How turtles can so quickly change their floating ability has never been fully explained. Now, experiments by a scientist at the University of Pennsylvania, in Philadelphia, suggest how they do it.

Dr. Donald C. Jackson changed the floating ability of freshwater turtles by taping either weights or floats to their shells. He watched to see what the turtles did to float or sink. To float a turtle takes air into its lungs and releases water from the opening in its body through which wastes usually pass. To sink, a turtle does just the opposite—releases air from its lungs and takes water into its body.

The train of the future may travel swiftly, silently, and smoothly, with no air-polluting fumes. That's the hope held out by a new type of railway car now being tested by the United States Department of Transportation. Made by the Garrett Corporation, a California aerospace firm, the railway car is propelled by magnetism.

The car straddles a thin rail, but doesn't touch the rail. In the car on each side of the rail is an electromagnet. Electricity flowing through the rail and through the electromagnets creates magnetic forces between them that can propel the car to an estimated speed of 250 miles an hour. Though the present car has wheels, future trains will ride on a thin cushion of air. Air blown out through thousands of small holes on the underside of a train will lift it and provide the cushion.

Painful stings spoiled ocean bathing for many Australians two summers ago. Bathers blamed the stings on small blue sea slugs carried into shallow water by waves. But sea slugs had not been believed to possess stinging equipment harmful to man. Were the bathers mistaken?

Two scientists who studied the sea slugs cleared up the matter. A sea slug does not itself have stinging equipment. But it feeds on the Portuguese man-of-war, a jelly-like sea creature noted for its stinging cells. The largest of these stinging cells aren't digested by the sea slug, but are stored near the surface of its body and used when the sea slug is "threatened" by fishes or even men.

Orange frogs are common in Panama. Called Zetek's frogs, they're easy to see as they sit on dark rocks by streams. They're easy to catch, too. They are slow to move when approached, and they jump and swim poorly. It seems strange, therefore, that hungry animals haven't caught and eaten most of them. How do they survive so well?

The answer was reported recently in the journal *Science* by Harry S. Mosher and Frederick A. and Geraldine J. Fuhrman of Stanford University in Palo Alto, California. The skin of Zetek's frog is highly poisonous. A small amount of the poison can kill a small animal in minutes. The distinctive color of the frog warns other animals not to eat it.

Milking polar bears may seem an unlikely interest for the Atomic Energy Commission (AEC), but that's just what the AEC has asked Dr. Bruce E. Baker, of McGill University in Montreal, Canada, to do. In fact, the AEC wants to obtain milk from a number of "unlikely" arctic and subarctic mammals—such as wolves, caribou, bighorn sheep, and whales. Dr. Baker will then analyze the milk to see whether it might contain tiny amounts of radioactive substances, or whether it might show any unusual characteristics that could be due to radiation. The AEC wants to know what happens to both natural and man-made radiation after it is produced, and what effects it may have upon living things. Radiation is already known to have some harmful effects on life.

When asked how you milk a polar bear, Dr. Baker jokingly said, "very carefully." Actually, the bear is first caught in a snare-like trap, and then put "to sleep" for an hour or so while the milking is being done. This procedure is harmless and painless to the bear, notes Dr. Baker.—RJL

NEW ATOMS from OLD

by Roy A. Gallant

Part 3 of this series told how Henri Becquerel discovered that the element uranium gives off energy in mysterious "rays." This article tells how investigations of these "rays" led to the discovery of other elements that are radioactive, and how their atoms change into atoms of different elements.

■ At first, no one seemed to take much interest in the mysterious rays Becquerel had discovered coming from uranium. Roentgen's X rays had, for the time being at least, "stolen the spotlight." With X rays one could photograph the bones inside living organisms, as well as other "hidden" things. Becquerel's rays did not act that way.

It may be because these rays seemed so uninteresting to other scientists that a young woman student decided in 1897 to study them. She was a Polish girl named Marya Sklodowska, who had married the French physics teacher Pierre Curie and changed her name to Marie Curie.

A Project for Her Doctor's Degree

By 1897, Marie Curie had already earned two college degrees, one in physics and one in mathematics, and was ready to start work on the highest degree of all, a doctor's degree. To earn one meant doing a very difficult and long research project. Becquerel's mysterious rays seemed a perfect topic for her research. No one else seemed interested in finding out what they were, so there would be a pretty good chance that another scientist would not solve the mystery before she could.

Becquerel had roughly measured the strength of uranium rays by observing by how much they clouded photographic film. Marie Curie wanted to measure their strength more exactly than that. One thing she knew was that the rays did something to the air they passed through, making it easier for electricity to flow through the air. If she had an instrument sensitive enough to measure a small change in the flow of electricity through the air, she would have an excellent measure of the strength of the rays passing through the air. It so happened that her husband and his brother Jacques had made just such an instrument (an *electrometer*). Now she could begin work.

She started by trying to find out, as Becquerel had, how a piece of pure uranium metal got the energy that it gave off in the form of rays. No matter what she did to the metal —exposing it to X rays, to ultraviolet light, or to heat—the strength of its rays remained the same.

Perhaps other metals also gave off rays. She wondered. One by one, Marie Curie tried all the metals known to her. No luck, except in one case—the mineral pitchblende. But she had expected pitchblende to give off the rays, because it contains uranium. (The pure uranium she worked with had been obtained by separating it from the other substances that make up pitchblende.)

Discovering a "New" Element

What surprised her was that pitchblende gave off the mysterious rays *more strongly* than pure uranium did. How could that be? An ounce of pitchblende is made of other

This photo shows Marie and Pierre Curie in their laboratory in Paris where they discovered the elements polonium and radium. Marie Curie was to become the world's most famous woman scientist. She was the only person to win two Nobel science prizes—science's highest awards.

substances along with uranium, so she expected it would give off weaker rays than an ounce of pure uranium. Could it be that some other substance in the pitchblende besides uranium was also giving off rays? Here was a new idea to test.

For months, Marie and her husband tested sample after sample of pitchblende. They were trying to separate the pitchblende into each of the elements that make it up. In July 1898, they ended up with a gray smudge at one end of a test tube. It was not uranium, and it was not any other element known at the time; but it gave off rays, as uranium did. (Marie had come to call this process *radioactivity.*) The smudge was, in fact, a newly discovered element. Marie decided to call it *polonium*, after her country of birth.

During their work, the Curies had detected still another radioactive substance in the pitchblende. In December of 1898 they managed to get a tiny sample of it out of the pitchblende. It was another "new" element—this one nearly a thousand times more radioactive than uranium! They named it *radium*. To get only a tiny fraction of an ounce of radium, they had to process eight tons of pitchblende!

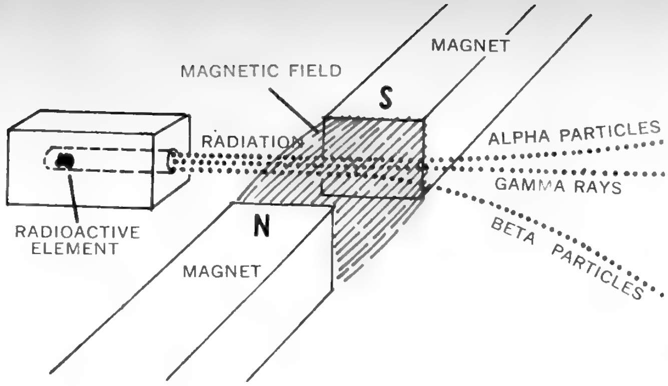
Self-Changing Atoms

By the early 1900s, several scientists—in France, Germany and Canada—had become fascinated by radioactivity, and, like the Curies, were experimenting with it. New ideas were being published thick and fast. In England, Sir William Crookes was experimenting with uranium and discovered a puzzling "new" substance. It was so much like uranium that he called it *uranium X*. In Canada, Ernest Rutherford and Frederick Soddy were experimenting with the radioactive element *thorium*. During their investigations, they, too, came across what seemed to be a "new" substance. It was so like thorium that they called it *thorium X*.

Was it possible that the atoms of thorium and uranium had the ability to change from thorium into thorium X, and from uranium to uranium X? Rutherford and Soddy felt this did happen. Certain kinds of atoms, all by themselves, could change the way they were put together, the two scientists said. At the very moment that such a change took place, the atom would give off a burst of *radiation*.

Tracking Down the "Rays"

What, exactly, was this "radiation?" Was it moving particles of matter, like cathode rays? Or waves of energy, like light waves? Or what? Rutherford found out by passing the rays from different radioactive elements through a *magnetic field* (*see diagram*). Some of the rays were bent sharply in one direction. Those "rays" turned out to be fast-moving electrons, the lightweight particles that J. J. Thomson had said make up part of all atoms *(see "Exploring the Atom—Part 2," N&S, February 2, 1970)*. Rutherford called them *beta* particles.



This diagram shows how the "rays" given off by radioactive elements act when they are passed through a *magnetic field* —the space through which the opposite poles of two magnets "pull" on each other. *Beta* particles (moving electrons) are bent sharply in one direction. *Alpha* particles (moving clumps of two protons and two neutrons each) are bent a little, in the opposite direction from *beta* rays. *Gamma* rays (waves of energy, like light waves) are not bent.

But there were two more kinds of rays to be explained. One kind went straight through the magnetic field without being bent. Rutherford called them *gamma* rays. Since they were not pulled off course by the magnets, they were probably not particles of matter, but waves of energy instead. They seemed to be extremely powerful—even more powerful than X rays—and came from only a few radioactive elements.

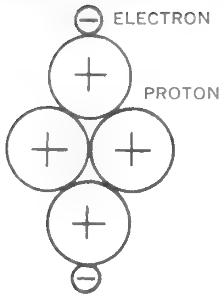
The third kind of "rays" were bent slightly by the magnetic field, which meant that they must be moving particles, not waves of energy. Furthermore, they were bent in a direction opposite to the beta particles. Because beta particles have a negative electric charge, the opposite bending of these particles meant that they must carry a positive electric charge. Rutherford called them *alpha* particles. Since the path of the alpha particles was bent only a little, it seemed that they were much more massive (heavier) than beta particles. It turned out that they were four times as massive as protons, the particles that had earlier been found in the nucleus, or center part, of atoms *(see "Exploring the Atom—Part 2")*.

Could that mean that each alpha particle was a clump of four protons? If so, then an alpha particle should have a positive electric charge four times as strong as a single proton. But it didn't; each alpha particle had a positive charge equal to that of only two protons. Why, if there were four particles?

Balancing the Alpha Particle's "Charge" Account

One possible answer was that two of the four protons of an alpha particle each had one electron sticking to it.

(Continued on the next page)



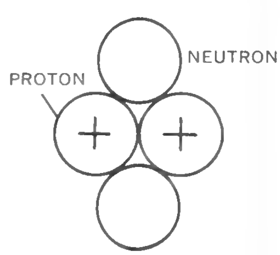
For 30 years, scientists thought an *alpha* particle was made up of four protons and 2 electrons, with the electrons' negative charges cancelling the positive charges of two protons.

Exploring the Atom (continued)

The negative charges of the two electrons would cancel out the positive charges of the two protons. That would leave the alpha particle with the two positive charges of the other two protons (*see diagram*). (Electrons are so tiny that they would add hardly any mass at all to the alpha particle.)

This was an easy explanation, and it seemed to explain what made alpha particles behave the way they do. But Rutherford was not very happy with the idea. To him, a particle of radiation made up of six pieces of matter seemed too clumsy. About 30 years passed, though, before someone came up with a better explanation of the alpha particle.

In 1932, the English physicist James Chadwick did an experiment suggested by Rutherford, and discovered another kind of particle that makes up part of atoms. This particle turned out to have just about the same mass as a proton, but it did not have any electric charge at all. Because it was electrically neutral, it was called a *neutron.*



When Chadwick discovered the neutron—a particle with the mass of a proton but with no electrical charge, Heisenberg realized that an alpha particle is made up of two protons and two neutrons.

Immediately, the German physicist Werner Karl Heisenberg saw the importance of Chadwick's discovery. An alpha particle, he said, does not have two electrons stuck to two of its four protons. Instead, each alpha particle is made of two protons and two neutrons. That explains why an alpha particle has the positive charge of two protons and the mass of four protons (*see diagram*).

Atoms and Radioactivity

With the discovery of radiation and neutrons, man's view of the atom had changed dramatically since the 1700s. The atom could not be pictured as a lump of matter made up of protons and neutrons packed together in a central core called the nucleus, with electrons moving around the nucleus.

For some reason, the atoms of certain elements sometimes throw off one or more pieces of themselves, and this changes them into atoms of a different element (*see "How a Uranium Atom Changes . . ."*). Such elements are called *radioactive elements,* and the particles and the waves of energy that shoot out of them are kinds of *radiation.* Some of this radiation is weak; the beta particles (electrons) can be stopped by a sheet of paper. Gamma rays, are very powerful, energetic, and dangerous.

None of the scientists trying to solve the puzzle of radioactivity around the early 1900s realized the dangers they were exposing themselves to; nor did they realize that decades later science would find ways of using radiation to benefit man. Marie Curie, whose work as a scientist cannot be praised highly enough, died in July 1934 at the age of 67. She died of *leukemia,* or cancer of the blood. Undoubtedly, the disease was caused by her exposure to high-energy radiation during her years of scientific work. Since that time we have learned about many of the dangers of radiation. We have also learned how to use radioactivity in ways that help us cure certain illnesses ■

Part 5 of this series, in the next issue, will describe radioactive "isotopes" and their uses in medicine.

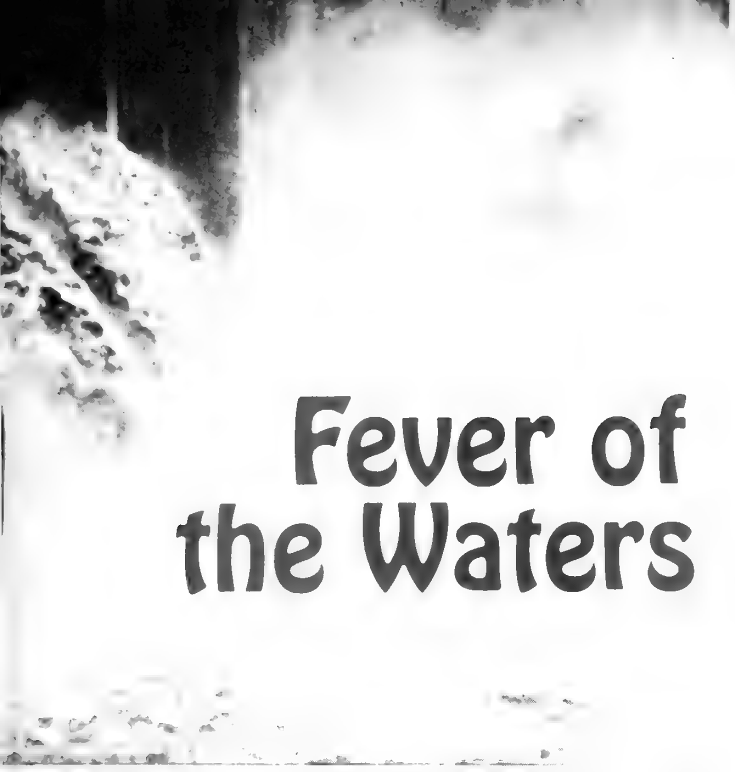
How a Uranium Atom Changes into an Atom of Thorium

When an atom of the radioactive element uranium 238 turns into an atom of the radioactive element thorium 234, here is what happens. First of all, notice the difference in "weight" of the two atoms. One weighs 238 units, the other 234.

Since the uranium atom loses two protons and two neutrons (an alpha particle) during the change, it loses 4 units of weight. In other words, it changes from an atom weighing 238 units to an atom weighing 234 units. The number of neutrons drops from 146 (for uranium) to 144 (for thorium); the number of protons drops from 92 (for uranium) to 90 (for thorium).

By giving up a beta particle, the new thorium atom changes into still another kind of atom, and that one in turn changes, too. Eventually, after more than a dozen such changes involving the loss of alpha and beta particles, the original uranium atom ends up as an atom of lead, an element that is *stable* (not radioactive), so it does not give off particles.

KIND OF ATOM	WEIGHT	NUMBER OF NEUTRONS	NUMBER OF PROTONS	PARTICLE LOST
URANIUM ↓	238	146	92	α
THORIUM ↓	234	144	90	β
LEAD	206	124	82	STABLE



Fever of the Waters

Hot water from an industrial plant makes this river steam.

■ The Connecticut River is running a fever. In some places, its temperature is higher than it should be. Its fever, like a sick person's, is a sign of trouble.

Upstream from an electric power plant, the temperature of the river is about 60° F. The plant cools its equipment with river water. Then the water is dumped back into the river—at a temperature almost 30 degrees higher.

Power plants and other industrial plants in many parts of the world are raising the temperature of lakes, rivers, and streams. Many power plants being built today use atomic energy, which produces even more heat than coal or other fuels. The waters are getting so much heat that fish and other water animals may be harmed.

Faster Pace of Life

Fish and other "cold-blooded" animals have body temperatures close to that of their surroundings. When the outside temperature increases, the animals' body temperatures increase. Their life processes speed up, and their hearts beat faster. The animals need more food and oxygen—but warm water holds *less* oxygen than cold water.

Some animals can adjust to slight temperature increases. But laboratory experiments show that a temperature increase often harms animals—by killing them directly, shortening their lives, or affecting their reproduction. Because the heat that industries add to water can harm living things, it is called *thermal* (heat) *pollution.*

So far, biologists know of only a few cases in which thermal pollution has killed many animals at one time. But the expected increase in the heat produced by power plants could have a gradual harmful effect on all living things, from tiny protozoa to fish-eating mammals. Thermal pollution needs to be controlled *before* it gets worse.

Keeping Cool

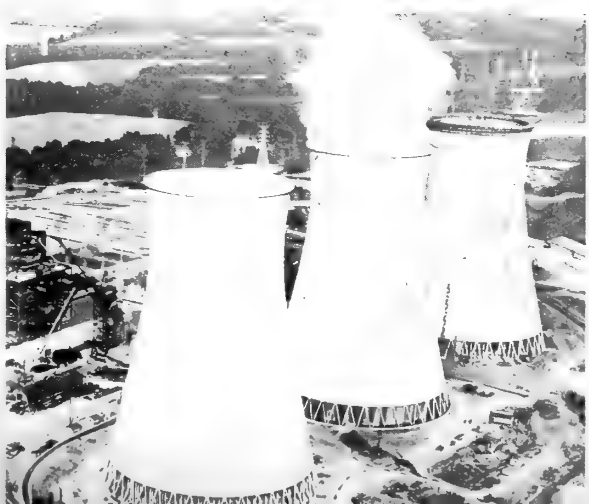
In a few states, temperature limits for some waters have been set; industries will not be allowed to raise water temperatures above these limits. These laws do not prevent the use of water for cooling, but they may force industries to cool the warmed water before returning it to the stream.

Some companies have built towers in which drafts of air cool the warmed water *(see photo).* But on cold days, moisture evaporating from the towers may condense into a thick fog. Another way of cooling the water is to store it in man-made lakes, which could also be used for raising some kinds of fish. (Water warmed slightly by power plants in the British Isles actually speeded up the growth of two kinds of fish.) Power companies in Oregon are investigating ways to use the heated water in farming *(see photo).*

These are only a few of the ways in which the water heated by industries can be used, and thermal pollution of streams and rivers stopped. If industries *use* these methods, rather than simply dump the water back into streams, a lot of "fever" and "sickness" can be prevented.

—Susan J. Wernert

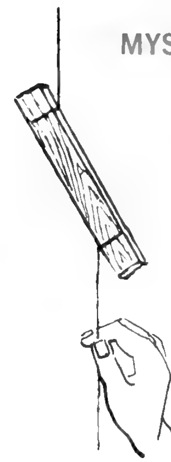
Special towers *(1)* can cool water warmed by an industrial plant, but they waste water and heat. One way of using the warm water is to spray it on peach trees *(2)* to prevent frost damage in the spring.



2

BRAIN BOOSTERS

prepared by **DAVID WEBSTER**



MYSTERY PHOTO

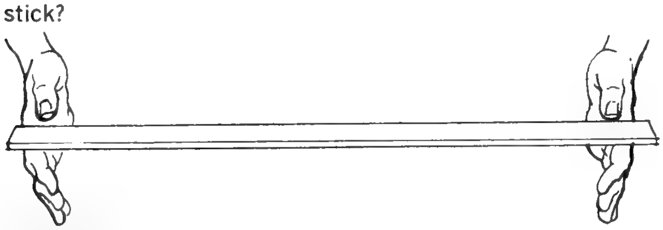
What is it?

CAN YOU DO IT?

Tie a thin string to one end of a piece of wood, and hang the wood from the other end by another thin string. If you pull down slowly but hard on the lower string, the top string will probably break. Can you pull on the bottom string in such a way as to make the bottom string break instead?

WHAT WILL HAPPEN IF . . .

Place the two ends of a yardstick on your hands as shown, and move your hands slowly together. You will probably find that your hands meet at the 18-inch mark. What will happen as you move your hands slowly apart from the middle of the stick?



JUST FOR FUN

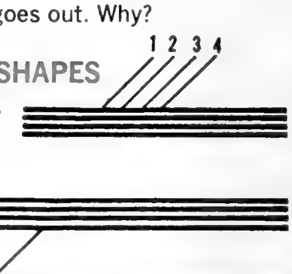
Pour a little vinegar into a glass of milk and watch what happens.

FOR SCIENCE EXPERTS ONLY

An astronaut tries to light a candle inside a space ship while it is in orbit around the moon. Every time he tries, the candle burns for a short while and then goes out. Why?

FUN WITH NUMBERS AND SHAPES

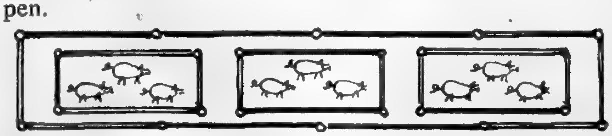
Which of the four numbered lines is an extension of the line below them?



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

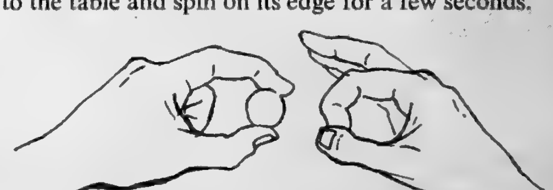
Mystery Photo: The icy formation is salt-water spray that froze on a ship's railings.

Fun with numbers and shapes: Here is how to put nine pigs into four pig pens with an odd number of pigs in each pen.



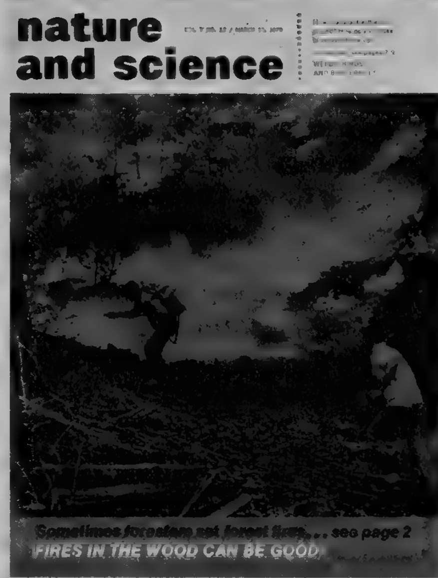
For science experts only: The towers holding up the Verrazano bridge each stick "straight up" from the earth. Since the earth is round, and the towers are so far apart, this means that they are not exactly parallel to each other. So they get farther and farther apart as they rise above the water.

Can you do it? To drop a coin so that it stays on its edge, you must make it spin. Hold the coin loosely between your thumb and forefinger a few inches above a table, and snap its edge with your other forefinger. The coin should drop to the table and spin on its edge for a few seconds.



What will happen if? Frozen milk does become hard, but never as firm as ice. When thawed out, it tastes like normal milk.

nature and science
TEACHER'S EDITION
VOL. 7 NO. 13 / MARCH 16, 1970 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Good Forest Fires

Smokey the Bear's slogan does not take into account the possible benefits of a forest fire. Your pupils might be able to think of new, better slogans, such as "Only you can prevent *wildfires.*"

Topics for Class Discussion

• *Why is it important to understand the difference between wildfires and prescribed burns?* Wildfires still burn about four million acres in the United States each year. Although foresters are setting fires, we cannot afford to become careless about fire. Also, people whose land can benefit from prescribed burns should understand exactly what prescribed burning is so that they use this "tool" in the right place at the right time.

• *What role does fire play in the growth of a forest?* Periodic fires are necessary for the growth of fire-type trees. Without fire, these trees cannot compete with, and are eventually replaced by, trees that can grow in shade and on covered soil. The replacement is one step in the development of a forest on land that was once unforested. This development is called *succession.* Fire returns a forest to earlier stages in its succession. Often this is beneficial for wildlife, which is most plentiful in early stages of succession, not in mature forests.

• *How do we know the role fire has played in forests of the past?* Fires scar some trees. Eventually wood grows over the scars. Later the scars can be dated by counting the annual growth rings between the bark and the scars *(see "Dating the Past,"* N&S, *Sept. 16, 1968).* Knowing when the fires occurred, and observing the ages of different kinds of trees in a forest, scientists can figure out how fires affected the succession in the forest.

Sometimes a forest's history can even be traced back before the oldest living trees. At the bottom of one deep Minnesota lake, different kinds of pollen from nearby plants has settled in thin annual layers for the past 9,000 years. Some layers have bits of charred wood and leaves. Scientists hope to learn more about the effects of long-ago fires in this forest by studying each year's layer of sediment.

What's in a Color?

Separating the pigments that make up dyes and inks of different colors reveals some surprising mixtures of colors and shows your pupils how an important method of analyzing mixtures works. Before your pupils discuss their findings, you might explain that the ability of tiny particles of matter to cling to the surface of a solid or liquid is called *adsorption.* (This phenomenon is important in certain biological processes, such as carrying nutrients from the soil into plants in water taken in through the roots; in industrial processes such as air purification, sugar and oil refining, and desalting sea

(Continued on the next page)

IN THIS ISSUE

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

IN THE NEXT ISSUE

A geologist tells how the *Glomar Challenger* drills deep into the ocean floor . . . Energy from atoms . . . How atoms are recycled in nature . . . Huge earthen mounds that puzzle geologists and biologists . . . Investigating tent caterpillars.

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

water; and in laboratory processes such as chromatography, for *analyzing,* or separating, different gases, liquids, or solids from a mixture.)

Topics for Class Discussion

- *How are different pigments separated out of a dye as water carries them along a strip of paper?* A pigment is attracted to (adsorbed by) the water strongly enough to be moved by the water, but the pigment's attraction to the paper keeps it from moving as fast as the water does. The different pigments also "compete" for adsorption space on the paper, so the pigment that clings most strongly to the paper drops out of the moving water first. This leaves the next section of the paper surface free to adsorb the pigment that clings second most strongly to the paper, so it drops out of the water; and so on.
- *Are all of the pigments, or other substances, that make up a dye separated by chromatography?* Not necessarily. Pigments of two colors might be attracted equally to the paper surface, so they would drop out of the water at the same place on the strip. Other substances might cling to the water so strongly that they travel on through the paper with it.
- *If you made a chromatogram of a colored liquid and found a band of uncolored paper between two bands of different colors, how would you explain it?* The liquid must contain an uncolored substance that clung to the paper in the "blank" area. Colorless substances can sometimes be separated by chromatography, then sprayed with a liquid that makes each of the separated substances turn a different color. Certain colorless substances can be detected by shining ultraviolet light (see *"What's in a Rainbow?"*, N&S, *Jan. 19, 1970)* on the chromatogram.
- *What can you learn from a chromatogram about the* permanence *of an ink or dye?* The pigment that forms the first band on a chromatogram is the most permanent (of those present) for coloring the paper the strip is made of—and probably for coloring other kinds of paper as well. *(Which of the pigments that make up permanent black ink is the most permanent?)*

Activities

- You might have your pupils try to make chromatograms using strips of different kinds of paper and cloth that water can move through by capillary action. Is the same pigment the most permanent one for coloring all of these materials?
- A chromatogram of washable black ink yields red, blue, and green pigments. By touching the end of the strip to the inside of the empty glass, a few drops of green liquid can be recovered and used as ink with a toothpick "pen". Or several drops of the green liquid can be used to make a new chromatogram. After the new strip dries, you can see a small blur of yellow at the far end from the origin, showing that the green is composed of blue and yellow pigments. (Holding the strip against white paper makes the yellow more visible.)
- "Which Colors Will the Leaves Turn?", *N&S,* Oct. 2, 1967, shows how to separate the pigments in leaves that are hidden by chlorophyl (green pigment) most of the year. (Various methods of chromatography used by scientists are also described on page 4T of that issue.)

Weeds, Birds, Butterflies

This article delves into some of the complex relationships that evolve among living things. Biologists believe that the poisonous chemicals in many species of milkweed plants are a result of evolution through *natural selection.* An individual plant has a greater chance to survive and reproduce if chemicals in it repel animals that would otherwise feed on it. A plant without poisons is more likely to be eaten before it can reproduce. So, after a long period of time, most kinds of milkweeds evolved the characteristic poisons that make them repellent to most animals. Monarch butterflies also acquired the ability to feed on milkweeds through natural selection, since this proved to be beneficial to the survival of the species *(see page 9).*

Many kinds of insects (and other animals) that are unpalatable "advertise" this fact by having bright warning colors *(see "What's New?",* N&S, *March 2, 1970).* The bright orange monarchs are a good example. The color reminds predators of earlier, unpleasant experiences with food of that color. The warning color is an advantage to both predator and prey: The prey is less frequently attacked, and the predator can hunt more efficiently because it doesn't waste time catching unpalatable food.

Once unpalatable insects with warning colors evolved, there were opportunities for evolution of palatable species that looked like unpalatable ones. This is an example of *mimicry.* The viceroy butterfly is a mimic of the monarch. It does not contain the bad-tasting poisons found in many monarchs. Yet, because of its close resemblance to its model (the monarch), the viceroy is avoided by predators which have learned to avoid monarchs.

Mimicking species such as the viceroy butterfly cannot become too common with respect to their model. The advantage of mimicry would dwindle if predators met and ate too many of the palatable mimics.

For Your Reading

- "Raise Your Own Butterflies," *N&S,* Sept. 18, 1967, and "Mating Monarchs," *N&S,* Oct. 2, 1967.
- "Ecological Chemistry," by Lincoln Brower, *Scientific American,* February 1969. *(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.

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

Changing Poles—Part 2

To understand the concept of the earth's core as a "self-magnetizing dynamo," your pupils need to understand the relationships between an electric current and a magnetic field. While these relationships are stated in the article, they will mean more to your pupils if they investigate the magnetic field around a wire with electricity flowing through it (Project 1), and make electricity flow through a wire by moving the wire through a magnetic field (Project 2).

• *How do we know that the earth's core probably has an inner part of solid metal and an outer part of molten metal?* From the speed and paths of earthquake waves traveling through the earth from the site of a quake to other points on the earth's surface. There are two kinds of earthquake waves, primary (P) and secondary (S). S waves, which can travel only through solid material, disappear when they reach the earth's core, indicating that it is a dense liquid—probably molten iron. But P waves, which can travel through liquid, pass through the earth's core *(see diagram)*. Those that pass through the inner part of it are speeded up so much that scientists think the inner core is made of rigid material—probably solid iron.

• *If the movement of molten iron through the earth's magnetic field produces the electric currents that produce the magnetic field, where did the magnetic field come from in the first place?* This is like the question: Which came first, the chicken or the egg? So far as we know, no one has come up with an answer to either question yet. To start a model self-magnetizing dynamo working, a magnetic field has to be provided until the machine is generating enough current to make its own magnetic field.

Exploring the Atom

The discovery of *isotopes* (atoms of the same element that have different numbers of neutrons and therefore different weights) and some of their many uses in research and medicine are described in this article.

To further clarify the concept of isotopes, you might refer your pupils to the table on page 15, and point out that all isotopes of carbon have the same number (6) of proton-electron pairs. This is the *atomic number* of carbon; all atoms with the same atomic number combine in the same ways with atoms of other elements.

If you steal one proton-electron pair from an atom of carbon, it becomes an atom of the element boron (atomic number 5). Add a proton-electron pair to a carbon atom and it becomes a nitrogen atom (atomic number 7).

The word "isotope" means "same place," and was chosen because all the isotopes of one element fit in the same space in the *periodic table of the elements,* which lists the elements in order of atomic number in groups with similar chemical characteristics.

The half-life of a radioactive isotope is a measure of the *rate* at which its atoms decay into another isotope. The actual decay of a single atom takes only a tiny fraction of a second, but the time at which a particular atom in a sample of a radioactive isotope will decay cannot be predicted. It may decay in the next second—or, in the case of an atom of uranium^{238}, billions of years from now. The half-life of a particular radioactive isotope is the time it takes for an average of half the atoms in the sample to decay.

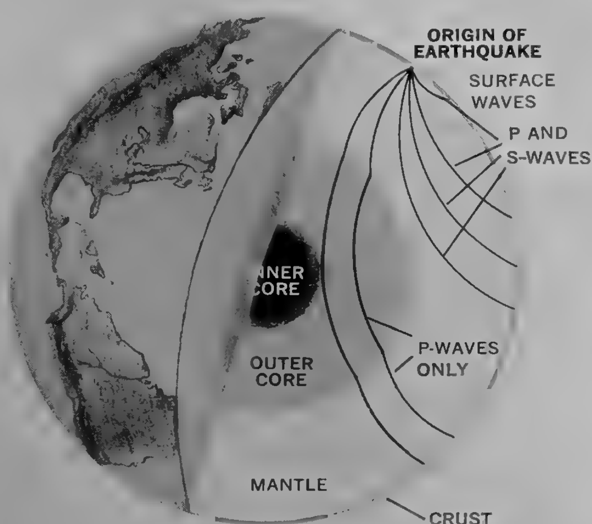
In each successive half-life period, half of the remaining atoms decay. If the piece of old wood being dated by the carbon^{14} method *(see diagram and caption, page 16)* were giving off only five radiation "signals" per minute, it would contain only *one-quarter* as many carbon^{14} atoms as the new wood. This means that *two* half-lives of carbon^{14} (about 11,460 years) had passed since the old wood was part of a living tree.

Brain-Boosters

Mystery Photo. You can tell that the wind was blowing from left to right because a sand dune always builds up steeper on the windward side of an obstacle. Blown snow also forms dunes.

What would happen if? Bottle D would collect the smallest amount of rainwater, while bottle B would fill up first. Encourage your pupils to bring in bottles of different sizes and shapes, and set them outdoors to collect rain. The class can then use rulers and measuring cups to measure the weight and volume of the rainwater collected by each bottle.

A cone-shaped container (such as E in the diagram) is usually chosen for a rain gauge. Such a container collects water over a wide area, but funnels it into a narrow space. Thus a small amount of water can have a relatively great effect on the water level in the
(Continued on the next page)



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.

Using This Issue . . .

(continued from page 3T)

gauge, making very precise readings possible.

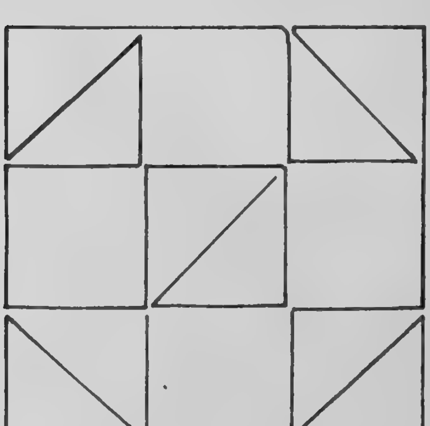
Can your pupils figure out how the weatherman decides how many "inches" of rain have been collected in such a container? (By figuring out how high the water would have risen in a cylinder-shaped container that had a top opening of the same size as that of the cone-shaped container.)

Can you do it? Distribute some paper matches (separated from the matchbook so that they can't be lit) and challenge your pupils to make one land on its side. Perhaps someone will discover that bending the match into a V-shape will do the trick.

Fun with numbers and shapes. This puzzle will require careful study before anyone can come up with the answer, but all of your pupils should be able to see that ring 3 is the "master" ring, because it is the only ring through which all the other rings are looped. Rings 1, 2, and 4 each go either completely under or completely over one another, but not *through*. Let the class experiment with string loops to see how one loop can hold together three others in this way.

For science experts only. The South Pole consists mainly of a huge land mass, while the North Pole has a great deal of water surrounding it. Since water can hold more heat than land can hold, the oceans of the North Pole have a warming effect on that area as they store and slowly release their heat.

Just for fun. Here is how to draw the design without crossing or retracing any lines.



nature and science

VOL. 7 NO. 13 / MARCH 16, 1970

How many butterflies to a pound? How do you make blue jays throw up?

To find out, see pages 7-9

WEEDS, BIRDS, AND BUTTERFLIES

Sometimes foresters set forest fires... see page 2

FIRES IN THE WOOD CAN BE GOOD

nature and science
VOL. 7 NO. 13 / MARCH 16, 1970

CONTENTS

PICTURE CREDITS: Cover, United Press International; pp. 2, 5, 7-16, drawings by Graphic Arts Department, The American Museum of Natural History; pp. 2-3, photo courtesy of U.S. Forest Service; p. 4, top photos by Leonard Lee Rue III, bottom photo courtesy of U.S. Forest Service; p. 6, photos from AMNH; p. 7, photos by Lincoln P. Brower; p. 8-9, photos by Laurence Pringle; p. 13, photo by David Webster; p. 14, photo by Morris Warman, New York Medical College.

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

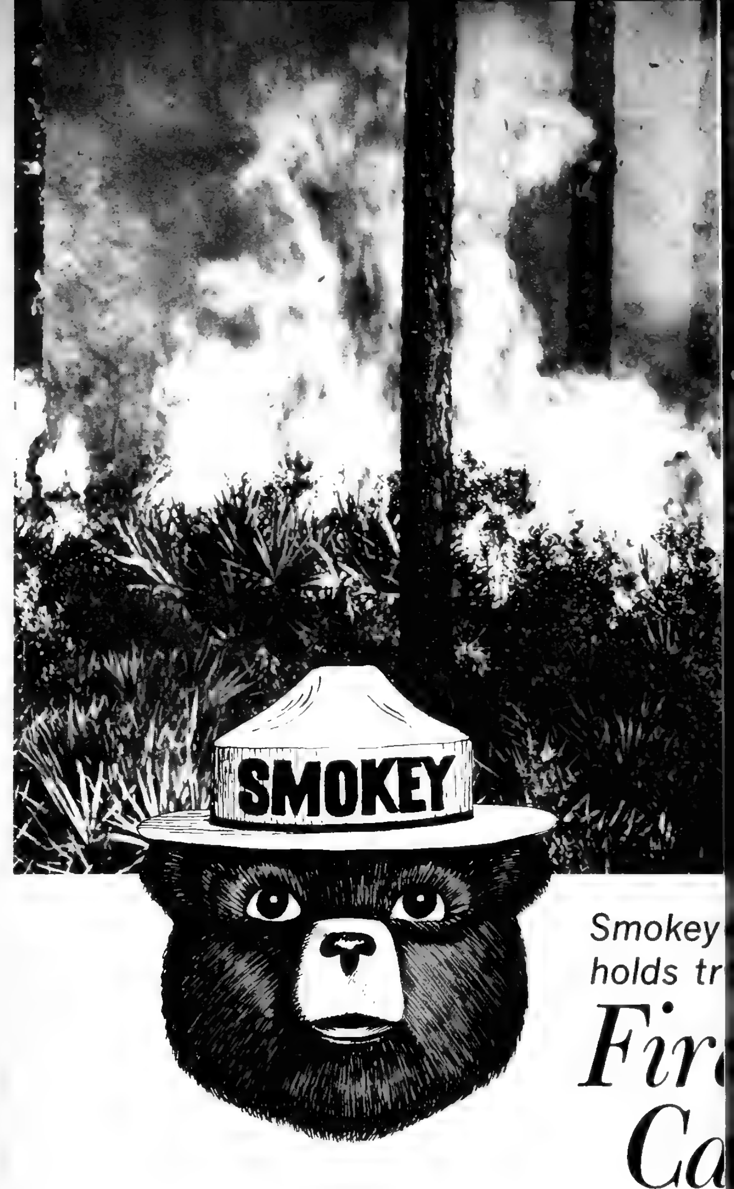
EDITOR-IN-CHIEF Franklyn K. Lauden; **EXECUTIVE EDITOR** Laurence P. Pringle; **ASSOCIATE EDITOR** R. J. Lefkowitz; **ASSISTANT EDITORS** Margaret E. Bailey, Susan J. Wernert; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

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.



Smokey
holds tr

Fir
Ca

by James E. Coufal

■ "Remember—only *you* can prevent forest fires!" is t message spread by Smokey the Bear. People cause ni out of every ten forest fires.

The warnings of Smokey, and of foresters, have help make people more careful. Fewer acres burn each ye although more people use forests for hiking, camping, ar hunting. But each year, more and more forest fires *are s by the foresters themselves.*

Foresters have learned that fire is a good way of helpi certain kinds of trees grow. A wildfire is as dangerous ever. It destroys trees and animals, and makes the lar ugly and scarred. The difference between a wildfire and fire set by foresters (called a *prescribed burn*) is in t amount of heat that the fire produces.

Light My Fire

Prescribed burning copies what happens in natural fir caused by lightning. These fires, and those set long ago b Indians to clear land or drive out game, have made mar

ear's warning about forest fires still
ut at certain times, in certain places...

n the Wood
Be Good

valuable kinds of trees plentiful in the United States. Known as the "fire types," some of these kinds of trees are Douglas fir (the leading timber producer in the country), most kinds of southern yellow pine (the leading source of wood for making paper), ponderosa pine, western and eastern white pines, lodgepole pine, red pine, jack pine, and aspen.

The seedlings of most of the fire-type trees can't grow if the soil is covered with a deep *litter layer* of fallen leaves and twigs. But many less valuable trees can grow through this layer. Most pine seedlings can't grow in the shade of taller trees, while other trees can. Most of the fire types can't compete with the others for sunlight and water. When other trees are growing in an area, the fire types do not thrive there.

But the fire types have characteristics that help them "capture" a fireswept area. Many of the pines have thick bark and can live through the heat of a small fire. The seed-bearing cones of some pines actually need heat to open and release the seeds. After a fire, the seeds fall on uncovered soil; there is little or no litter layer to block the growth of the fire-type seedlings. Once they begin growing in an area where there are few other trees, the fire types grow very fast. In these ways, fire helps establish crops of the kinds of trees most valuable to man *(see photos).*

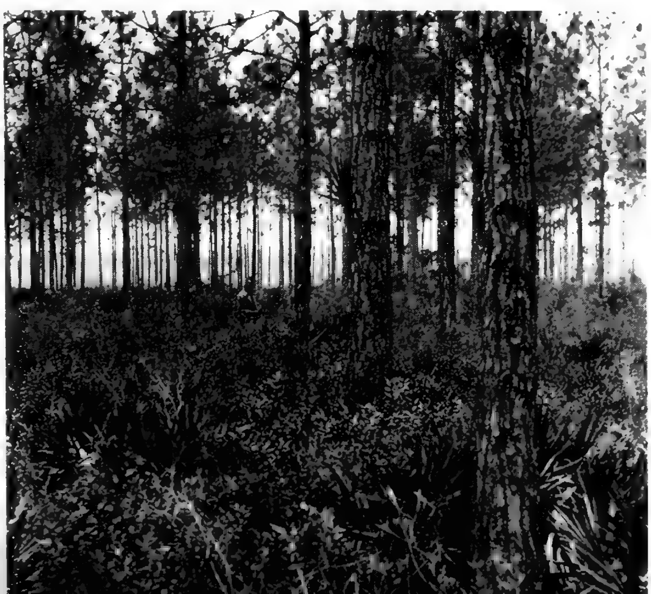
Whether To Burn

Burning a forest can start the growth of valuable trees. But foresters set fires only after careful planning. They watch the weather closely. Usually, a prescribed burn is set a few days after a rain, so that the fuel is damp, and on a day when the air is damp. These conditions keep the fire from producing too much heat, and help keep it under control. Most fires are set in winds of three to five miles an hour—winds light enough to keep the fire under control, and yet strong enough to help it spread.

The area to be burned is kept small, and the fire is closely guarded. On one four-acre burn, a "fire break" was made by clearing away all the vegetation in a narrow strip

(Continued on the next page)

Underbrush in this forest (left) blocked the growth of valuable seedlings. Prescribed burning removed most of the underbrush (right).



Elk, bobwhite quail, and other animals need shrubs and grasses for food. Burning their ranges every few years has increased the food supply by preventing the growth of other plants.

Fires in the Wood (continued)

surrounding the area. Six men with a bulldozer stayed near the fire break so that if the fire jumped across the strip, they could make another fire break.

Fighting Fire with Fire

Prescribed burns can do more than establish forests of valuable pine. Wildfires do a lot of damage in forests that have a lot of fuel in the litter layer and underbrush. If this fuel is burned in a prescribed fire, a later wildfire can be put out before much destruction occurs.

In 1962, a fire whipped through a California forest—but when it reached a plot of land where a forester had been trying out the method of prescribed burning, the fire was easily controlled. This use of fire, called *hazard reduction,* protects not only the trees, but also the animals and soil in the forest.

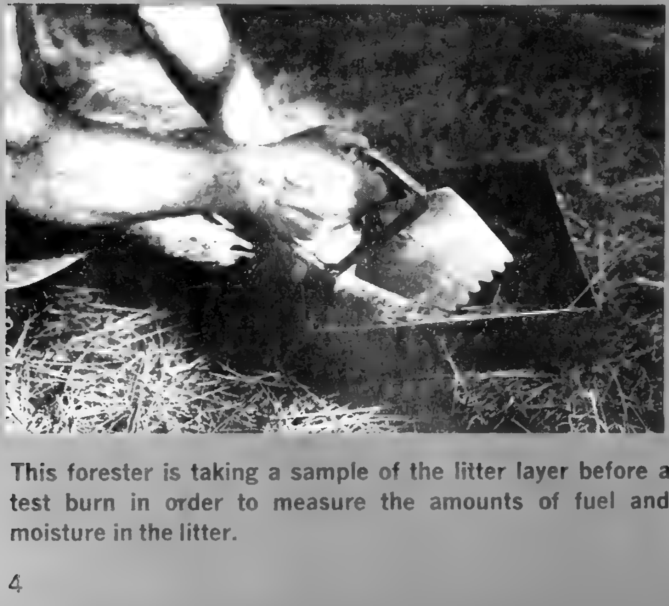
Prescribed burns can be good for wildlife in another way, as the tale of Kirtland's warbler shows. This small bird nests only in northern Michigan. Five years ago, its population was less than a thousand, and still decreasing.

Wildlife biologists discovered that the warbler nests only near jack pines of a certain height. Jack pines are fire-type trees. Foresters had been preventing the forest fires that had swept the area in the past and helped jack pines grow. The only jack pines left in the area were too tall for the warblers.

To save the warbler, foresters have been burning a small part of Huron National Forest in Michigan every few years. In this way, they hope that there will always be enough young jack pines to provide nesting sites for the rare warbler.

This job, and the others done by prescribed burns, could be accomplished in other ways. The less valuable trees could be removed with chain saws, rather than with fire. Chemicals could be used to destroy the litter layer and underbrush in a forest, so that wildfires could not start. But until these ways become less expensive, foresters will continue both to prevent forest fires, and to start them ■

FOREST FIRE—FRIEND OR FOE?



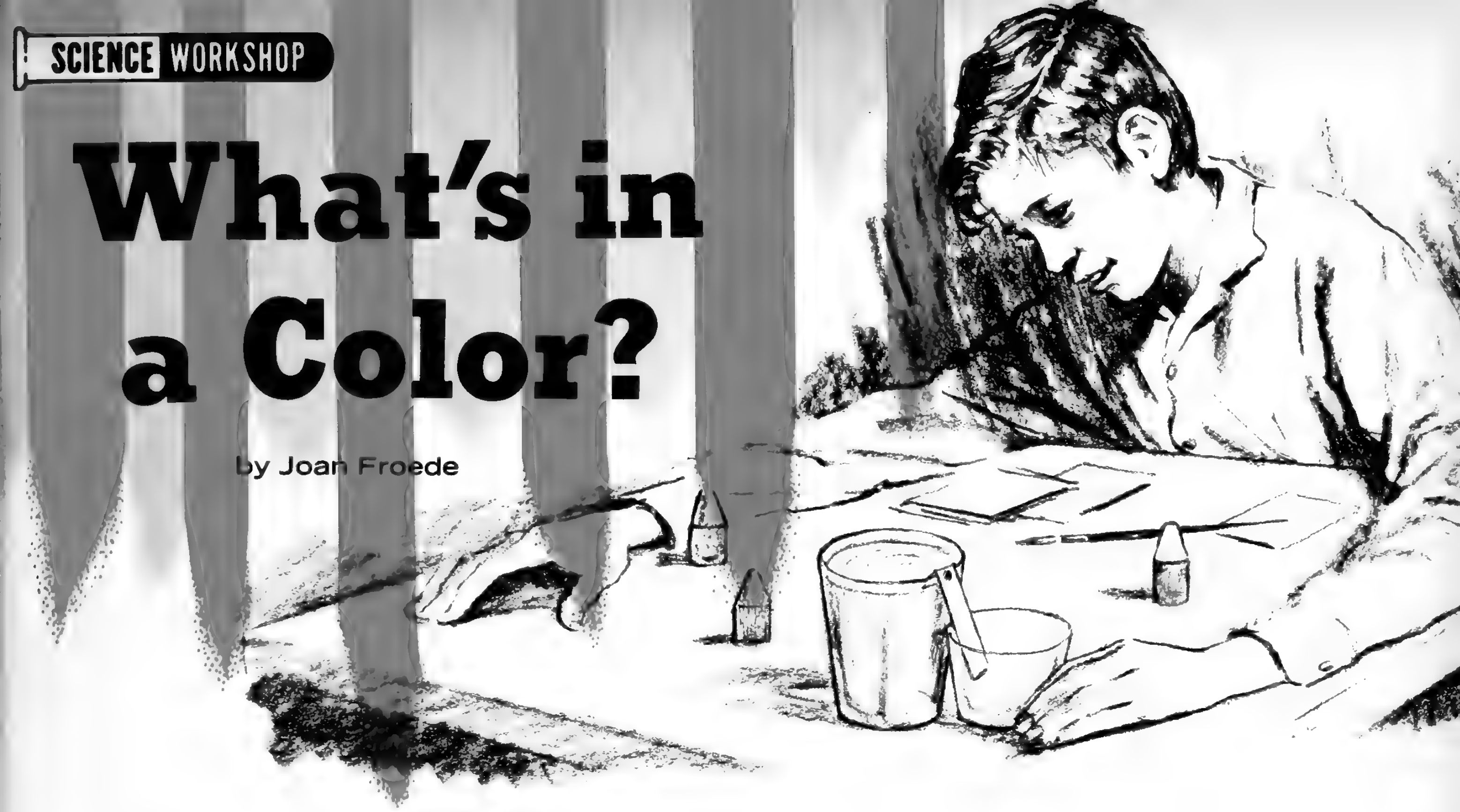
This forester is taking a sample of the litter layer before a test burn in order to measure the amounts of fuel and moisture in the litter.

The idea of burning part of a forest, even in a controlled fire, inflames some foresters. One reason is that even a prescribed burn can escape its controls. One such fire in California caused five million dollars in damages. Another reason that some foresters oppose prescribed burning is that fires can increase *erosion* (the wearing away of soil by wind and water), because much of the vegetation that holds the soil is removed. Also, the smoke from fires can pollute the air, prevent some kinds of fruit from ripening, and drive away game animals.

But erosion and the effects of smoke also occur after a wildfire—probably more so. Prescribed burning can prevent some of these wildfires. In many indoor and outdoor laboratories, scientists are trying to figure out the best ways of burning for different weather conditions, so the burns will never escape their controls.

What's in a Color?

by Joan Froede



■ If you have dyed Easter eggs with food coloring from a grocery store, you probably know that you can make many different colors of dye by mixing the red, yellow, green, and blue dyes that come in the package.

Food coloring is made of *pigment,* or coloring material, dissolved in water. *(To find out how pigment gives a substance its color, see "What's in a Rainbow?",* N&S, *January 19, 1970.)* When a hard-boiled egg is dipped in the dye and allowed to dry, the water evaporates, leaving the pigment clinging to the shell.

When you mix dyes of different colors, do their pigments change into a pigment of the new color? You can find out by a simple process called *chromatography.* (You can use this method to investigate nearly any colored liquid or a colored solid that can be dissolved in a liquid.)

Making a Chromatogram

You will need a set of food colors, a clean watercolor brush (or some clean toothpicks), a glass nearly full of tapwater, several strips of white paper towel about 8 inches long and ¾ of an inch wide, and an empty glass that is shorter than the glass with the water in it.

Dip the brush (or toothpick) into one of your dyes, and use it to make a spot of color about ¼ inch wide on a strip of paper towel, about an inch from one end. Let the spot dry for several minutes.

Now fold the strip about ½ inch from the tip of the spotted end. Hang the folded end over the rim of the glass of water so the tip just touches the water *(see diagram).* The spot should be on the outside of the glass. Place the long end of the strip in the empty, shorter glass so the paper does not touch anything between the rims of the two glasses.

Watch what happens as the water moves through the paper. As it passes the color spot, it will probably pick up some pigment and carry it down the paper. If the dye you are testing contains more than one kind of pigment, you can tell by the colors you see.

Do you think that some pigments tend to stick to paper more strongly than others do? How can you tell?

The strip of paper on which the colors in this dye are recorded is called a *chromatogram.* You might make a chromatogram of each of the other food colors in your package and see whether any of them contain pigments of more than one color. What will happen if you mix several of the dyes in your package to make a "new" color, and then make a chromatogram of it?

More Things To Investigate

Does the ink in your pen contain pigment of more than one color? Does blue ink contain the same pigments as blue food color? How about other colors of ink and food color? Which clings to paper more strongly— the pigment in *permanent* ink or the pigment in *washable* ink of the same color? How can you find out?

Try making chromatograms of other colored liquids around your house—watercolor paints, colored mouthwash, tea, coffee, beet juice, and so on. Which substances have "pure" colors (colors made by only one pigment)? Which contain at least several different pigments? You may find some surprising ways to combine pigments or dyes and make "new" colors ■

WHAT'S NEW

by
B. J. Menges

When a chimpanzee sees itself in a mirror for the first time, it acts as if it were seeing a stranger, and makes theatening noises. But after several days of using the mirror, the chimp seems to recognize itself. For example, while looking at its reflection, the chimp may pick bits of food from its teeth.

These observations were made with captive chimps by Gordon G. Gallup Jr., of Tulane University, in New Orleans. In one test, the psychologist put dye marks above the eyebrows of sleeping chimps. When the chimps later awoke and looked in the mirror, they touched the marks with their fingers. This was further evidence that they recognized themselves in the mirror. When monkeys were given the same tests, they showed no signs of recognizing themselves.

To make a geyser, drill a hole 6 inches wide to a depth of 115 feet in an area that is known to have hot springs. That's what scientists did near Adel, Oregon. The resulting geyser erupts every eight to 10 hours, shooting hot water and steam to a height of more than 100 feet. Scientists have been studying this man-made geyser to learn more about the workings of natural geysers.

After the man-made geyser erupts, water fills the hole and begins to heat. Water part-way down the hole gets hotter than the water above or below. It soon begins to boil slightly, sending bubbles of steam into the cooler water above, where they condense into liquid again. This gradually adds heat to the water above until it, too, reaches the boiling point. Then, much of the water suddenly turns into steam, expanding with such explosive force that water and steam are flung high into the air.

Ants play host to certain beetles. Some species of rove beetles are welcome guests in the nests of the ants because they give off a liquid that the ants drink. Young rove beetles hatch in the nest of one species of ant, migrate to the nest of a second species of ant, and finally return to a nest of the first species, where they lay their eggs.

Scientists have known about this for almost 60 years, but they've been puzzled about one thing. Many different species of ants nest in the home grounds of the rove beetles, and the nest entrances of one species of ant look like those of another species. So how do the beetles find the right nest? Recently Bert Hölldobler of the University of Frankfurt am Main, in Germany, found the answer. The beetles are drawn to the right nests by certain odors that are given off only by these ants.

How do you wake up a "sleeping" seed? That's what two Canadian scientists wanted to know. E. H. Halstead and B. T. Vicario of Saskatchewan University were studying the seeds of wild rice, a grass that grows in shallow northern lakes. These seeds must spend six months at near-freezing temperatures before they will sprout. The delay enables the seeds to survive the winter and sprout in spring. But the scientists wanted to grow the seeds indoors during the winter. A delay could ruin their studies.

Knowing that heat, light, or chemicals can "awaken" some "sleeping" seeds, the scientists experimented with wild-rice seeds. When these were exposed to *ultrasound*—sound too high-pitched for the human ear to hear—most of the seeds sprouted. The scientists think ultra-sonic vibrations may cause tiny air bubbles to form and break rapidly in the hard seed coat. This could make it easier for air or water to enter the coat, and possibly trigger the sprouting.

"An earthquake is coming!" A warning like this, if accurate, could save many lives. But such warnings cannot be given now, because scientists cannot yet predict earthquakes.

A new instrument may change that. It's a highly sensitive magnetometer—a device that can measure the earth's *magnetic field (see "The Mystery of the Changing Poles," page 10)* 10 times as accurately as most instruments now in use. According to one theory, stresses that build up in part of the earth's crust before an earthquake cause changes in the earth's magnetic field in that area. If this theory is correct, and if the new instrument can detect those changes, then scientists may have the key to earthquake prediction.

Getting rid of bustards was a problem at an airbase near Madrid that is run jointly by the United States Air Force and Spain. Over 10,000 of these large game birds had taken up residence along the runways. Collisions between aircraft and flocks of bustards were causing damage costing more than a million dollars a year, as well as endangering airmen. Attempts to scare the birds away by firing rifles did no good.

Then the Air Force called in a naturalist named Félix de la Fuente. An expert in falconry, he trapped six falcons and trained them to hunt at the airbase. These hawks are natural enemies of the bustards, and before long most of the bustards had fled.

Recognize any of these animals? Don't try to buy one, or anything made from them. All belong to species that are in danger of dying out, so the states or countries where they are found have laws against exporting such animals or their hides, fur, shells, feathers, and so on. And now the United States has made it a federal crime to *import* any animals (or parts of animals) that are considered "endangered species" in their native country, or to take any animal or part of an animal out of a state that has laws protecting the animal.

Dr. Lincoln Brower tried to answer some "simple" questions about some common plants and animals. But each discovery he makes leads to new and more fascinating puzzles about . . .

WEEDS, BIRDS, and BUTTERFLIES

by Laurence Pringle

■ Milkweeds . . . blue jays . . . monarch butterflies—three very different forms of life. Yet they are tied together in complex and surprising ways.

They have been studied for the past 12 years by Dr. Lincoln Brower, Professor of Biology at Amherst College in Amherst, Massachusetts. Recently I visited Dr. Brower's laboratory and he told me about some of his investigations.

Dr. Brower chose to study birds and insects because he is fascinated by the ways in which colors and patterns are important in their lives. For the same reason he hopes someday to study the lives of coral-reef fish (see *"Forests Beneath the Sea,"* N&S, *December 1, 1969).*

Dr. Brower began his studies by testing an idea that had been around for many years. For a long time, scientists have known that many kinds *(species)* of milkweed plants contain poisons that cause animals to throw up, or even to die. Some animals, however, aren't affected by the poisons. The caterpillars *(larvae)* of monarch butterflies eat the leaves of milkweeds. The poisons in the plants do not bother them. Later the larvae change into adult butterflies and fly about — targets for insect-eating birds. But birds usually avoid monarch butterflies. One possible explanation: birds avoid monarchs because the insects contain poisons from the milkweed plants. Dr. Brower decided to see whether this was true.

Butterflies by the Pound

Dr. Brower and his assistants raised great numbers of monarch butterflies *(see "Down on the Butterfly Farm," page 8),* feeding the larvae on milkweed leaves that were known to contain poisons. They raised about two pounds of butterflies. (It takes about 770 monarchs to make a pound!) A Swiss scientist then identified some of the chemicals in the milkweeds and butterflies. He found at least three of the same poisons in both the plants and the insects. This was evidence that milkweed poisons do become part of the bodies of adult monarch butterflies.

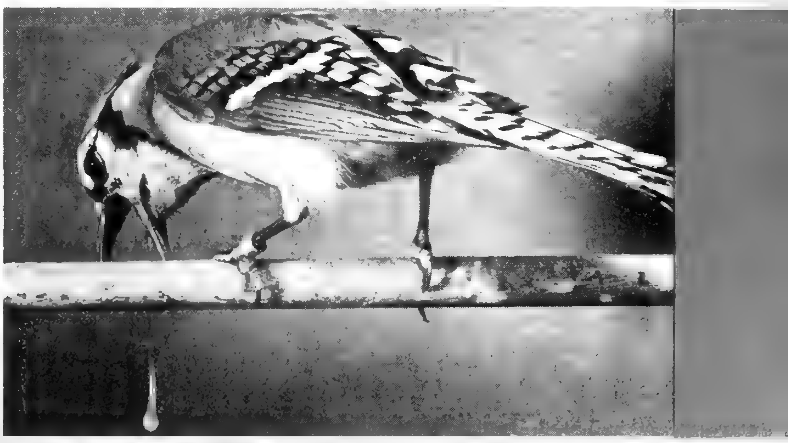
Next the biologists managed to raise some monarch caterpillars on cabbage leaves. Cabbage doesn't contain the poisons that are in milkweed. After some cabbage-reared caterpillars had changed to butterflies, they were offered as food to blue jays that were kept in cages *(see photos).*

"At first the blue jays didn't attack the butterflies," Dr. Brower said. "We found, however, that jays kept from food

(Continued on the next page)

A blue jay can eat monarch butterflies if the monarch caterpillar wasn't raised on poisonous milkweed.

When a jay eats part of a monarch raised on poisonous milkweed, it throws up, and avoids monarchs from then on.



for several hours would become hungry enough to attack and eat the butterflies. Once the jays tried the monarchs, they would eat them readily."

Then Dr. Brower offered the same jays some monarchs that had been raised on a poisonous milkweed. "Most of the birds promptly ate at least one butterfly. Within about 12 minutes, every bird became violently ill. The birds threw up as many as nine times over a half-hour period."

The birds soon recovered, but from then on they avoided eating monarchs. If the jays were very hungry, they would eat monarchs that had been raised on non-poisonous milkweeds. But the birds ate the butterflies very carefully, instead of swallowing quickly as before.

Where Do Monarchs Lay Their Eggs?

During the feeding experiments, Dr. Brower raised several different kinds of milkweed plant in a greenhouse. He was surprised to find out that one species contained no poisons. Blue jays ate butterflies raised on this species of milkweed just as readily as those raised on cabbage.

This led Dr. Brower to some new investigations. He found that some monarch butterflies are less poisonous than others, depending on the kind of milkweed the monarch caterpillars feed on. A single butterfly raised on one species of milkweed might contain enough poison to make eight blue jays sick. A butterfly raised on another species might contain enough poison to make just one jay sick.

Dr. Lincoln Brower *(right)* and Dr. Raymond Coppinger examine milkweed plants they are raising in a greenhouse. So far, they have collected about 60 species of milkweed from Costa Rica, Trinidad, Mexico, Florida, and New England.

There are many different species of milkweed, and scientists have studied the poisons of only a few. But it seems that some are very poisonous, some are not poisonous at all, and there are many in between. This raises a new question: Do monarchs lay their eggs on the more poisonous

Down on the Butterfly Farm

In order to raise the hundreds of monarch butterflies needed for his studies, Dr. Brower has a sort of "butterfly farm" in his laboratory. The room is specially designed to keep monarchs free of disease. The light dims automatically every few minutes, as if a cloud were passing over. In nature, this causes monarchs to fly, and the greater activity causes them to lay more eggs. These photos show how monarchs are raised at the butterfly farm.

Lab assistant Julie Fellows feeds a monarch by uncoiling its "tongue" into a sugar solution.

Female monarchs are put into a sack tied around a milkweed stem, where they lay eggs on the leaves.

species of milkweed, so that the butterflies that develop from the eggs will be highly poisonous to birds? Or do monarchs lay their eggs on just any milkweed, regardless of how poisonous it is?

Dr. Brower now has some partial answers to these questions. He found that some very common species of milkweed in the northeastern United States are not poisonous. Monarchs raised on them are readily eaten by birds.

Dr. Brower also found that wild populations of monarchs in the northeast contain many individuals that are not poisonous to birds. He caught many wild monarchs and fed some of them to 50 different jays. Only 12 of the birds (24 per cent) got sick. This means that just 24 per cent of the wild monarchs had eaten poisonous milkweed as caterpillars. The other 76 per cent had eaten non-poisonous milkweed.

Next Dr. Brower wants to find out whether about 76 per cent of the milkweeds in the Northeast are non-poisonous. If so, this would be evidence that butterflies *do not* seek out the poisonous plants on which to lay their eggs.

I was puzzled. From all the evidence, it was clear that blue jays (and probably other birds) stop eating monarchs once they have been made sick by eating a poisonous one. Why then, didn't all monarchs lay their eggs on poisonous milkweed? That way, all monarchs would be poisonous. A bird would eat just one, then learn to leave the monarch species alone.

Dr. Coppinger feeds mealworms to a blue jay. Some of the jays used in the experiments were caught in the wild as adults. Many others were nestlings that were brought to the laboratory and raised there. For a few weeks, several people worked from 7 a.m. until 11 p.m., caring for about 90 of the young birds.

A few days later the caterpillar attaches itself to the top of its container and forms a chrysalis.

About two weeks later an adult butterfly wiggles out of the chrysalis. The butterflies are killed and frozen, ready to be fed to birds. Whether they are poisonous depends on the kind of milkweed fed to the caterpillars.

After a caterpillar hatches from an egg, it is put into a container with milkweed leaves for food. After two weeks, the caterpillar is almost completely grown.

"All monarchs don't have to be poisonous for the poisons to protect the species," Dr. Brower explained. "If only one out of four butterflies is poisonous, this is still a great help in the survival of the species. A bird may eat several monarchs, but, sooner or later, it will eat a poisonous one and leave monarchs alone from then on."

More Puzzles To Solve

Dr. Brower and his assistants are raising still more birds and butterflies *(see photos),* for they have more questions to answer. For example, they wonder whether older, experienced birds teach young birds to avoid monarchs. They plan to test this idea in the laboratory, first training some jays to avoid monarchs, then putting them with birds that have never seen a butterfly. The reactions of the inexperienced birds will be compared with those of other inexperienced jays that have had no contact with older, "wiser" birds.

The biologists are also trying to learn more about the chemistry of the milkweed poisons. What happens to the poisons once they are taken into the body of a monarch caterpillar? So far, the biologists know that some of the poisons pass out of the caterpillar's body with wastes. Others end up in the body of the butterfly that develops from the caterpillar. Still others "disappear," probably changing into some other substances.

Tracing and identifying the poisons will be quite a job, and it will probably lead to still further questions about weeds, birds, and butterflies ■

The Mystery of the Changing Poles

by Diane Sherman

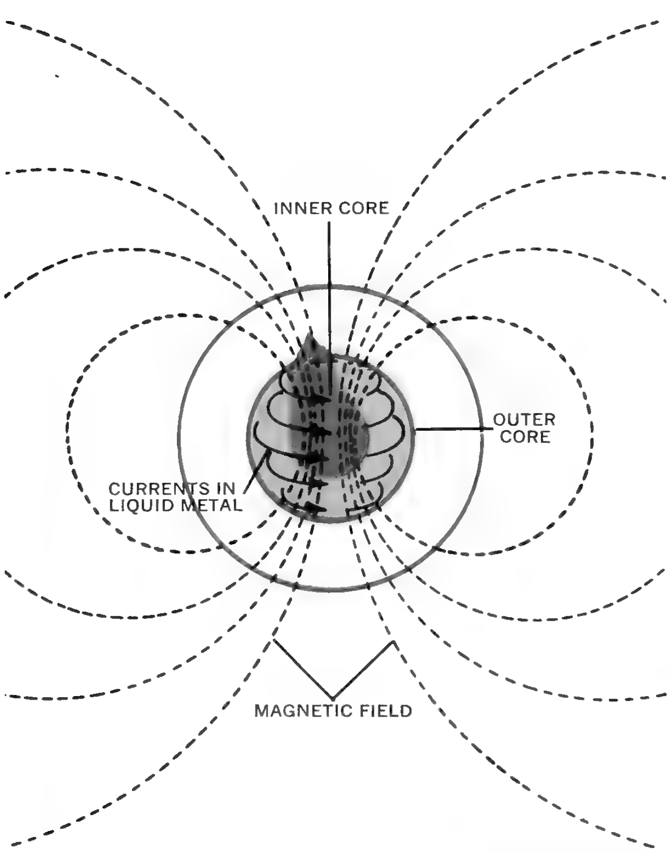
Part 2

Part I of this article told how scientists learned from "magnetic stripes" in the ocean floor that the earth's North and South Magnetic Poles have switched positions many times in the past. What could have caused this to happen? If it happened again, how might it affect life on earth?

■ Scientists have suggested several possible ways in which the earth's magnetic poles might get reversed. But it is hard to tell which of these theories is correct—or whether any of them is. The trouble is, no one knows for sure what makes the earth behave like a magnet in the first place.

All we know for sure is that the earth has a *magnetic field* (a space with lines of magnetic attraction running through it) shaped *as if* the earth's center were a magnet.

Scientists believe that the earth's *core,* or center part, is mostly iron—the most common magnetic element of all. But the outer part of the core seems to be made of iron and other metals that are kept melted by the tremendous heat inside the earth. If you've ever heated an iron magnet, you know that it quickly loses its magnetism—at least until it cools again. So the melted iron in the earth's core can hardly be a magnet.



The earth may have an *inner core* of solid metal surrounded by an *outer core* of molten metal. If the earth's rotation makes the liquid metal flow around the inner core from west to east *(see arrows)*, the motion of this metal through the earth's magnetic field may produce electric currents which, in turn, could produce the magnetic field.

A Dynamo in the Earth?

One way that such a core could produce the earth's magnetic field has been suggested by two geophysicists—Dr. Edward C. Bullard in Great Britain and Dr. Walter M. Elsasser in the United States. (Both came up with the same idea at about the same time.) It is based on two facts about magnetism and electricity that you can test for yourself:

- When electricity is flowing through a wire, a magnetic field surrounds the wire *(see Project 1).*
- When a wire is moving through a magnetic field, electricity flows in the wire *(see Project 2, on page 12).* The electric current that lights your home is produced when a coil of wire is turned through the field of a powerful magnet by a steam engine or a steam or water turbine. A coil-and-magnet device like this is called a *dynamo* or a generator.

Dr. Elsasser and Dr. Bullard suggested that the earth's core is a "self-magnetizing" dynamo. The "wire" in this dynamo is the melted iron in the earth's outer core. This liquid iron, they believe, moves around like water boiling in a pot—rising when it is hot and sinking as it cools. These up-and-down currents are twisted by the earth's rotation *(see "How Do We Know the Earth Is Spinning?",* N&S, *October 13, 1969),* which makes the iron flow around the inner core from west to east *(see diagram).*

Iron is a good *conductor,* or carrier, of electricity. So as the iron moves through the earth's magnetic field, electricity flows through the iron in the direction it is moving, from west to east. And this flow of electricity, in turn, produces the earth's magnetic field. Many geophysicists now accept the idea that the earth is like a dynamo that makes its own magnetic field.

Some scientists have built models of self-magnetizing dynamos and set them to work. Every so often, the magnetic field of one of these dynamos *reverses itself!* The time between reversals varies widely. (So does the time between the reversals of the earth's magnetic field.) Over long periods, though, the dynamo spends as much time with its magnetic poles lined up one way as it spends with them lined up the opposite way. (So does the earth.) Perhaps reversing poles is "natural behavior" for a self-magnetizing dynamo.

Wobbles, Earthquakes, Meteorites

Not all geophysicists accept this theory completely. Some think that heat currents may not be strong enough to power the earth's dynamo. Perhaps the currents that Dr. Elsasser thinks are caused by heat are instead caused by wobbles in the earth's rotation. We know that wobbling does take place. Some of it is caused by changes in the pull of gravity between the earth, the sun, and the moon. Earthquakes, too, may tend to keep the earth wobbling.

Dr. L. Mansinha and Dr. D. E. Smylie of the University of Western Ontario, in Canada, compared the dates of the last 22 major earthquakes with the dates of "extra" wobbles in the earth's spin. Fifteen of the 22 quakes happened at about the same time as an extra wobble, so there may be some connection between the wobbles and at least some of the earthquakes. Some scientists think that extra-strong wobbles might cause changes deep within the earth, and that some wobbles might even be strong enough to make the earth's magnetic poles flip.

Another possible cause of pole reversal was suggested by Dr. Bruce Heezen, of Lamont Geological Observatory, in Palisades, New York, and Dr. Bill Glass, who worked with Dr. Heezen. While studying sediments from the ocean floor, they found many tiny glass-like stones called *tektites*. Some scientists believe tektites are formed when comets or meteorites collide with the earth.

Heezen and Glass found tektites that were all the same age strewn over a 6,000-square-mile area of the sea bottom. The tektites are about 700,000 years old, so they may have been flung across the earth about the same time the last magnetic reversal took place.

To spread tektites over such a large area, it would take a meteorite a mile wide, weighing a billion tons or so. If a meteorite like that crashed into the earth, it surely would have disturbed the flow of molten iron in the earth's core. Could it have caused enough disturbance to reverse the earth's magnetic poles?

Scientists also know that tektites fell on the Ivory Coast in Africa about a million years ago, when an earlier magnetic switch took place. Still, this would account for only two of the 171 magnetic reversals that we know about. It may be, of course, that such changes can be triggered by more than one cause; geophysicists just don't know.

Could Magnetic Reversals Affect Life on Earth?

When the magnetic poles flip, startling events may occur on earth. We know that a reversal took place about 2,500,000 years ago. When Dr. Heezen examined fossil remains in ocean sediments that were laid down at that time, he discovered several new kinds of tiny animals that do not appear in earlier sediments. The new forms continued without much change until the most recent pole reversal, 700,000 years ago. Then—again quite suddenly—some

(Continued on the next page)

PROJECT 1
Making Magnets with Electricity

Here's a way to investigate the magnetic field that forms around a wire when electricity is flowing through the wire. Place a long wire over a pocket compass so that the wire runs in the same direction as the compass needle (*see Diagram A*). Connect the ends of the wire to a flashlight cell. (Don't leave the wire connected to the cell very long. Do you know why?) What happens to the compass needle when electricity flows through the wire?

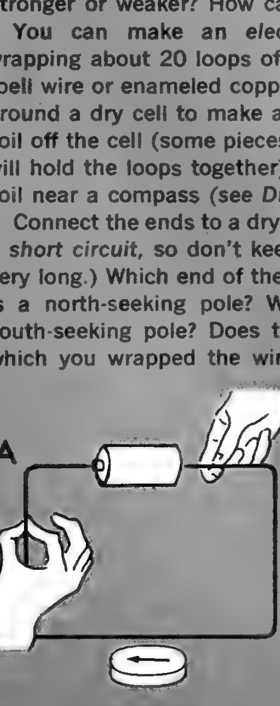
See what happens when you place the compass above the wire. Try turning the cell around. Will the compass needle turn if you place the wire across, or *perpendicular* to, the needle before you connect the wires to the cell? Turn the cell around again and watch what the needle does.

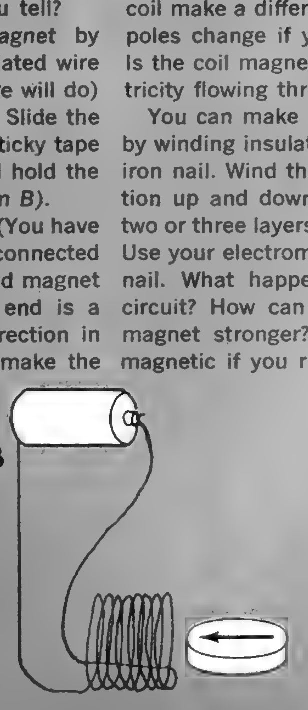
How far from the wire is the magnetic field still strong enough to affect the needle when electricity starts to flow through the wire? If you hold two cells together in series (as they are in a flashlight), they will send more electricity through the wire. Does this make the magnetic field around the wire stronger or weaker? How can you tell?

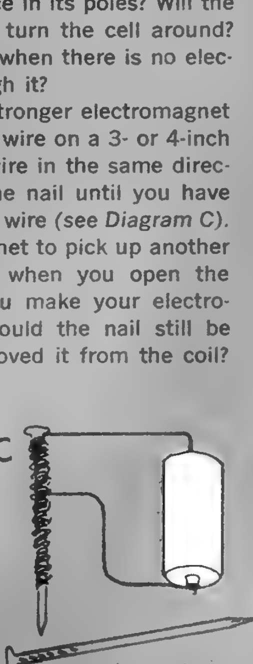
You can make an *electromagnet* by wrapping about 20 loops of insulated wire (bell wire or enameled copper wire will do) around a dry cell to make a coil. Slide the coil off the cell (some pieces of sticky tape will hold the loops together), and hold the coil near a compass (*see Diagram B*).

Connect the ends to a dry cell. (You have a *short circuit*, so don't keep it connected very long.) Which end of the coiled magnet is a north-seeking pole? Which end is a south-seeking pole? Does the direction in which you wrapped the wire to make the coil make a difference in its poles? Will the poles change if you turn the cell around? Is the coil magnetic when there is no electricity flowing through it?

You can make a stronger electromagnet by winding insulated wire on a 3- or 4-inch iron nail. Wind the wire in the same direction up and down the nail until you have two or three layers of wire (*see Diagram C*). Use your electromagnet to pick up another nail. What happens when you open the circuit? How can you make your electromagnet stronger? Would the nail still be magnetic if you removed it from the coil?

A


B


C


kinds of animals disappeared; others changed more rapidly than usual; and some brand new forms of animals appeared. This posed another puzzle: How could magnetic reversals have such a great effect on life?

Dr. Heezen and others have suggested that when the poles reverse, there may be a period when the earth has no magnetic field. If the magnetic field disappeared, it could no longer block the particles of deadly *radiation* that stream toward us from the sun.

Besides being able to destroy life, radiation can cause changes in the cells of an animal that determine what characteristics the animal passes on to its offspring. If certain kinds of radiation from the sun could reach the earth's surface, they could wipe out many kinds of plants and animals, and also lead to the creation of new forms of life.

The question of what might happen during a magnetic reversal took on more importance when two scientists suggested that the earth might be due for another reversal. Using records dating back to 1670, Keith McDonald of the United States Environmental Science Services Administration and Robert Gunst of the U.S. Coast and Geodetic Survey figured out that the strength of the earth's magnetic field has gone down 15 per cent in the past 300 years. If the field continued to weaken at the same rate, it would disappear by the year 3991. McDonald and Gunst suggested that for 500 years before that date and 2,000 years after, the magnetic field might provide no protection from the sun's deadlier forms of radiation.

Other scientists disagree. Men like Dr. Allen Cox, a geophysicist at Stanford University, in Palo Alto, California, admit that the earth's magnetic field is getting weaker but they doubt that it is heading for a reversal. They point out that the magnetic field has grown weaker, then stronger, many times in the past without reversing its poles.

In any case, new studies suggest that even if the poles should reverse, men might not be affected. The earth's atmosphere helps shield us from the more dangerous kinds of radiation. So even if the earth's magnetic field disappeared for a time, there might not be much more radiation reaching us than we get now at times when the sun sends out more radiation than usual.

If extra radiation does not reach the earth during a magnetic switch, though, how can we explain the changes Dr. Heezen found in ocean life? Dr. Cox thinks those changes may have been caused by changes in the climate.

We know that volcanoes were unusually active at the times of some of the magnetic reversals. The dust thrown into the atmosphere by volcanoes blocks some of the sun's heat and light from reaching the earth's surface. Perhaps so many volcanoes were active that their dust caused the climate of the earth to cool. A change in climate can kill off some kinds of animals, and cause other kinds to change rapidly. So Dr. Cox suggests that volcanic dust, not radiation, could have caused the changes in life on earth.

From the record of the past, we can be pretty sure that the earth's magnetic field will reverse again some time in the future. Perhaps by then scientists will know more about its causes and effects. Perhaps you can help find out ■

PROJECT 2
Making Electricity with Magnets

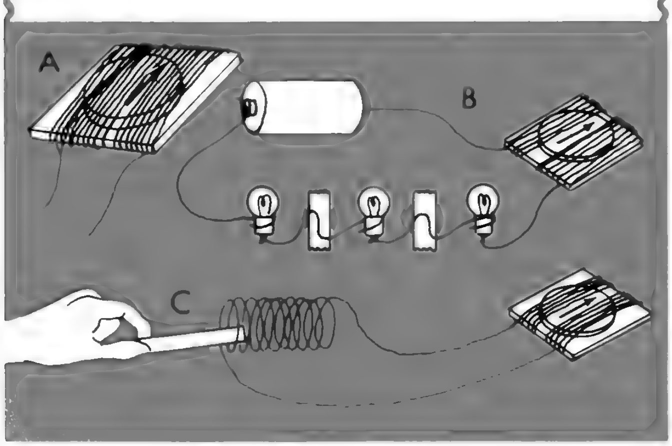
You can make electricity flow in a wire coil by moving it through a magnetic field. The currents you make will be very small, so you will need a sensitive current detector, called a galvanometer. You can make one with a pocket compass and some No. 24 enameled or cotton-covered copper wire. In a small square of stiff cardboard, cut a hole just large enough to hold the compass snugly. Turn the cardboard until the compass needle points to opposite sides of the square, then wind about 50 turns of wire around the center of the compass, in line with the needle *(see Diagram A)*. Leave a few inches of wire at each end, and cut or scrape about an inch of insulation off the wire at each end.

To test your galvanometer, connect enough flashlight bulbs in series with a single dry cell so that they get too little current to glow. Now connect your galvanometer in the circuit (see *Diagram B*). Can you detect a current?

Now make a coil by wrapping 50 turns of wire around a flashlight cell. Leave several feet of wire at each end of the coil, and remove an inch of insulation at each end. (Some pieces of sticky tape will help you hold the coil together as you slip it off the cell.) Connect the ends of the coil to your galvanometer. If you have a strong bar magnet, try moving it in and out of the coil *(Diagram C)*. (Or you can use the electromagnet you made by wrapping wire around a nail.)

Does electricity flow in the wire when the magnet is not moving? When it is going into the coil? When it is coming out of the coil? Is the electricity always flowing in the same direction? (How can you tell?) What happens if you turn the magnet around?

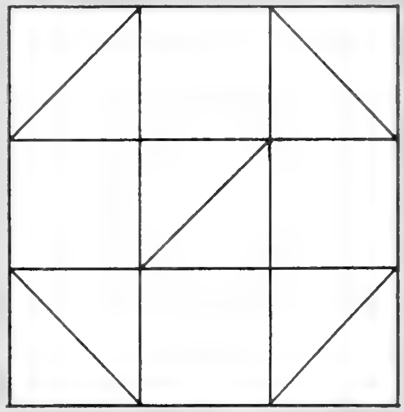
Would electricity flow if you moved the coil above the magnet? Try it and see. Do you think the speed with which the magnet is moved makes any difference?



prepared by
DAVID WEBSTER

MYSTERY PHOTO

Notice how miniature sand dunes have formed over the small bushes. Was the wind blowing from the left or from the right?

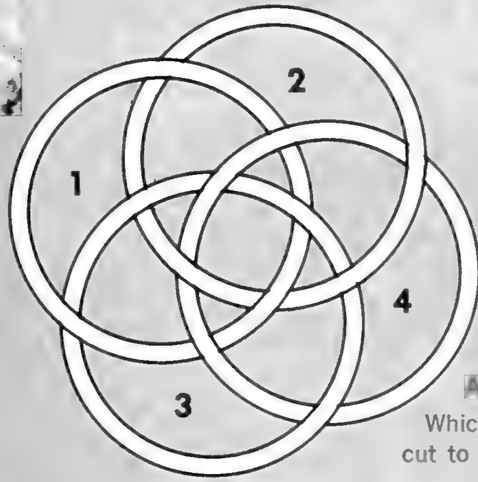


JUST FOR FUN

Trace the design shown without crossing a line or going over the same line twice.

FOR SCIENCE EXPERTS ONLY

Why is the South Pole colder than the North Pole?



FUN WITH NUMBERS AND SHAPES

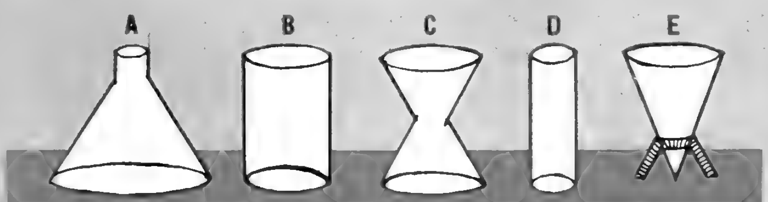
Which one of these rings must be cut to make all the rings come apart?

CAN YOU DO IT?

If you drop a paper match, it will usually land on its side. What can you do to a paper match to make it land on its edge?

WHAT WOULD HAPPEN IF?

Suppose these five bottles were set outside to measure rainfall. Which bottle would collect the smallest amount of rain? Which one would fill up first?



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The Mystery Photo is a close-up view of dry, cracked mud. The tiny "craters" were made by raindrops.

What will happen if? When you move your hands apart, one hand will remain under the 18-inch mark. The other hand will travel under the yardstick all the way to the end.

Can you do it? If you pull the bottom string slowly, the top string will probably always break. If you jerk the string, however, the bottom string usually breaks.

Fun with numbers and shapes: Line 4 is an extension of the line below it.

For science experts only: A candle would not burn well in a space ship that is in orbit, even though the atmosphere inside the capsule is much like air. Usually, the air is moving around a flame, as the warmed-up air rises and cooler air moves in to take its place. But in a "weightless" condition, hot air would not rise. Then the flame would go out when the oxygen in the air surrounding it became used up.

Radioisotopes and How We Use Them

by Roy A. Gallant

Part 4 of this series took man's idea of the atom one step further. It told how the Curies, Rutherford, and others discovered what radioactivity is, and that it is produced when certain kinds of atoms change into atoms of a different element. In the process, they throw off bits and pieces of themselves as energy.

■ Until about 1913, most scientists had thought that each atom of any particular element was exactly like every other atom of that element. According to this idea, each atom of gold was just the same as every other atom of gold; every atom of uranium was just the same, and so on.

As early as 1886, however, at least one scientist had questioned the idea of sameness. In 1912, J. J. Thomson *(see Part 2,* N&S, *February 2, 1970)* and F. W. Aston, also began questioning the idea.

They were experimenting with atoms of the gas neon. First, they stripped away electrons from the neon atoms. That left each atom with a positive electrical charge, so that the paths of the atoms would be bent as they passed through a magnetic field *(see Part 4,* N&S, *March 2, 1970).* On passing through the magnetic field, the charged atoms curved and struck a sheet of unexposed photographic film *(see diagram).*

If all of the atoms in the stream had been exactly alike, they all would have followed the same curved path, and when the film was developed, there would have been only one gray patch where the atoms had struck the film. But there were *two* gray patches, one nearer the magnets than the other. That meant that some of the neon atoms were affected by the magnetic field more than others were.

Thomson and Aston's experiment suggested that there were at least two different kinds of neon atoms, one kind more massive, or weightier, than the other. But the two scientists failed to explore this idea much deeper; it was left to another scientist to see its importance.

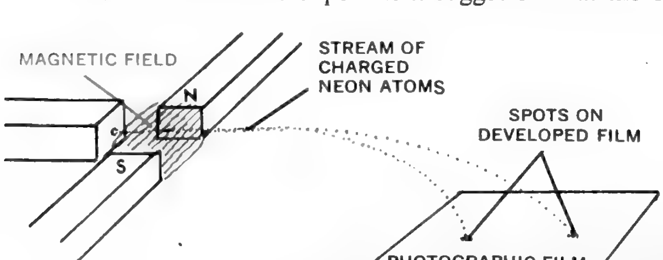
Man-made radioactive substances such as cobalt[60] are useful in medicine. This machine at the New York Medical College in New York City contains a bit of cobalt[60] and directs the radiation from its decaying atoms at a tumor deep in the patient's body. The radiation kills cells that make up the cancerous growth.

Weighing Atoms

The method Thomson and Aston used gave scientists a way of weighing atoms. Lighter charged atoms curved more sharply than heavier, or more massive, atoms as they passed through a magnetic field. By comparing the amount of curving, an experimenter could say that one kind of atom was two, or 15, or whatever times as heavy as another kind.

At that time, the hydrogen atom was used as a standard unit of atomic weight and was given a weight of 1. Using that weight scale, Thomson and Aston's light neon atoms could be given a weight of 20 units, and the heavy neon atoms a weight of 22 units.

About the same time Thomson and Aston were experimenting with neon, the English chemist Frederick Soddy was experimenting with the radioactive element thorium. His experiments showed that thorium is made up of at



Thomson and Aston sent a stream of charged neon atoms through a magnetic field that pulled the atoms downward to a photographic film. The developed film had two gray spots instead of one, showing that some of the atoms were lighter than the others, because they were pulled downward in a sharper curve.

least two different kinds of atoms—one kind with an atomic weight of 232, the other with a weight of 228. Even though they were different in weight, the two kinds of atoms were so alike in other ways that Soddy felt they should be thought of as the same element. Here was the important idea overlooked by Thomson and Aston. Soddy called such substances, whose atoms are alike in every way but weight, *isotopes*.

Let's take a look at isotopes of the element carbon. Every whole atom in the universe that has 6 protons and 6 electrons is a carbon atom. That makes each carbon atom enough like every other one so that all of them can be called "carbon." But there is one kind of carbon atom that weighs 10 units, another that weighs 11 units, another that weighs 12 units, and so on, as shown here.

Isotope of Carbon	Number of Protons	Number of Electrons	Number of Neutrons
Carbon^{10}	6	6	4
Carbon^{11}	6	6	5
Carbon	6	6	6
Carbon^{13}	6	6	7
Carbon^{14}	6	6	8

Notice that carbon^{12}, for example, weighs more than carbon^{10} because carbon^{12} has two more neutrons. The important difference between isotopes of the same element, then, is the number of neutrons they have.

With the idea of isotopes, it became easy to see why one cubic inch of lead, say, from one part of the world might weigh a little bit more or a little bit less than one cubic inch of lead from another part of the world. Each sample might contain different mixtures of lead isotopes.

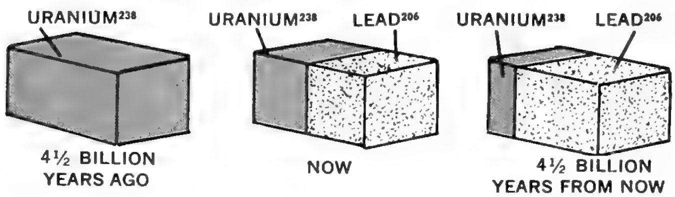
Man-Made Isotopes

In 1934, Marie Curie's daughter, Irène, and Irène's husband, Frédéric, made an important new breakthrough. They were the first to make a man-made isotope. They did it by shooting *alpha* particles at aluminum. (An *alpha* particle is a cluster of 2 protons and 2 neutrons. *See "Exploring the Atom—Part 4,"* N&S, *March 2, 1970.*) Their *alpha*-particle "gun" was a lump of the radioactive element polonium, whose atoms give off *alpha* particles.

Ordinary aluminum has an atomic weight of 27, because each atom has 13 protons and 14 neutrons. As the *alpha* particles bombarded the aluminum, the Curies saw that the aluminum gave off neutrons and electrons. When they stopped the bombardment, they were surprised to find that the aluminum kept giving off electrons.

They had made the aluminum radioactive. Each aluminum atom that was struck by an *alpha* particle ended up by gaining two protons and one neutron. Because the atoms gained protons, they became the atoms of a different element. They were changed from aluminum^{27} to phosphorus^{30}, which has 15 protons and 15 neutrons.

But this was not ordinary phosphorus, or phosphorus^{31}, which has 15 protons and 16 neutrons. Phosphorus^{30} turned out to be an artificial isotope—a radioactive isotope with a *half-life* of 3¼ minutes (*see diagram*).



The half-life of a radioactive isotope is the time it takes for half the atoms in a sample of the substance to decay, or change into atoms of another isotope. For example, in 4½ billion years, half the uranium^{238} atoms in a piece of rock have changed into atoms of lead^{206}. After 4½ billion years more, half the remaining uranium^{238} atoms will have decayed, and so on. Other radioactive isotopes have half-lives measured in thousands of years, in days, in hours, or even in tiny fractions of a second.

Since that important discovery made by the Curies in 1934, about a thousand artificial isotopes have been made by scientists. All are radioactive, and their atoms decay at such rapid rates that none of these artificial isotopes are found in nature.

Measuring the Past with Atomic Clocks

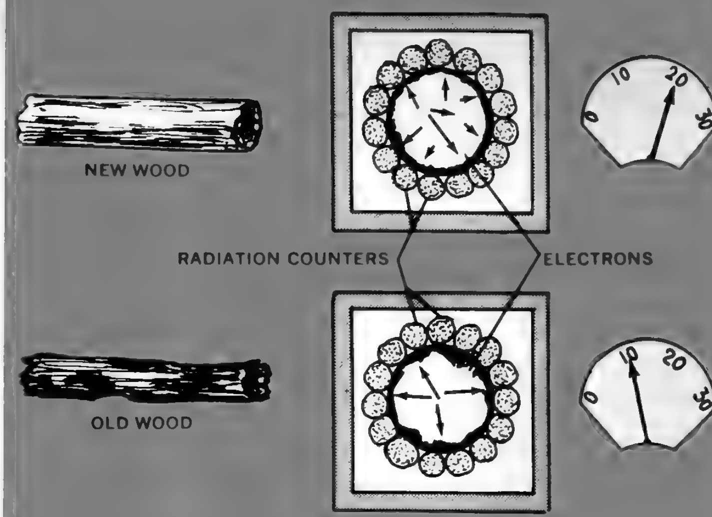
Some radioactive isotopes have very long half-lives, so they can be used as "atomic clocks." They can tell us the age of ancient rocks and of fossils.

The atoms of uranium^{238}, for example, gradually break down and change into atoms of other elements, ending up as lead^{206} *(see* N&S, *March 2, 1970, page 14).* It takes 4,510 million years for half the uranium^{238} in a newly formed rock to change into lead^{206}. By comparing the amount of uranium^{238} with the amount of lead^{206} in a rock, we can say that the rock is so many millions of years old. So far, the oldest earth rocks dated with uranium^{238} are about 3,500 million (3.5 billion) years old.

To find out how long ago a fossil was part of a living plant or animal, scientists use another radioactive isotope —carbon^{14}. Carbon^{14} makes up a tiny fraction of the carbon in the earth's atmosphere, and this fraction seems to have remained about the same for thousands of years.

Living plants take in carbon from the atmosphere, and living animals get carbon from the plants, or the plant-eating animals, they eat. So carbon^{14} makes up the same fraction of the carbon in living plants and animals as it does of the carbon in the atmosphere. When a plant or

(Continued on the next page)



An ancient piece of wood can be dated by comparing the carbon^{14} radiation coming from it with the radiation coming from a piece of wood the same size and weight that was recently cut from a living tree. If radiation counters show that the new wood gives off 20 signals per minute and the old wood only 10 signals per minute, the old wood must contain only half as many carbon^{14} atoms as the new wood. Since half the carbon^{14} atoms in a piece of wood decay within 5,730 years after the wood was no longer part of a living tree, then the wood must be about 5,700 years old. (If the old wood gave off only 5 signals per minute, how old would it be?)

Exploring the Atom (continued)

animal dies, it stops taking in carbon. The fraction of the carbon in its remains that is carbon^{14} gradually gets smaller as the atoms of carbon^{14} decay and change into atoms of nitrogen^{14}.

You can detect how much carbon^{14} there is in a piece of wood, say, by holding a radiation counter near it. If the piece of wood is about the size of a pencil and comes from a tree that was cut down a few weeks ago, the radiation counter will record about 20 "signals" a minute—each signal announcing that a carbon^{14} atom has decayed and given off an electron *(see diagram).*

Now, suppose that you find a piece of charred wood in a fireplace used by ancient people. You cut off a piece that weighs the same as the piece of "new" wood whose carbon^{14} count you already know. Next, you hold the radiation counter near the piece of old wood.

Suppose it counts only 10 signals a minute coming from the old wood. That would tell you that the old wood had only half as many carbon^{14} atoms as the new wood. It would also mean that the old wood had lost half the number of carbon^{14} atoms it had when it was part of a living tree. Since it takes 5,730 years for half of the carbon^{14} atoms in a dead animal or plant to decay, you can tell that the piece of charred wood was cut from a tree about 5,700 years ago.

Some Other Ways We Use Radioactive Isotopes

Over the years we have found many uses for radioactive isotopes. Their use in medicine has become particularly important. The high-energy radiation some isotopes give off can be directed at a tiny spot in the body to kill cancer cells *(see photo, page 14).*

Less powerful isotopes can be injected into a person's bloodstream, or be included in something we eat or drink. By tracing the signals given off by the isotope as it becomes trapped or absorbed by some tissue or organ along the way, doctors can learn about a person's blood circulation, or about how well he digests what he eats.

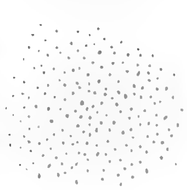
Such "tracer" isotopes, as they are called, can also be used to find out how certain nutrients are used by plants. And they can be used to study certain behavior of insects and other animals *(see diagram).*

When scientists of the early 1900s did their work with radioactivity and isotopes, they could not possibly have known what an important new tool they were putting into the hands of scientists of the next generation ■

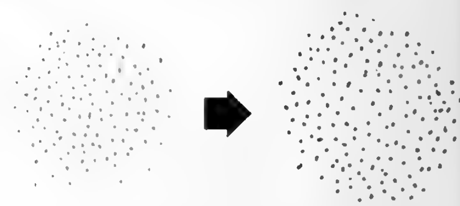
Part 6 of this series will describe man's successes and current attempts to harness the atom as a source of power.

Biologists use the radioactive isotope strontium^{90} to help them count populations of small animals and trace their travels. This diagram shows how strontium^{90} is used to count mosquito populations. A tiny capsule of strontium^{90} placed under the skin of a field mouse makes it easy to follow the animal with a radiation counter.

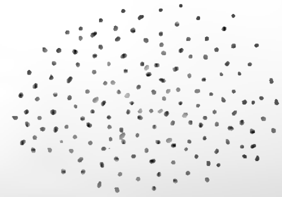
1 **Strontium^{90} fed to mosquito larvae in laboratory tanks makes them grow into radioactive adults (brown) that can be detected by a radiation counter.**



2 **One hundred radioactive mosquitos are released in an area where biologists want to count the mosquito population.**



3 **A sample of 100 mosquitos captured in the area includes only one-tenth of the radioactive insects, so there must be about 10 times 100, or 1,000, mosquitos in the area.**



nature and science
TEACHER'S EDITION
VOL. 7 NO. 14 / MARCH 30, 1970 / SECTION 1 OF TWO SECTIONS

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Travels of an Atom

This WALL CHART illustrates two basic "conceptual schemes":

- *Under ordinary conditions, matter can be changed but not annihilated or created.* (The particles called atoms are rearranged into new molecules but are not changed themselves.)
- *There is an interchange of materials and energy between living things and their environment.* (The drawings in the WALL CHART illustrate some of these interchanges.)

With your class, follow the carbon atom in its travels around the chart. You might discuss alternate routes for the atom. For example, many of the atoms that make up coal are released when coal is burned as fuel. The carbon atoms combine with oxygen atoms forming carbon dioxide and giving off energy in the form of heat *(see "Exploring the Atom," below)*. The burning of carbon fuels (coal, oil, wood) by humans releases about six billion tons of carbon dioxide into the air each year *(see "Is 'Pop Gas' Warming the Atmosphere?"*, N&S, *Sept. 29, 1969)*.

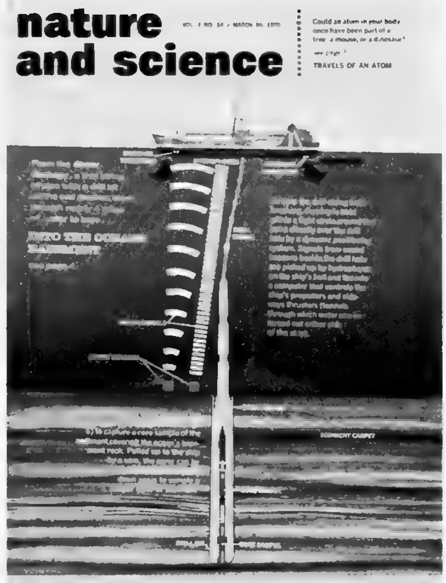
At the carbon atom's last stage in the WALL CHART, the reader is asked to speculate about where it might travel next, and how it might visit the reader. Let your pupils' imagination run wild on this. Two possibilities: C becomes part of a carbon dioxide molecule and goes into the atmosphere, then is inhaled by a human. C becomes part of a plant and is eaten by an animal (such as a cow) that then is eaten by a human.

Some of your pupils may wonder whether it is actually possible to trace an individual atom in its travels. It isn't, because of an atom's size, but the "travels" of a substance through an organism, or of an organism through its environment, can be traced for a time by use of radioactive isotopes *(see "Exploring the Atom—Part 5,* N&S, *March 16, 1970)*.

A lot of today's ecological research is devoted to the study of the cycling of elements in nature. Elements move in what are called *biogeochemical cycles* (*bio* for life; *geo* for water, rocks, air, and soil; *chemical* for the processes involved). No matter what element is involved in a cycle, both living and non-living agents are involved. Without green plants and decay organisms *(see "A Bow to Bacteria,"* N&S, *Feb. 2, 1970)*, most cycling would stop, though atoms would continue to "travel" as long as the earth had an atmosphere and oceans. Without air or water, atoms would probably not "travel" at all, except perhaps deep inside the earth.

One other facet of atom cycling you might discuss with your class is that of radioactive materials that might be released from nuclear explosions or from wastes from nuclear power plants. A common component of atomic fallout and atomic wastes is strontium^{90}. It loses its radioactivity slowly, and cycles in nature like cal-

(Continued on the next page)



IN THIS ISSUE

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

Tentful of Caterpillars
Your pupils can investigate the lives of caterpillars that build communal living tents in trees.

Into the Oceans' Basement
A scientist takes your pupils aboard the *Glomar Challenger*, an ocean-going laboratory being used to unravel some of the mysteries of the ocean floor and drifting continents.

● **Travels of an Atom**
A WALL CHART shows how individual atoms persist through time in both living and non-living things.

The Baffling Bumps
A SCIENCE MYSTERY introduces your pupils to the large, unexplained earth mounds in Washington that have puzzled scientists for years.

● **Brain-Boosters**

● **Exploring the Atom—Part 6**
How scientists first split the atom —and what part atomic energy may play in our future lives.

IN THE NEXT ISSUE

A special issue examines the problem of food for the future—Why our growing populations are a problem . . . How the "green revolution" solves some problems and helps create others . . . The promise and problems of food from the sea . . . How new plant discoveries may improve present crops.

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

cium. It is taken in by plants, and later may become concentrated in the bones of animals (including man). For more information on the possible dangers of such isotopes, see "Exploring the Atom—Part 7," in the May 4, 1970 issue of *N&S*.

For Your Reading

• "Odyssey" is an essay about atoms recycling in nature in a classic book about ecology and conservation, *A Sand County Almanac,* by Aldo Leopold, Oxford University Press, 1966, $6.50 hardcover, $1.75 paper.

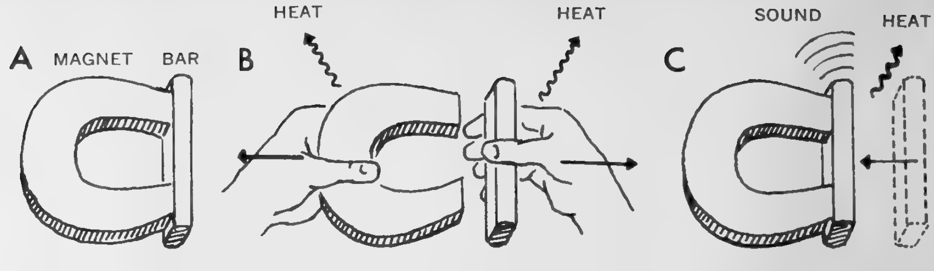
• *The Tale of Whitefoot,* by Carl Brandhorst and Robert Sylwester, Simon and Schuster, 1968, $3.50, tells how the atoms of a dead woodland mouse travel through nature and eventually become part of another mouse.

Exploring the Atom

By discussing the concepts of *matter, mass,* and *energy* with your pupils, then showing them how energy is released when coal burns, you can help them understand how energy is released from the fission or fusion of atomic nuclei.

Topics for Class Discussion

• *What is* matter? Anything that occupies space. All matter is made up of three basic kinds of particles, or building blocks: electrons, protons,



Let a magnet and bar held together by magnetic energy *(A)* represent a molecule—two atoms held together by electrical energy. To overcome this "binding" energy and pull the two "atoms" apart *(B)*, you must change chemical energy in your muscles into kinetic energy in your arms. Motion of your arms, the magnet, and bar speeds up the motion of nearby molecules in the air, giving them more heat energy. Place the bar where the magnet will attract it *(C)*. As the bar moves and slaps against the magnet, some magnetic energy is changed into kinetic energy, then into heat and sound energy, just as carbon and oxygen atoms give up some of their binding energy as heat and light when they combine to form a CO_2 molecule *(see text)*.

and neutrons. Protons and neutrons form the core, or nucleus, of an atom; electrons orbit in patterns around the nucleus to form the atom. Atoms combine with like atoms or with different kinds of atoms to form a molecule; groups of molecules form the matter we see around us.

• *What is* mass? The *mass* of an object is usually described as the amount of matter that makes it up. To measure an object's mass, we usually *weigh* it (measure the pull of the earth's gravity on the mass). Another way is to measure how much force it takes to accelerate, or change the motion of, the object. (Part 5, in *N&S,* March 16, 1970, showed how Thomson and Aston compared the masses of atomic nuclei by their changes in motion as they passed through a magnetic field.)

• *What is* energy? *Energy* is another word for "the ability to do work." (Work is done when matter is moved.) There are many forms of energy (heat, light, mechanical energy, and so on), and energy can be changed from one form into another form (*see "The Spirit That Moves Things,"* N&S, *April 10, 1967, or enlarged* N&S WALL CHART, *same title*).

Every bit of matter, from the largest star down to a tiny electron, has energy. A moving particle has *kinetic* (motion) energy that enables the particle to move (or at least *tend* to move) another particle that it bumps into.

Each particle also has *gravitational* energy, which makes it attract, or "pull on," every other particle of matter. Electrons and protons also have *electrical* energy that makes electrons repel each other, and an electron and a proton attract each other. In an atom, electrical energy holds the electrons in orbits around the nucleus, which contains one or more protons. The electrical energy in atoms is also what holds two or more atoms together in a molecule.

To break up a molecule, some energy from outside must be used to overcome the energy that holds the atoms together. You can demonstrate this by using a horseshoe magnet and a small iron bar to represent two "atoms" locked together in a "molecule" (*see Diagram A*). To separate these two "atoms," you have to use chemical energy from your muscles to move your arms and pull the bar apart from the magnet (*Diagram B*).

Now have your pupils think of the magnet as a carbon atom in a piece of coal, and the bar as an atom of oxygen. Use some muscle energy to move the bar close enough for the magnet to pull the bar to it (*Diagram C*). As the two "atoms" move together, they speed up the movement of surrounding air molecules, giving them more heat energy. As the "atoms" lock together, they send waves of energy through the air that you hear as a "click." This heat and sound energy given off by the bar and magnet represent the heat and light energy given off when a carbon atom and two oxygen atoms combine into a molecule of carbon dioxide (CO_2). This process of rapid oxidation is called *burning*.

• *Why doesn't coal burn up as soon as it is exposed to air?* The oxygen in the air is in the form of oxygen molecules (two oxygen atoms locked together). A carbon atom can only combine rapidly with *individual* oxy-

(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.

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

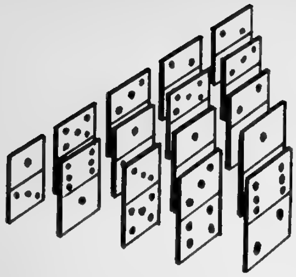
gen atoms, so you must light a match to provide heat energy to break an oxygen molecule apart so its atoms can combine with the carbon atom. (The combining atoms release *more* energy than it takes to separate the atoms in the oxygen molecule.)

- *When coal burns, where does the energy it releases come from?* The energy that holds together the particles in one carbon atom and in two individual oxygen atoms adds up to more energy than is needed to hold all these particles together in one molecule of carbon dioxide. The "extra" energy is given off in heat and light when the three atoms combine.

Your pupils will be surprised to learn that the total mass of the three separate atoms is larger than the mass of the molecules they form. The molecule is made up of the same particles that make up the three separate atoms, but the more energy a particle has, the more mass it has. So the energy that is lost when the atoms combine also reduces their total mass slightly. The energy lost in this reaction is so small that you can't detect the change in mass by comparing the weight of the carbon and oxygen before burning with the weight of the carbon dioxide and ash (mostly carbon) that result.

- *How is the release of energy in burning different from the release of energy when an atom of uranium is split, or when heavy-hydrogen nuclei are fused?* The energy that holds protons and neutrons together in the nucleus of an atom is different from the electrical energy that holds electrons around the nucleus. This nuclear "binding" energy is not very well understood by scientists as yet. But over the short distances in a nucleus (100,000 times smaller than the size of an atom), the binding energy is immensely strong. (It has to be to overcome the electrical energy that makes protons—each with a positive electrical charge—repel each other.)

When a moving neutron strikes the nucleus of a uranium^{235} atom, the nucleus splits up into nuclei of several lighter atoms. A few neutrons are shot



Set up dominoes ("uranium^{235} atoms") like this, and give the front domino a push to demonstrate how splitting one atom releases neutrons that split two more atoms, and so on in a *chain reaction*.

away from the others by the energy released in this reaction; some of them go on to split other nearby uranium atoms (*see diagram*). The energy released is part of the binding energy that held the particles together in the uranium nucleus; it is "extra" energy that is not needed to hold the particles together in the nuclei of the "new," lighter atoms. This released energy is mostly heat. It causes a tremendous explosion when released from many splitting atoms at once, but when released from only a few splitting atoms at a time, it can be used to heat water and make steam.

The particles in the nucleus of a heavy-hydrogen atom are held together with more binding energy than is needed to hold together the particles in the nucleus of a helium atom. When enough heat energy is applied to make two heavy-hydrogen nuclei fuse into a helium nucleus, even more "extra" binding energy is released than when a uranium atom is split.

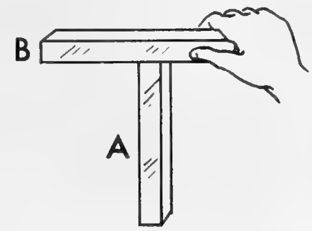
In either case, some of the *mass* of the particles that made up the uranium atom's nucleus or the two heavy-hydrogen nuclei is "lost" as the extra binding energy is released.

Brain-Boosters

Mystery Photo. The photo is a close-up of a boot sole. Can your pupils find reasons why it could not be a waffle or a snow-tire track?

What will happen if? Put a rubber ball in the school refrigerator and let your pupils see how cooling affects its "bounciness." Then let them see whether warming the ball has the opposite effect. Ask your pupils whether they think the facts that cooling *contracts* the ball (brings its molecules closer together) and warming *expands* the ball (moves its molecules farther apart) have anything to do with the noted effects.

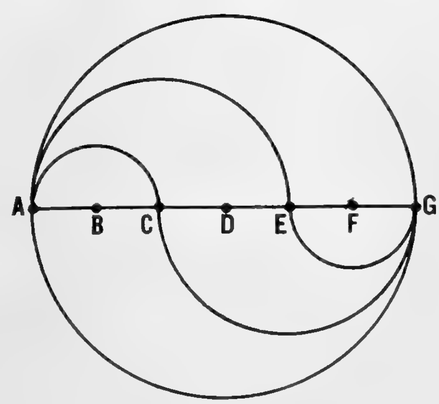
Can you do it? To determine which of the two metal bars is the magnet, arrange the bars in a T-shape as shown in the diagram, holding the upper bar.



If bar A sticks to the middle of bar B, bar A is the magnet. If it falls, then bar B is the magnet.

Touching the ends of the bars together will never tell you which is the magnet, because the two bars will always stick together. *Can your pupils explain why?* A look at the "map" of the magnetic field around a bar magnet (*see* N&S, *March 2, 1970, p. 5*) will show them that the lines of magnetic force come together at the poles of the magnet but spread out away from the middle of the magnet. So most of the magnet's attraction for the nonmagnetic bar is concentrated at the ends of the magnet. Placing a bar magnet sideways into a box of pins or paper clips also demonstrates this phenomenon.

Fun with numbers and shapes. To divide a circle into three equal areas, first draw a diameter and divide it with a ruler into six equal parts. Then draw semicircles from A to C, E to G, A to E, and C to G, above or below the diameter, as shown in the diagram.



Perhaps you could illustrate this construction on the chalkboard, using a yardstick in place of the ruler, and

(Continued on the next page)

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

a length of string attached to a piece of chalk in place of the compasses. Can any of your pupils figure out a way to divide a circle into four equal areas? (How do you cut a pie into four equal parts?)

For science experts only. When a thin tube is placed in water, some of the water "climbs" up the side of the tube because the water next to the glass is attracted to the glass (*adhesion*) more strongly than it is attracted to the water next to it (*cohesion*). Water in the center of the tube is then pulled upward by the water at the sides by *surface tension* – the tendency of surface water to behave like an elastic "skin." Surface tension results when water at the surface coheres more strongly to the water beneath it than it adheres to the substance above it—in this case, air. Once a new level has been reached by the water in the center of the tube, the water near the sides of the tube again "creeps" a short way up the tube. The water continues to rise in the tube in this way until the forces of adhesion and surface tension are balanced by the weight of the column of water in the tube.

The forces of adhesion and surface tension also keep the water from dripping out of the open end of a curved tube like the one shown. Adhesion keeps the water at the sides of the tube sticking to the tube, while surface tension keeps the water from dropping out of the middle.

Just for fun. Have your pupils bring in a variety of substances and place each in a small container of vinegar. Allow everyone an opportunity to examine the substances. Keep the containers undisturbed for several weeks and check again to see what changes have occurred.

If you invert a glass jar of vinegar over some limestone in the vinegar-filled pan, hydrogen will collect in the jar. You can test for hydrogen by inserting a burning match into the jar (keep holding the jar upside down after removing it from the pan.) The highly flammable hydrogen will "pop" when ignited by the flame.

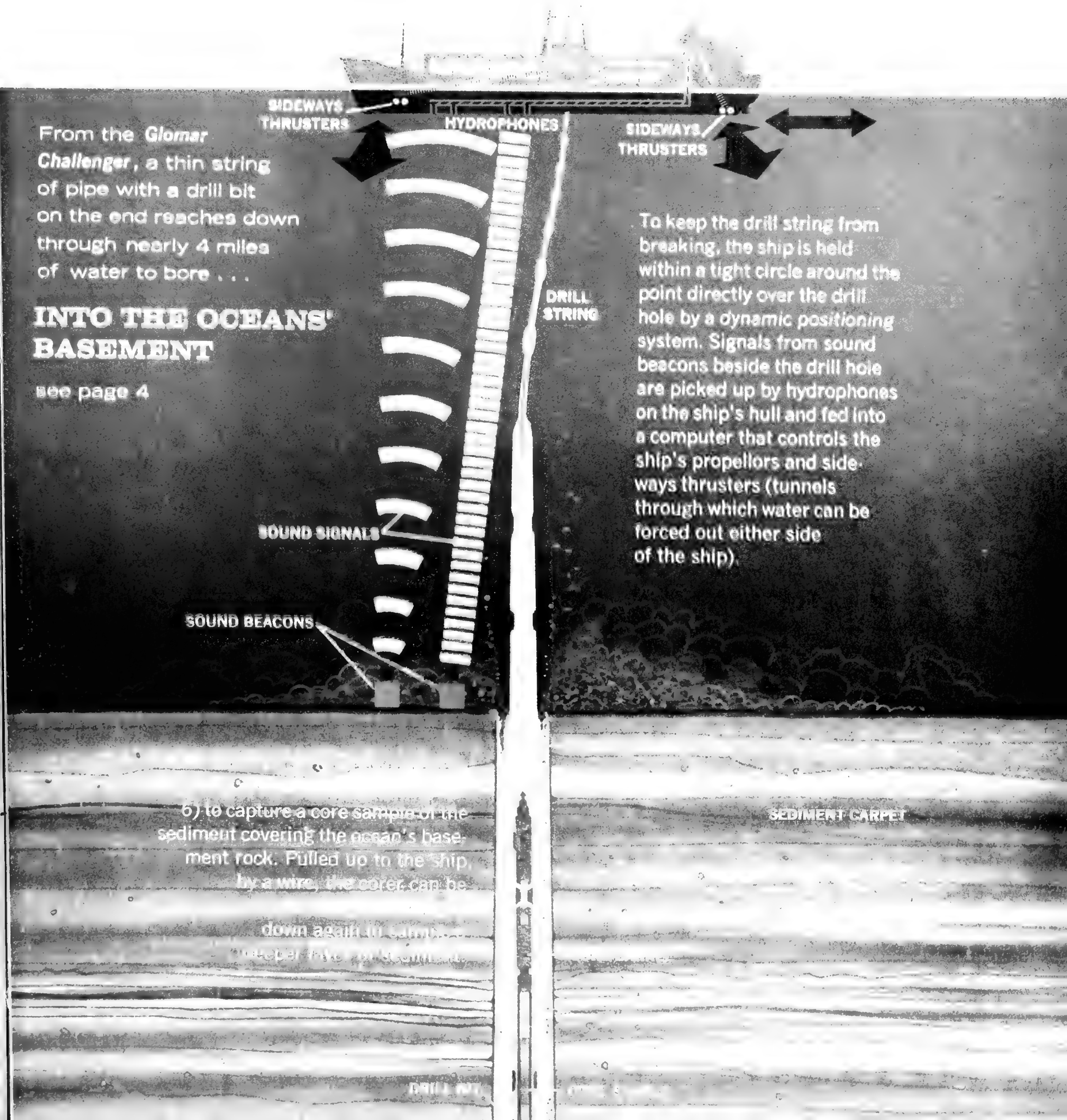
nature and science

VOL. 7 NO. 14 / MARCH 30, 1970

Could an atom in your body once have been part of a tree, a mouse, or a dinosaur?

see page 8

TRAVELS OF AN ATOM



From the *Glomar Challenger*, a thin string of pipe with a drill bit on the end reaches down through nearly 4 miles of water to bore . . .

INTO THE OCEANS' BASEMENT

see page 4

To keep the drill string from breaking, the ship is held within a tight circle around the point directly over the drill hole by a *dynamic positioning* system. Signals from sound beacons beside the drill hole are picked up by hydrophones on the ship's hull and fed into a computer that controls the ship's propellors and sideways thrusters (tunnels through which water can be forced out either side of the ship).

6) to capture a core sample of the sediment covering the ocean's basement rock. Pulled up to the ship, by a wire, the corer can be [illegible] down again in [illegible]

nature and science
VOL. 7 NO. 14 / MARCH 30, 1970

CONTENTS

PICTURE CREDITS: Cover, pp. 4-7, Scripps Institution of Oceanography (except p. 5, bottom, profile from Lamont-Doherty Geological Observatory); pp. 2-3, Jerome Wexler; pp. 5, 6, 8, 9, 11-13, 15, drawings by Graphic Arts Department, The American Museum of Natural History; p. 10, Ruth and Louis Kirk; p. 11, photo from AMNH; p. 12, photo by Richard Iwema; p. 14, Wide World Photos Inc.; p. 16, Joe Rychetnik.

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; ART DIRECTOR Joseph M. Sedacca; ASSOCIATE ART DIRECTOR Donald B. Clausen • CONSULTING EDITOR Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; PROMOTION DIRECTOR Elizabeth Connor; SUBSCRIPTION SERVICE Frank Burkholder

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.

Look! Up in that tree. Is it a bird? Is it a paper airplane? No, it's a...

TENTFUL OF CATERPILLAR

by Margaret J. Anderson

■ Most caterpillars spend their lives alone. They a busy with their main concern—eating. But some cate pillars stay in groups. These caterpillars build a shelt where they sleep, and even go out for meals together.

Tent caterpillars build shelters of silk in trees such chokecherry, birch, alder, apple, and poplar *(see photo*

The tents sometimes measure two feet across. Watch for them this spring. When you find one, you can begin to investigate the lives of the unusual insects that live inside.

The tent caterpillars you find this spring had their beginnings last summer, when a female moth laid about 200 eggs around a twig, in a band like a collar. The eggs were covered with a hard, shiny varnish *(see photo)*. This protected them through the winter.

In the early spring, look on twigs for masses of moth eggs like these. Tent caterpillars will hatch from them.

The tiny caterpillars come out of the eggs just as the buds on trees are opening in the spring. For several days they lead a carefree life, exploring the branch and eating their first meals of tender leaves.

After a few days they gather together in a mass. Each caterpillar is about a quarter of an inch long. They settle into a routine that lasts through the rest of their caterpillar life. They spin a mat-like floor of silk in a crotch of a tree, then roof it over. As the caterpillars grow and need a bigger tent, they use the old roof as their new floor and add another roof and sides.

Life in the Tent

These tents are easy to see in the spring. When you find one, watch it and keep a record of what you see. Make a note of the activities of the caterpillars at different times of the day.

Dr. R. E. Snodgrass, an *entomologist* (scientist who studies insects), studied tent caterpillars. He found that the caterpillars led a very organized life. Their day started early. The caterpillars left for "breakfast" about 6:30 a.m., marching in columns toward the ends of the twigs, where they fed for about two hours. After "breakfast" the caterpillars did a little spinning on the tent. Then they all went inside. Some appeared for "lunch" and did a little more spinning. But the busiest time of the day was just before "dinner," when all of the caterpillars gathered on the roof and worked on the tent. Then, as if answering a dinner bell, they all made their way to the feeding grounds.

See if you can find a routine in the eating habits of the caterpillars you watch. There are several kinds *(species)* of tent caterpillar, so your findings may not be the same as those of Dr. Snodgrass. Once you know the caterpillars' pattern, you can watch for changes in it and try to find a reason for the changes. For example, do the caterpillars keep their schedule in wet and cool weather, or do they stay in the tent?

You'll have no trouble spotting the feeding grounds, because the caterpillars strip many leaves from the branches. Can you find out how far the caterpillars travel from the tent to food? How much does one caterpillar eat in a day? When the caterpillars travel, they lay down a path of silk and then follow it back to the tent. With your fingers, rub a branch clean at some point between the caterpillars and their tent. Then see how the caterpillars act when they come to the broken trail. Can they find the tent?

When a Caterpillar Grows Up

The caterpillars shed their skins when there is no longer any room inside for growth. They do this six times as they develop. (When it happens, you'll notice that the caterpillars stay in the tent for about two days.)

As the caterpillars get bigger they need more food. By the time they shed their skins for the last time, they have such an appetite that "dinner" lasts through the night.

The caterpillars' need for the tent is almost over. They lose interest in spinning. After about a week they leave the tent for good. Each caterpillar walks to the end of a twig and steps off, as if it were "walking the plank" on a pirate ship. Then it looks for a hiding place and spins a cocoon. In about three weeks a small brown moth emerges from the cocoon.

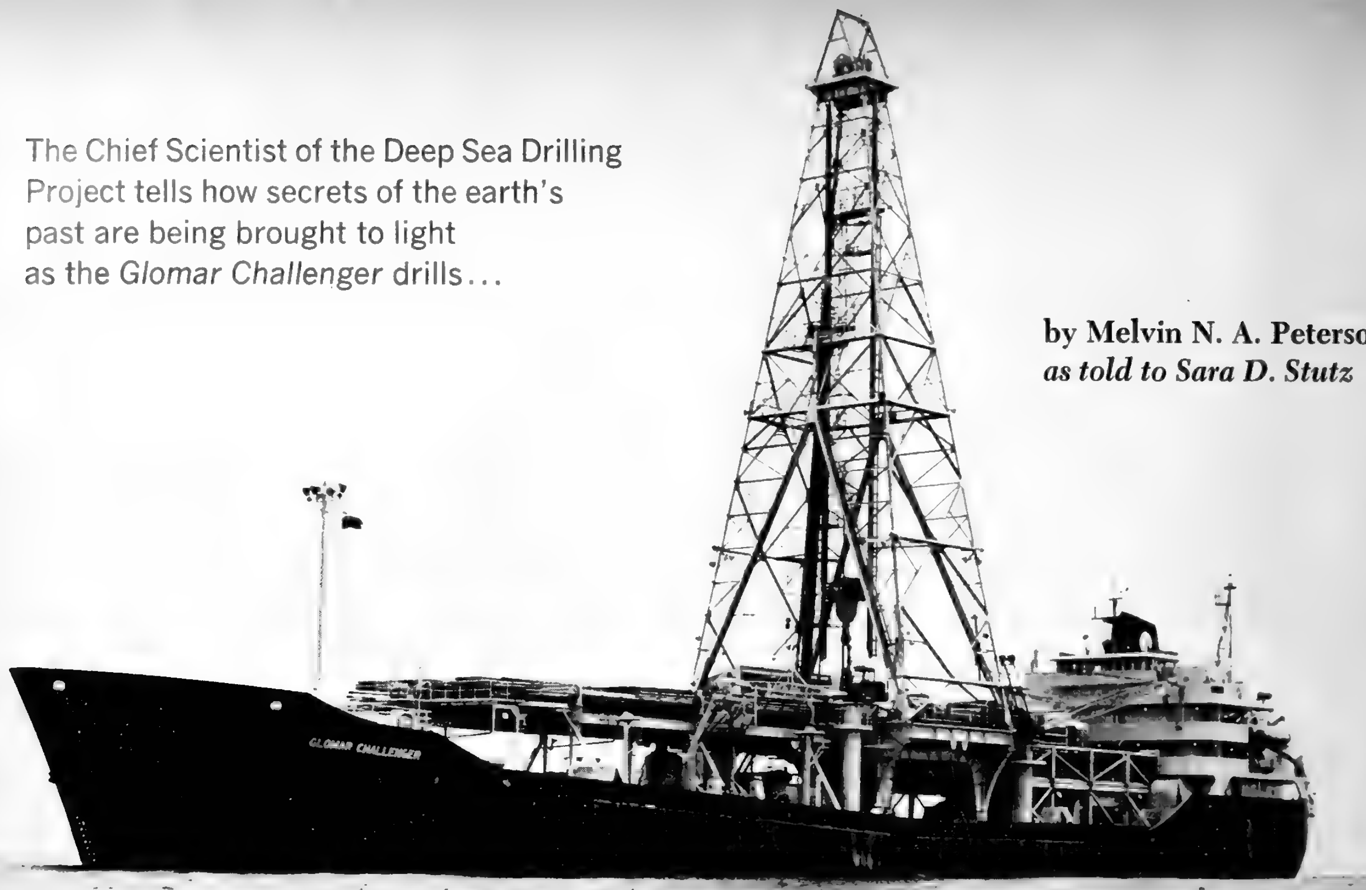
As the caterpillars scatter, collect a few and put them in jars with some twigs as supports for the cocoons they will spin. You might also try moving some caterpillars to a jar early in their life. Give them plenty of leaves from the tree on which you found them. Can you raise them away from their colony? Do they try to spin a tent of their own? Do they develop at the same rate as the caterpillars in the tree? ■

ANOTHER TENT MAKER

There is another tent-spinning caterpillar, called the fall webworm. Its tent usually appears later in the spring than that of tent caterpillars. There is an easy way to tell them apart. Fall webworms build their tent over leaves at the ends of branches, and use these leaves as food. They don't leave the tent to eat. You can't observe their eating habits, but you can try to raise some of the caterpillars on tree leaves. The adult is a satiny-white moth, sometimes marked with dark spots.

The Chief Scientist of the Deep Sea Drilling Project tells how secrets of the earth's past are being brought to light as the *Glomar Challenger* drills...

by Melvin N. A. Peterson
as told to Sara D. Stutz



INTO THE OCEANS' BASEMENT

■ This is an exciting time for *oceanographers,* the scientists who study the oceans, and for *geologists,* the scientists who study the history of the earth as it is recorded in rocks. I'll tell you why.

In recent years, oceanographers have found evidence that floors of the world's oceans are like giant tape recorders on which much of the earth's history has been recorded. For some time, they have been taking samples of the thick layers of *sediment* that carpets most of the ocean floor. This "carpet" is made up of particles of sand, clay, and remains of dead sea animals and plants that have settled to the bottom over millions of years.

Samples of this sediment have given scientists clues to past changes in the world's climate, for example. But with the equipment they had, oceanographers could only reach down 80 feet or so into the sediment carpet, which may be as much as a thousand feet thick. No one had ever obtained a sample of *basement* rock, the once-molten rock that oceanographers believed lies under the sediment. Now, at last, we have equipment that can drill straight down through the sediment carpet and bring up samples of both it and the underlying rock.

I am a geologist at Scripps Institution of Oceanography, a branch of the University of California at San Diego. So you can imagine how delighted I was when I was asked to be the Chief Scientist of the Deep Sea Drilling Project, with its new research ship, the *Glomar Challenger (see photos).*

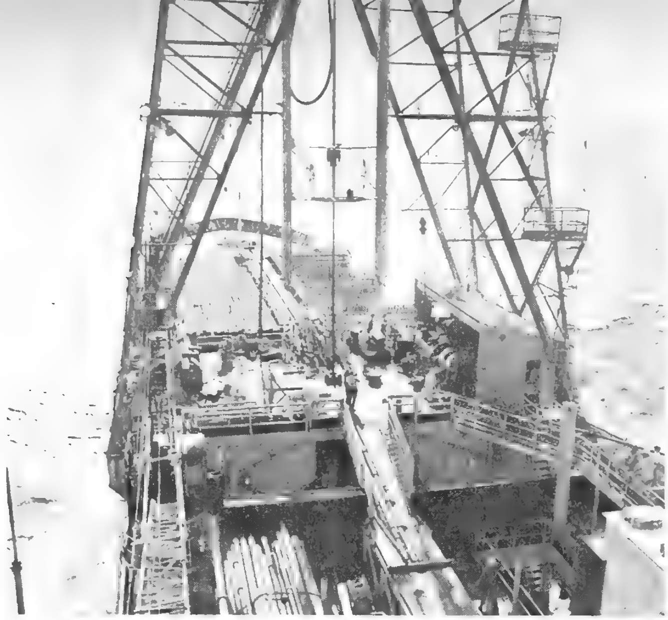
A Challenge for the *Challenger*

As scientists for the project began planning the ship's journey across all the oceans, we were particularly interested in testing the theory that the sea floor is spreading. The spreading seems to start at the *mid-ocean ridge,* a giant mountain chain that winds through the world's oceans. Deep valleys, or *rifts,* run along the center of this ridge. Magnetic patterns in the rock at both sides of the ridge suggest that the sides are gradually being pushed apart as molten materials from inside the earth gradually rises into the rifts to form new rocks there *(see "The Mystery of the Changing Poles—Part 1,"* N&S, *March 2, 1970.)*

Oceanographers have suggested that the ocean floor is like a conveyor belt, with the newly formed rock gradually moving away from the ridges and toward the continents. If this is so, then the oldest parts of the ocean floor should be nearest the continents, and the newest parts should be near the mid-ocean ridge. Also, the sediment carpet should be thickest on the oldest part of the sea floor, where it has the longest time to pile up.

A 142-foot derrick, like those used to drill oil wells, towers above the deck of the *Glomar Challenger*, the world's most advanced deep sea drilling ship. Racks on the deck hold 23,000 feet of pipe that can be put together in a "string" to drill into the ocean floor.

A crane lifts each 90-foot length of pipe to the derrick platform, where it is automatically raised and threaded into the end of the section below it. You can see the slender drill string in the center of the derrick, running down through a hole in the ship's hull. (One observer said deep sea drilling is like drilling a hole in a concrete sidewalk with a string of soda straws from the top of the Empire State Building.)



We planned to test this idea during the project by drilling deep into the sea floor at sites near the mid-ocean ridge, near the continents, and between the ridge and the continents. The samples of sediment and rock that we brought up through the hollow drill could then be dated to find out how old they were.

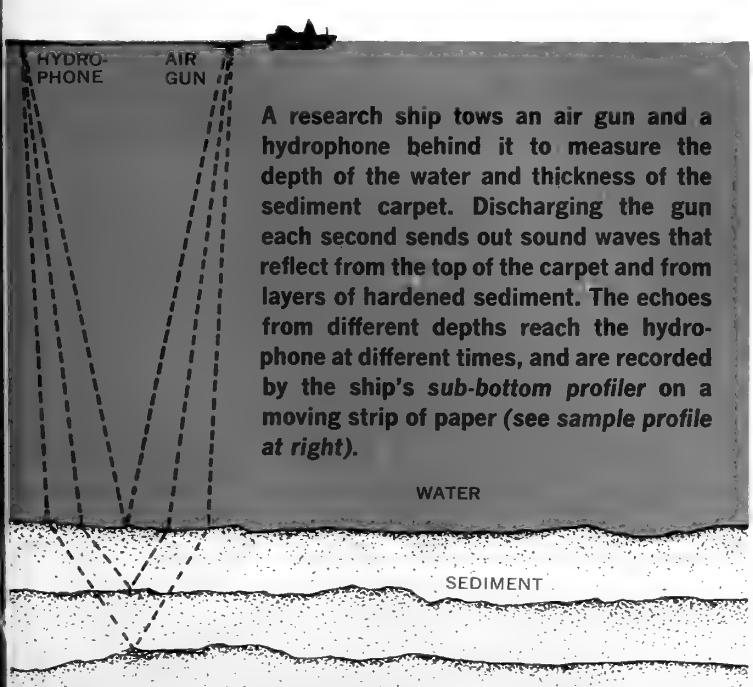
A core sample from the sediment carpet shows the layers of sediment that make it up. From the thickness of a particular layer and its depth in the carpet, scientists can get a good idea of how long ago that layer of sediment was deposited on the ocean floor. A sample of basement rock, on the other hand, could be dated by measuring the amounts of certain radioactive isotopes in the rock *(see "Exploring the Atom—Part 5," N&S, March 16, 1970)*.

Getting to the Drilling Site

Our first explorations began in August 1968 in the Gulf of Mexico and the Atlantic Ocean. By the time I arrived on board for a North Atlantic cruise, it was October—hurricane season in that area. Hurricane Gladys was churning north of us as we steamed toward the Bermuda Rise, an immense mass of volcanic rock that is covered with limestone built by corals and other sea animals that give off calcium carbonate *(see "Forests Beneath the Sea," N&S, December 1, 1969)*. It was windy, and the waves would have caused unsettled stomachs on an ordinary ship. The *Glomar Challenger* is remarkably stable, though.

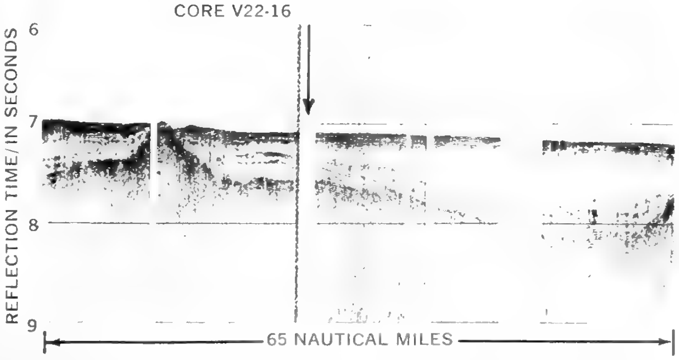
As usual, we had sent another research ship ahead to survey Site 9, where we planned to drill. From a cross-sectional "map" of the sea floor made with the survey ship's *sub-bottom profiler (see diagram)*, we already knew the depth of the water and the thickness of the sediment carpet at the drilling site. As we traced the survey ship's

(Continued on the next page)



A research ship tows an air gun and a hydrophone behind it to measure the depth of the water and thickness of the sediment carpet. Discharging the gun each second sends out sound waves that reflect from the top of the carpet and from layers of hardened sediment. The echoes from different depths reach the hydrophone at different times, and are recorded by the ship's *sub-bottom profiler* on a moving strip of paper (see sample profile at right).

A sub-bottom profile of a 65-mile stretch of ocean floor near the Bahama Islands is shown below. Numbers at the side tell how many seconds sound waves took to travel from that level to the surface at a speed of about 750 meters per second through water and about 1,000 meters per second through sediment. (Can you figure the depth of the water in meters? In feet?) Core V22-16 contained sediments about 100 million years old from a layer about 7.4 seconds "deep." Scientists believe the lower part of the profile shows rock made of sediments, rather than basement rock.



path, we checked their information with our own profiler and a *magnetometer* (to measure the strength of the earth's magnetic field along our path).

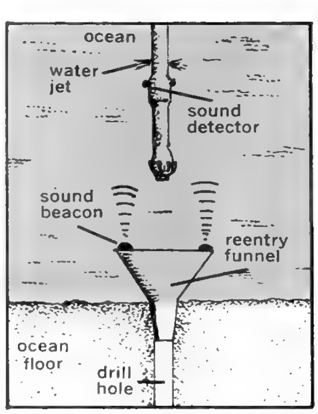
After we had passed over the drilling site, we steamed on down the track, hauling in and storing the profiling and magnetic gear. Then we made a 180-degree turn and returned to the site, testing the sound beacons of our *dynamic positioning* equipment as we went along. This equipment *(see cover)* automatically holds the ship within a few hundred feet of the point directly above the drilling site. The water is too deep to anchor the ship, and if it drifted more than 600 feet from a point above a drill hole 20,000 feet down, the long drill string would break.

When the ship was on site, we dropped the sound beacons over the side, allowing them to fall freely to the ocean floor. Then, orders were given for the drill string to be assembled. That is another automatic process aboard the *Glomar Challenger*. As the 90-foot lengths of pipe were lifted to the drilling derrick from their storage racks on the deck, I thought about what we hoped to find at this important site.

Drilling and Coring

According to the sea-floor spreading theory, the basement rock at the Bermuda Rise should be old, because it is near a continent. Also, our sub-bottom profile showed that

These are some of the drill bits used by the *Glomar Challenger*. The small ones fit inside the larger ones when the coring tube is not being used *(see cover)*. Scientists hope a device like the one below may permit them to replace a worn bit and return it to a partly drilled hole.



A funnel with sound beacons on its edges would be dropped down the drill string until it lodged in the drill hole. The string could then be withdrawn and put down again with a new bit. Sound detectors on the bit control water jets that move the bit sideways and guide it into the funnel. Drilling could then be continued with a tremendous saving of time and effort.

Scientists study a split core of sea-floor sediment in the Core Laboratory aboard the *Glomar Challenger*. Cores are examined and photographed before being stored in a refrigerator for dating and further study ashore.

the sediment is thick and contains layers of hardened sediment that appeared to extend to places a thousand miles away where we had already drilled. We wanted to get samples of the basement rock that would tell us exactly how old it is.

The weather was still foul as we lowered the drill through the 20-by-22-foot hole in the ship's hull, and down into the choppy, gray water. First came the bit, followed by the core barrel for collecting specimens of sediment and rock *(see cover)*. Next were drill collars, heavy lengths of pipe to provide weight for the bit. Above them were grooved joints that would allow the drill to move up and down with the motion of the ship while leaving the weight of the drill collars on the bit to help in the drilling. Next were several more heavy drill collars, and finally the string of drill pipe, up to four miles long.

Because we were working in more than 16,000 feet of water, it took 12 hours for the bit to make contact with the bottom. We tried to take the first *core sample (see cover)* at that level, but the barrel returned to the ship empty. There were smears of sediment in the container, but apparently we had been unable to hold onto the slippery mud. Again and again we tried to get cores, but after failures, we decided to have the hole drilled to 630 feet, where the sediment would be more firmly packed.

We managed to cut two 30-foot cores from that depth. Immediately we turned them over to our *paleontologists,* scientists who study fossils, to find out their age. We needed that information to decide how far we should drill before coring again. As we continued the drilling, many scientists and technicians were busy photographing, describing, and testing the cores before putting them in the refrigerated storage area *(see photo)*. Even though scientists at many universities would eventually study these cores in their labs, it was necessary to study them on the ship because there would be changes in their color and condition as time went on.

Cautiously we drilled deeper and deeper, taking corings at various intervals. We had been working for two days in rough weather, and were now experiencing 10-to-12-foot swells. The gloom increased when, with the bit 2,052 feet below the mud line, our drillhole began to collapse.

We decided to completely withdraw the drill string to the top of the sediment layer and drill at a spot nearby (Site 9A). This time we drilled without coring until we had penetrated deeper than before.

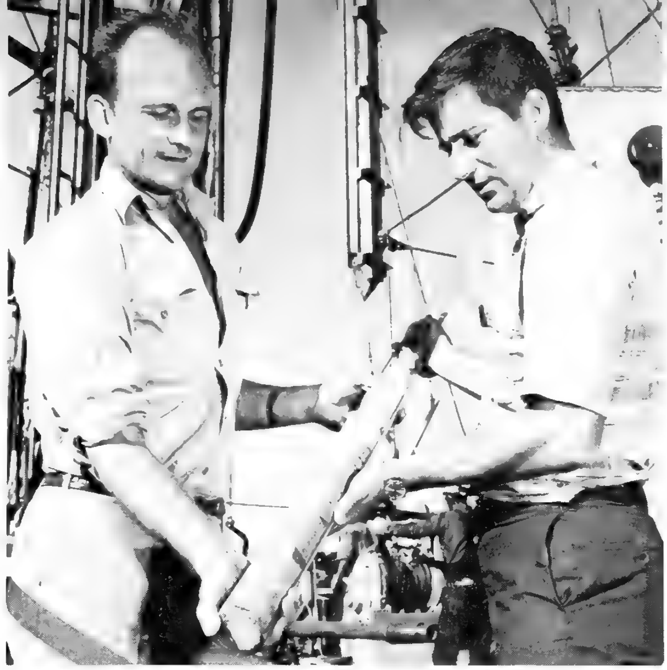
Touchdown!

The first core we took from the new hole contained sediments that must have been deposited 40 to 60 million years ago. The second had sediments about 80 million years old! But, according to our sub-bottom profile, we had several hundred feet of sediment yet to core before reaching the basement. It was an exciting time, but a tense one, too. We were worried that this second hole might collapse as the first one had. We were drilling through very hard rock (compressed sediment), and had no assurance that the bit wouldn't wear out before we reached our goal.

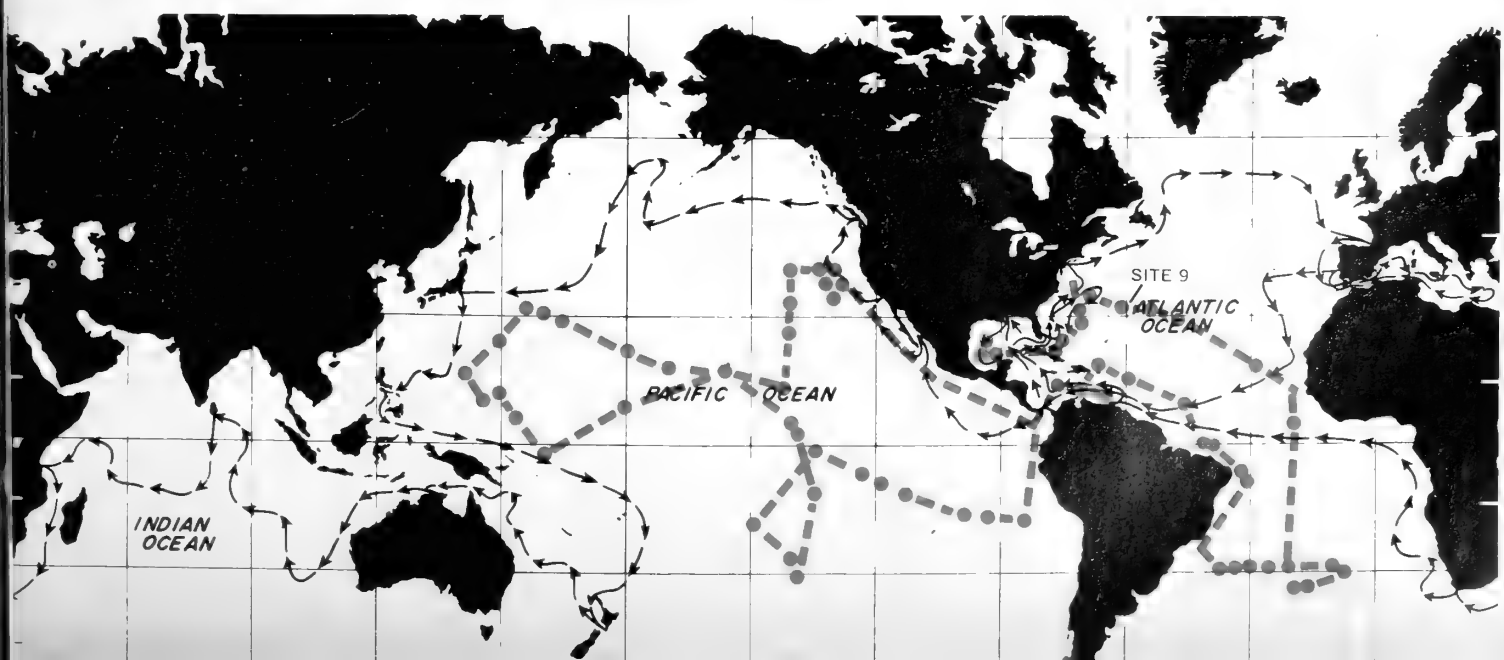
You can imagine our sense of accomplishment when, nine days after we had arrived at Site 9, after drilling through 2,738 feet of sediment, we got a core sample of the basement rock—the first one ever recovered. We had only about seven ounces of rock, but enough to give scientists definite information about the formation of the ocean basins. We had, incidentally, drilled the deepest hole ever made in the deep ocean floor up to that time.

From Site 9 we would move closer and closer to the crest of the Mid-Atlantic Ridge, testing to see if the basement were younger and younger as we approached the ridge. We would also try to get specimens of special kinds of fossils. Each site would present a different problem.

From what the deep sea cores have shown, most scientists now believe that the theory of sea-floor spreading is correct. If so, it probably explains how North and South America could have split away from Europe and Africa about 200 million years ago and been pushed to their present positions by the spreading rock that formed the floor of the "new" Atlantic Ocean. What happens where the spreading ocean floor meets the edge of continents is one of the main things scientists will investigate as the *Glomar Challenger* keeps drilling into the oceans' basement for at least 2½ years more ■



Dr. Peterson *(left)* and Dr. Terence Edgar, his Co-Chief Scientist for Leg II of the drilling project, examine a core of rock from the ocean basement.



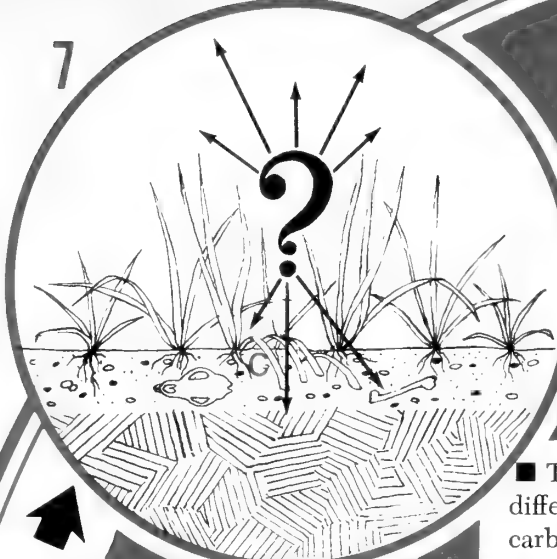
The route and drilling sites covered by the *Glomar Challenger* in the first part of the project are shown in solid color.

Black arrows starting in the Gulf of Mexico show the route the ship will cover by August 1972.

March 30, 1970

Tr
o
A

7



Where do you suppose **C** will travel next? The rabbit's bones will eventually decay. **C** may live in a bacterium for a time. **C** may join two oxygen atoms and escape into the air as carbon dioxide. **C** may stay in the soil until a plant's root reaches close. Can you figure out some ways in which **C** might visit *you* in its travels?

6

The rabbit died several months later. Birds, insects, and other animals ate most of its flesh. Bacteria released chemicals that broke down big molecules into smaller ones. Then the small molecules passed through the cell walls of the bacteria. From these molecules, the bacteria got energy to live and grow. Soon only some hair and the rabbit's bones were left.

5

Protein molecules are complex, made of thousands of atoms. They are especially plentiful where growth is taking place. That is why **C** was near the growing tip of a grass stem that was nipped off by a cottontail rabbit. Inside the rabbit, the molecules of grass were broken down and rearranged into molecules needed by the rabbit's body. **C** combined with atoms of oxygen and calcium to become a molecule of calcium carbonate in part of a rib bone.

■ To grow and develop
different elements. Your b
carbon, hydrogen, oxyge
iron. The same elements,
in all living things—in a fr

Each element is made u
ploring the Atom—Part
sometimes exist by thems
with other atoms. These g

When a plant or animal
are used again and again (
to become molecules in
living things. Some of the
have been recycling sinc
came to your body in the
drunk, or air you've breat

Before that, their trave
locked up in rocks for mill
in the ocean, or miles hi
atoms were part of other l
atoms in your body may
tree, a mouse, or a dinosa

The drawings on this W
journey of an atom throu

Hydrogen atoms are
combined with car-
bon atoms from car-
bon dioxide to form
molecules of sugar.

4

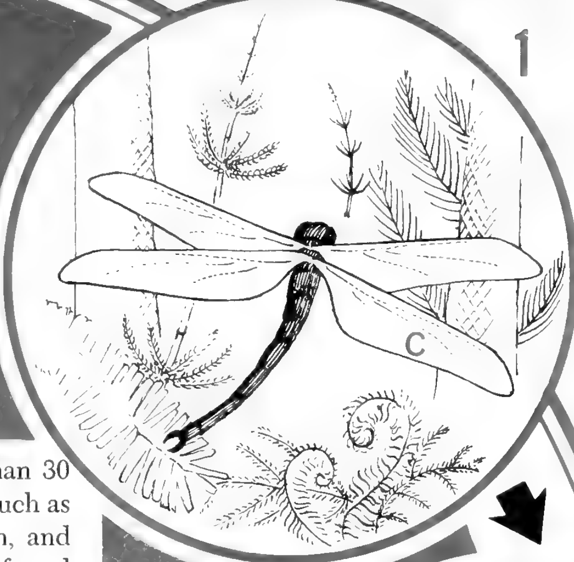
A green
phyll abso
and chang
ergy. The
water mol
oxygen at

vels
an
om

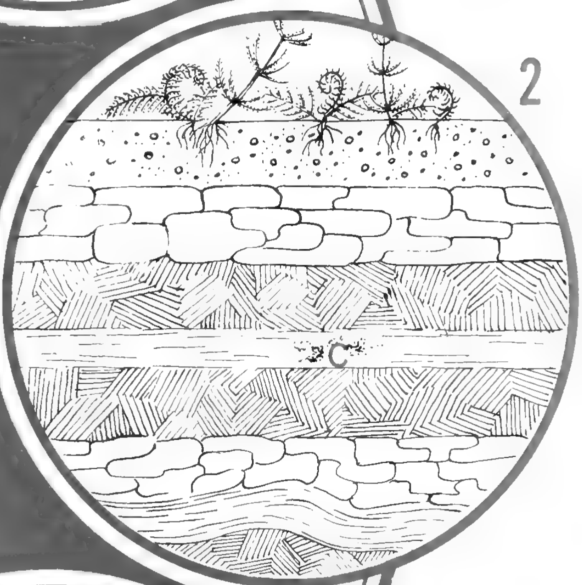
things need more than 30
ıade up of elements such as
gen, sulphur, calcium, and
ing amounts, can be found
nt, a blade of grass.
t one kind of atom *(see "Ex-*
, January 5, 1970). Atoms
ıt they usually form groups
re called *molecules.*
s atoms are not "lost." They
1), joining with other atoms
water, rock, and in other
ıat make up your body may
arth began. Most of them
ou've eaten, liquids you've

mystery. Most atoms were
ears. Some were miles deep
he atmosphere. And some
ings. Think of it. One of the
ce been part of a redwood

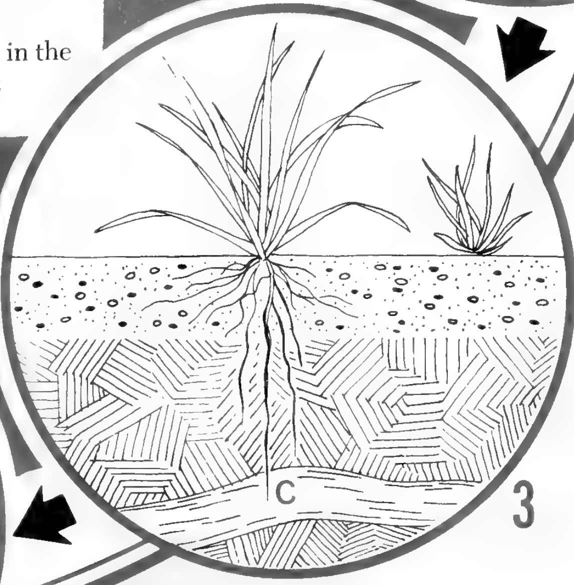
ART show some stages in the
.—LAURENCE PRINGLE



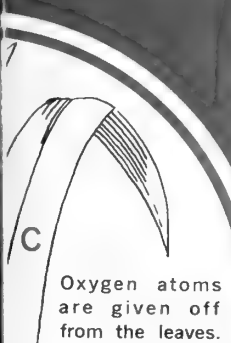
Let's follow a carbon atom, called **C**. We'll pick up its trail 300 million years ago, when it was part of a giant insect like a dragonfly. The insect died and its body settled to the bottom of a swamp.



As the insect decayed, many of its atoms were arranged in new molecules and recycled into the air or water. But its body didn't decay completely. Many years passed and the insect's remains were buried deep under layers of dead leaves from the swamp plants. Eventually, pressure and heat caused by the weight of the material above produced changes in the bottom layers. The atoms of the insect's body and of the plant leaves were rearranged into new molecules, forming coal, a kind of rock. Coal is made up mostly of carbon atoms.



After many millions of years, most of the rock and soil above the layer of coal in which **C** rested was worn away. Roots from a grass plant found a watery crack in the coal and grew down into it, cracking it still wider. **C** joined with two oxygen atoms in the water, and together they became a molecule of carbon dioxide. The molecule was taken into the cells of the plant's roots and was carried upward, from cell to cell, through the roots to the leaves.



Oxygen atoms are given off from the leaves.

called chloro-
y from the sun
› chemical en-
energy splits
› hydrogen and

In the green leaf cells, molecules of carbon dioxide and water are rearranged in a process called *photosynthesis*. Molecules of sugar are formed. The sugar may later be changed to molecules of starch, fat, or cellulose—all of which contain atoms of carbon, hydrogen, and oxygen. When these kinds of atoms are rearranged with nitrogen atoms, molecules of proteins are formed.

Were these large piles of earth made by men . . . rodents . . . wind . . . water? Scientists still haven't figured it out.

The Baffling Bumps

by Ruth Kirk

■ Drive 13 miles south of Olympia, Washington, and you will find the Million Mima Mounds, known also as the Baffling Bumps and the Pimpled Prairie.

The area is a natural clearing in the forest, green with grass and ordinary, except for the mounds that reach smooth and rounded in all directions *(see photo).* Sizes vary from 10 to 70 feet across, and the tops of the mounds come about even with the head of a man walking among them. They look almost like giant eggs buried five to 15 feet apart and lightly covered with soil and grass.

What caused them? Scientists have puzzled for a century and still don't agree.

Grave Markers . . . Fish Nests . . . Gold Mines . . . ?

The mounds were first reported in 1845 by Captain Charles Wilkes, commander of an official government exploring party. He thought they must be Indian burial places, and spoke of how building them must have "required the united efforts of a whole tribe." He ordered his men to dig into several mounds, but in each case "nothing was found but a pavement of stones."

No investigator since then has found anything more. The mounds are made of clay, silt, and pebbles, and they rest on a bed of coarse gravel. Each is rounded top and bottom, scooping down into the ground as well as rising above the prairie.

Thirty years after Wilkes discovered the Mima Prairie, someone showed a sketch of the mounds to Harvard's famous biologist, Louis Agassiz. He said fish must have made the mounds when the area was covered by water long ago. For example, the mounds could have been made by a western relative of the suckers that build mound nests on pond bottoms near Boston.

Joseph LeConte, a geologist, disagreed. Fish had done no more than swim above the mounds in the ancient past, LeConte declared. When the ocean had covered the land, a blanket of silt had been laid down. When the ocean withdrew, most of the soil washed away, but plants held some of the soil in place with their roots—the mounds.

There have been other ideas too:

"Indians built the mounds to look like sleeping buffalo to decoy the real herds." (But buffalo would have had to fly to get the right effect, and there have never been buffalo in western Washington anyway.)

"The mounds are ant hills" . . . or "gas vents" . . . or "where Chinese miners dug for gold in pioneer days."

The Mima Mounds in the state of Washington. Can you think of what might have formed these huge lumps of earth?

"Beavers built platforms for their lodges when the whole area was a vast pond, and only the mounds remain today."

"A great forest grew here. Cyclone winds toppled the trees and blew away the soil except for what the roots held. The roots rotted, and only the soil mounds remain."

Most scientists today consider only two possible causes seriously—frost or gophers.

Frozen Soil or Gopher Nests?

Geologists such as Dr. Harold Malde, of the United States Coast and Geodetic Survey in Denver, Colorado, hold to the idea of frost. They point out that ground patterned much like the Mima Prairie is common in the Arctic. During the last ice age (which ended about 10,000 years ago in what is now the state of Washington), the soil froze. Frost heaved up mounds of earth, and cracks formed around them, in much the same way that the mud of a rain puddle shrinks and cracks as it dries. Water ran along the network of cracks and washed away some of the soil, but the frozen mounds were left.

Biologists such as Dr. Victor Scheffer, formerly of the U.S. Fish and Wildlife Service, argue that mounds are always found within the ranges of pocket gophers, and where soil is shallow *(see photo)*. Since the gophers cannot dig deep, they are forced to build soil up into mounds to provide space for digging a nest. One *zoologist* (a scientist who studies animals) has even collected and weighed all the soil brought to the surface of a meadow by gophers during a year. It totals between four and eight tons per acre. The ordinary habits of pocket gophers are enough to explain the mounds, Dr. Scheffer says.

That's fine, answer the geologists, but how do you explain this? Mounds often are built in layers. Cut one open and you find brown clay at the bottom, gray silt on top, and a thin scattering of stone in the middle like the filling in a sandwich. Can gophers do that?

The biologists have no answer. Instead they remind the geologists that mounds like those of the Mima Prairie are found not only in Washington, British Columbia, and the Arctic, but also as far south as California and Louisiana. Can frost explain that?

Gophers made these piles of earth on the campus of the University of Florida, in Gainesville. Could gophers have made the Mima Mounds?

The geologists do not answer. So far as is known, southern California and Louisiana have never been cold enough for soil to freeze solid.

Making Mountains out of Moundhills

Maybe several theories are right. Maybe the same landscape pattern can come from different causes. Maybe the Paul Bunyan story is right.

Paul had heard of the Great Wall of China and thought America should have one too. So he sent for some men, gave them wheelbarrows, and told them to get to work. They were spirited workers, and soon the Pacific Ocean appeared on one side and the Sierra Nevada and Cascade Mountains on the other. But the men began to grumble, mostly about the food. Paul refused to hire a new cook. The men still grumbled, and one day—before they had made the tops of the Cascades quite even with the peaks of the Sierra—they got disgusted. They dumped their wheelbarrows and walked off the job.

You can see where this happened. Just drive south of Olympia to the Mima Mounds ■

Unexplained mounds are found in other states besides Washington. The diagram shows a cross-section of a mound in Idaho. It is made of the same kinds of layers as the Mima Mounds, but they are arranged in a different order.

MYSTERY PHOTO

Is it a burned waffle, a snow-tire track, a boot sole, or something else? *Submitted by Mr. Richard Iwema, Grand Rapids, Michigan*

Brain Boosters

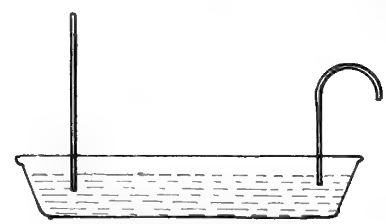
prepared by **DAVID WEBSTER**

WHAT WILL HAPPEN IF?

What will happen to a ball's bounce when it is cold? Drop a rubber ball from a tabletop and measure the height of its first bounce with a yardstick. Then cool the ball for an hour in your refrigerator. Will the cold ball bounce as high as it did before when dropped from the tabletop? Higher? Lower?

FOR SCIENCE EXPERTS ONLY

If a thin tube is placed in water, the water will rise up into the tube. Suppose the same tube is bent into a U-shape, as shown. You might expect that the water would drip continually from the open end. But this does not happen. Do you know why?

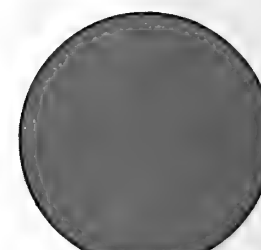


CAN YOU DO IT?

Suppose you had two iron bars, and you knew that one of them was a magnet. How could you find out which bar was the magnet, by using just the two bars?

FUN WITH NUMBERS AND SHAPES

How can you divide a circle into 3 equal areas using a ruler and a pair of compasses?



JUST FOR FUN

Vinegar can be used to test for limestone. If a piece of limestone is put into vinegar, the vinegar will fizz as hydrogen bubbles out. Test rocks, chalk, paper, seashells, plaster, and other things. How long does the fizzing continue?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The sand dunes were formed when a wind was blowing from the left. The sand piles up steeper on the windward side of a dune.

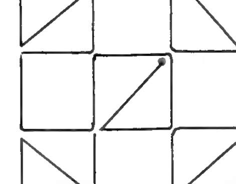
What would happen if? Bottle D would collect the smallest amount of rainwater, while bottle B would fill up first. Which bottle would make the best rain gauge?

Can you do it? To make a paper match land on its edge, just bend it a little before dropping it.

Fun with numbers and shapes: If ring 3 is cut, all of the other rings will come apart. Can you intertwine 5 loops of string so that they will all come apart when the special one is cut?

For science experts only: The South Pole consists mainly of a huge land mass, while the North Pole has a great deal of water around it. Water can hold more heat than land can hold, so the oceans have a warming effect on the North Pole as they store heat from the sun during the Arctic summer, and then slowly release the heat during the Arctic winter.

Just for fun:
Here is how to trace the design.



Energy from the Atom

by Roy A. Gallant

Part 5 of this series showed how scientists of the early 1900s discovered that all of the atoms of a single element are not exact copies of each other. Each element, it turned out, has two or more varieties of atoms, called **isotopes.** *Certain isotopes, as we now know, were to change men's lives by providing a source of energy beyond even their wildest dreams.*

■ For hundreds of years, men known as alchemists tried to make gold by mixing metals such as lead and mercury with "secret" substances. In 1941, an American physicist *did* make gold out of mercury, but not by mixing it with any secret brews. He did it by rearranging the building blocks that make up atoms – protons, neutrons, and electrons.

The alchemists wanted to make gold in order to get rich. Not so with the American physicist. He knew that it would cost more to change a few million atoms of mercury into atoms of gold than the gold was worth. The important thing was that man could reshape atoms. By so doing, he was well on his way to unleashing a rich source of energy—the *nucleus,* or core, of the atom.

Splitting the Atom

The scientist who first began to experiment along these lines was the Italian physicist Enrico Fermi (1901-1954).

The heaviest element known in 1934, when Fermi was doing his experiments, was uranium. An atom of ordinary uranium has 92 protons and 146 neutrons, so its atomic weight is 238. Fermi wondered if he could change uranium atoms into atoms of an even heavier "new" element by shooting neutrons into their nuclei. Although he succeeded in changing uranium into different substances, he could not identify those new substances.

Four years later, the German scientist Otto Hahn, who had joined in Fermi's investigations of uranium, came up with the explanation that Fermi had missed. It seemed so wild, though, that Hahn would not talk about it in public.

One substance produced by bombarding uranium with neutrons seemed to be an isotope of the element barium. But how could that be? Barium is much lighter than uranium; to make a barium atom from a uranium atom would mean that a uranium atom would have to be split more or less in half. Surely that was impossible. Or was it?

Here was the germ of an idea that was to give man a source of energy rich beyond his fondest dreams—also a weapon of war fearsome beyond his imagination: nuclear bombs.

It was Lise Meitner, a co-worker of Hahn's, who saw the importance of Hahn's and Fermi's work, and did something about it. When uranium atoms are split, she reasoned, they break down and become atoms of the elements barium and krypton. But the combined mass of one barium and one krypton atom is less than the mass of one uranium atom. What happens to the "lost" mass? Meitner saw the answer: The missing mass is not lost at all; it is changed into energy! That energy could be used for peaceful purposes—to power factories and to light homes. But it could also be packaged as a bomb.

Making Atoms Split Other Atoms

The time was World War II, when bombs were important. Otto Hahn had managed to bring about the *fission,* or splitting of uranium atoms. But this process was like lighting a match that went out right after it flared up.

By this time, Fermi and his family had come to America to live, because the Nazis were gaining power in his native Italy. Working at the University of Chicago, Fermi saw that the atomic match struck by Hahn could be kept going —if the right approach were used. Fermi reasoned that when a uranium atom was split in two by a neutron bullet, one or more neutrons were set free. If so, then why couldn't those neutrons become bullets and split other uranium atoms, and the neutrons from those atoms split still other atoms, and so on in a continuing chain of reactions? *(See diagram.)* *(Continued on the next page)*

The fission chain reaction in an atomic pile begins when a neutron from a decaying atom of uranium[235] strikes another U-235 atom, making it split and give off three neutrons as well as some energy. Some of these neutrons strike other U-235 atoms, and so on, releasing more and more energy as more and more atoms are split.

> *Do not think for a moment that you know the real atom. The atom is an idea, a theory, a hypothesis. It is whatever you need to account for the facts of experience. [As our ideas about the atom have changed in the past, so will they continue to change in the future.] An idea in science, remember, lasts only as long as it is useful.* —ALFRED ROMER

Exploring the Atom (continued)

The problem was to get a big enough pile of uranium so that there would be enough atoms to keep a chain reaction going. At that time, just after 1940, there wasn't much pure uranium around. Besides, pure uranium is a mixture of two isotopes—uranium^{238} and uranium^{235}. Although uranium^{238} atoms can be split, they cannot keep a chain reaction going by themselves. Uranium^{235} atoms can keep a chain reaction going, but in a sample of pure uranium, only about one of every hundred atoms is uranium^{235}; the rest are uranium^{238}.

With the help of the United States government, however, Fermi and his co-workers got together enough pure and partly purified uranium to make a pile that contained enough uranium^{235} to keep a chain reaction going *(see photos)*. Even though Fermi's "furnace" didn't give off very much heat, it worked. It proved beyond a doubt that the atom could be harnessed as a powerful new source of energy.

This new source of energy was developed during a world-wide war, and it was first used to make atomic bombs—the most powerful weapons man had devised up to then. The bombing of Hiroshima and Nagasaki followed, ending World War II. But those bombings also revealed the horrible destruction that man could bring upon himself.

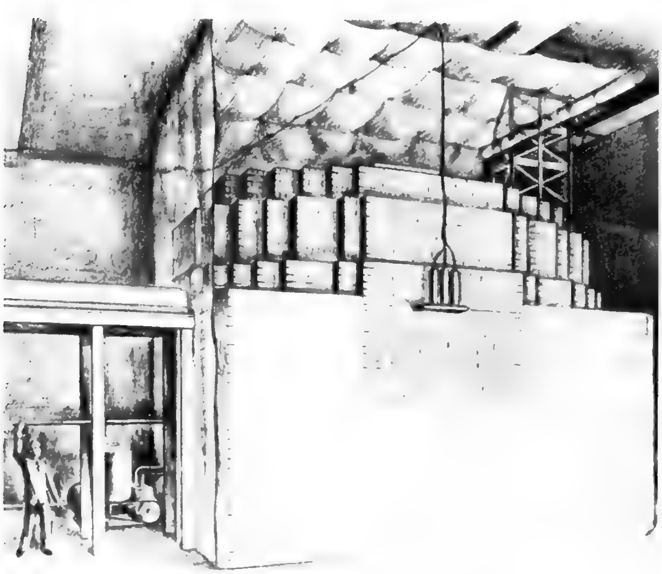
While we have made even more powerful bombs since then, we have also learned to use nuclear energy in peaceful ways. Many nuclear *reactors* (the new name for an atomic pile) were built during the 1950s and 1960s. Today they produce energy to drive ships at sea and to turn generators that make electricity to light our homes.

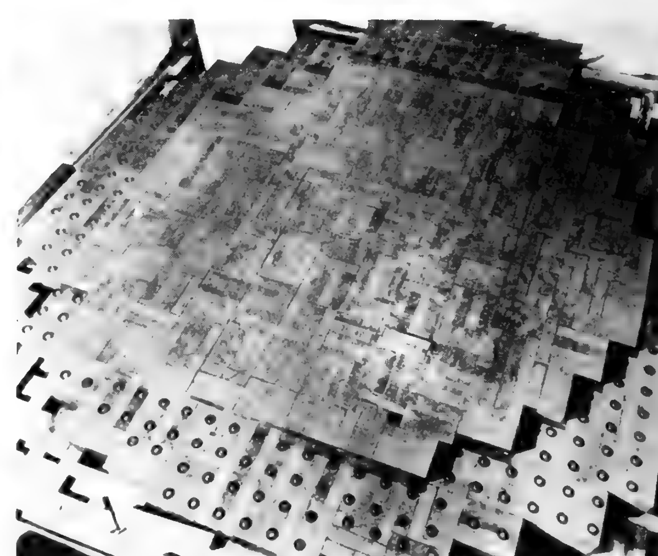
Slowing Down a Chain Reaction

The main difference between a nuclear reactor and a fission bomb is the rate at which uranium atoms in the pile are split. In a bomb, we just let the freed neutron bullets fly around as they will. The chain reaction then goes so fast that a huge amount of energy is released in an instant, causing an explosion.

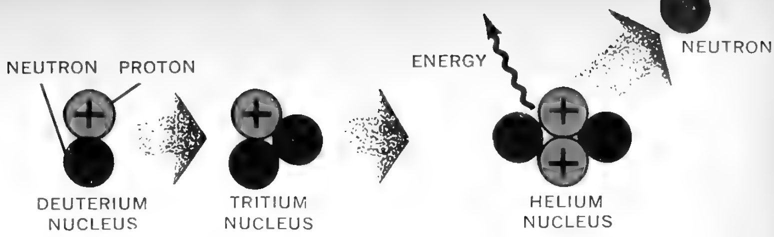
In a nuclear reactor, we slow down the chain reaction by putting shields in the way of the freed neutron bullets. The shields may be blocks or rods of graphite (carbon) or some other suitable material. The more shield rods that are inserted into a reactor, the more freed neutrons are blocked; so fewer atoms are split, resulting in still fewer neutron bullets. In this way the chain reaction is made to go slow. Energy trickles out only as fast as we want it to, instead of exploding out. Pull out all the shield rods, and the reactor would go wild. The heat energy that is released in a reactor is used to heat water and make steam to power a generator that produces electric current.

In the 1950s, a second kind of nuclear energy was un-

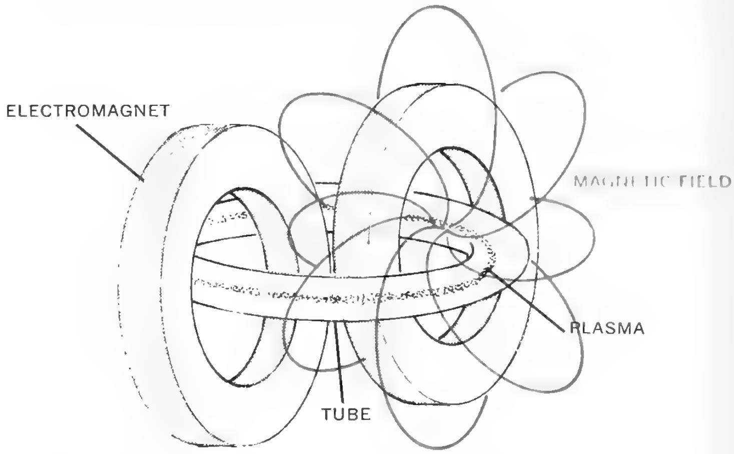




This drawing shows the first atomic pile, built by Fermi and his co-workers in 1942 in a squash court under a stadium at the University of Chicago. The photo shows how layers of graphite tile with uranium in the center were separated by layers of solid graphite tile to slow down the neutrons and keep them from escaping from the pile.



Intense heat makes the nuclei of heavy hydrogen atoms (deuterium and tritium) *fuse*, or combine, forming the nucleus of a helium atom and giving off a neutron. This fusion reaction releases more energy than the fission of a uranium atom does. The sun's energy is believed to come from fusion reactions taking place near its center.



To produce a continuous, controlled fusion reaction, scientists must heat *plasma*—a gassy mixture of heavy hydrogen nuclei—to very high temperatures while keeping the plasma squeezed together. One way this may be done is by sending electric sparks through plasma that is held in the center of a tube by the magnetic field from strong electromagnetic coils around the tube.

leashed by scientists. While fission reactors release energy by splitting apart very massive atoms, the new source of energy came from *fusing*, or joining, the nuclei of very light atoms. The fusion of two such atoms releases much more energy than the splitting of a uranium atom releases.

The sun's great outpouring of energy comes from the fusion of hydrogen nuclei. So does the energy from H- (for hydrogen) bombs. While uranium is the fuel for fission reactors, hydrogen is the fuel for fusion reactions. Actually, it is not ordinary hydrogen that is used in the fusion bomb, but "heavy hydrogen"—two isotopes of hydrogen. One is deuterium (which has one proton and one neutron in its nucleus), and the other is tritium (which has one proton and two neutrons). When the nucleus of a tritium atom and the nucleus of a deuterium atom are fused, they form the nucleus of the slightly more massive atom of helium, which has two protons and two neutrons. At the same time, energy is given off and one neutron is set free.

Energy from Fusion

While slow neutrons can set off a fission reaction, much more energy is needed to set off a fusion reaction. A neutron bullet fired at a uranium nucleus is not *repelled*, or pushed away, by the nucleus because the neutron does not have any electric charge. The positive charge of the protons in the nucleus does not act on the neutrons at all. But think about the nuclei of two hydrogen atoms being fired at each other. Both are positively charged, because each has a proton. That means that they repel each other. How, then, do we get them to join, or fuse? We must push them together with enough energy to overcome their pushing each other apart.

The explosion of a fission bomb releases enough energy to set off a fusion reaction by ramming the hydrogen nuclei together. An H-bomb is nothing more than a fission bomb surrounded by a certain amount of heavy hydrogen. When the fission bomb goes off, it causes the hydrogen nuclei to fuse and release energy. It all happens so fast that we see both events as a single explosion.

As we have been able to slow down the release of energy in fission reactions and use it to power machines, so scientists are now trying to control the energy coming from fusion reactions. This amounts to making a miniature sun in the laboratory.

Scientists can start a safe fusion reaction in the laboratory, but so far they have not been able to keep the reaction going for longer than about five one-hundredths (0.05) of a second. It is like trying to start a match in a windy tunnel. You can strike it and get a flame, but each time it goes out. If we could keep a fusion reactor going for only one second, that would be long enough for it to then keep going by itself. So far, scientists in the Soviet Union have come the closest to making a fusion reactor that works. Some scientists think that within five or six years a successful fusion reactor may be operating *(see diagram).*

There are two main advantages that fusion reactors have over fission reactors. The fuel for a fusion reactor is heavy hydrogen (deuterium), which is found in the oceans. And there is plenty of it—enough to last man for millions of years. Like coal and oil, uranium for fission reactors is in much shorter supply. Another important advantage of fusion reactors is that they would not leave dangerous radioactive wastes—and disposing of such wastes from fission reactors is becoming a serious problem.

Some scientists think that man has reached a major fork in the road of civilization. One way—the wise use of atomic energy—leads to peace and a life of plenty. The other way—a reckless use of atomic energy—will poison our environment and lead to a life of misery for all. Which will it be? ■

The final article in this series, examining the problem of radioactive pollution of our environment, will appear in the May 4th issue. (The April 13 issue will be devoted to a special topic: Food for the Future.)

WHAT'S NEW?

by
B. J. Menges

Weighing wild polar bears in the Arctic is just part of the job for scientists doing research supported by Norway, Denmark, Canada, the Soviet Union, and the United States. Information gained from this research will be used to frame a treaty to protect the huge white bears, whose survival is now threatened.

A bear is located by plane and helicopter. A biologist in the helicopter shoots the bear with a drug-filled dart that makes the animal inactive for a while. The biologist then puts a tag on the bear, examines it, and pulls a tooth to determine the animal's age. The bear is then rolled into a net and lifted by the 'copter (*see photo*). A scale registers the bear's weight—sometimes more than 900 pounds. Radio transmitters are attached to some bears to trace their later movements. So far, more than 300 bears have been checked in this way and released unharmed.

A trip to an asteroid should be man's next goal in space, say Dr. Hannes Alfvén of the Royal Institute of Technology, in Stockholm, Sweden, and Dr. Gustaf Arrhenius of the Scripps Institution of Oceanography, in San Diego, California. The thousands of asteroids that circle the sun are believed to be the remains of the matter that formed the planets. So, the scientists say, exploring one of these small bodies might reveal how the earth and other planets were formed.

The trip would be a fairly easy one. At times, some asteroids come closer to the earth than any other body except the moon. Most are only a few miles in diameter and have little gravitational pull. On such an asteroid, a 10-ton spacecraft would weigh only a few pounds and would need very little power for landing or takeoff.

The fastest-growing trees are now growing twice as fast as ever. Cottonwoods, regarded by many foresters as the fastest-growing timber trees in the United States, usually grow four to five feet in height a year. Now, after 15 years of research, scientists for the United States Forest Service have developed cottonwoods that grow as much as eight to 10 feet a year. Cottonwoods are used in making high-quality paper, furniture, and other products.

Scientists developed the new trees by first finding individual trees that grew much faster than the average. Then they cut small twigs from these trees and grew new trees from the twigs. These new trees make up the fast-growing group, and cuttings from them are used to grow still more trees. Since a tree grown from a cutting has the same inherited characteristics as the original tree, it will grow just as fast.

Whales landed on a beach in Florida recently. About 150 false killer whales, ranging from 15 to 20 feet long and weighing close to 1,500 pounds each, simply swam out of the water onto the sand. People tried to rescue them by tying ropes to their tails and pulling them out to sea by boat. But only 25 whales were saved. The rest swam back to shore, where 125 of them died.

Why did the whales act so strangely? Whales travel in herds, following a leader. An examination of the dead whales did not show that either the leader or any members of the herd had been sick. Cold weather had recently chilled the ocean, and possibly the whales had perished in a desperate search for warmer water. Or perhaps their sonar system failed. Whales send out sounds and locate obstacles by the returning echoes. If the sloping ocean bottom near shore didn't send back echoes, the whales might have "thought" they were headed toward the open sea.

Pollution on the farm is increasing, just as it is in the cities. Recently 300 agricultural scientists and engineers met to discuss this problem. Many agreed that farmers have done a fine job of raising more cattle and more crops, but a poor job of handling wastes.

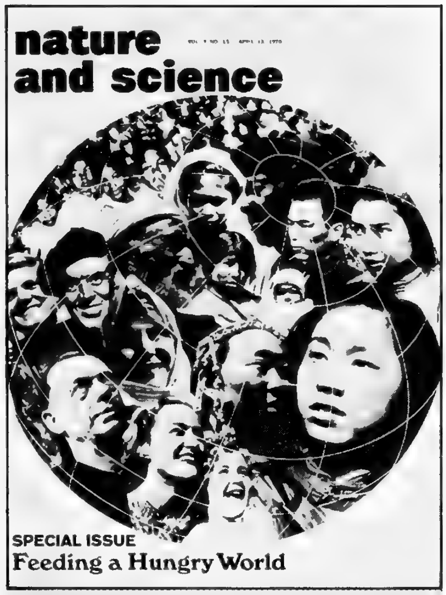
Cattle used to roam the range, where their body wastes fertilized plants that in turn provided the cattle with food. But cattle are now raised in small feed lots, where they grow faster because they don't burn up a lot of energy moving about. Their wastes are often dumped into streams, polluting them. Chemical fertilizers and biocides that are used to increase crop yields also find their way into fresh water. There, the fertilizers can cause an overgrowth of plants such as algae, upsetting the normal balance of life in the stream and killing fish and other life. The biocides kill fish, too, as well as birds and other animals that feed on the fish.

Scientists use a helicopter to weigh a polar bear in the Arctic. This three-year-old female bear weighed 350 pounds.

nature and science

TEACHER'S EDITION

VOL. 7 NO. 15 / APRIL 13, 1970 / SECTION 1 OF TWO SECTIONS



USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

About This Issue

Whether you are an optimist or a pessimist, you can find "facts" to support your views on the world food problem. In a complex situation like this, with so many economic, social, biological, and political factors in play, all "experts" and "facts" should be regarded with some doubt.

In preparing this special issue, the editors of *Nature and Science* found two "facts" that seem to be valid:

1) Nearly all experts agree that the world food problem cannot be truly solved until human population growth stops.

2) Generally, the most pessimistic "experts" are biologists.

Because of the above "facts," we have taken a rather pessimistic stance in this issue. We are inclined to respect the opinions of biologists—especially those who study populations and environments of living things—more than the opinions of economists, chemists, or even agricultural experts. After all, it was an environmental biologist (ecologist) who first warned us about the dangers of long-lasting biocides such as DDT; it was "experts" in the United States Department of Agriculture who attacked the ecologist and continued to promote the use of biocides. Now the case against DDT, and biocides like it, has been proved, and something is being done about them. Generally, it has been environmental biologists who have alerted people to the dangerous deterioration of the human environment due to misuse of technology and to population growth.

Today some biologists may be overly pessimistic about man's chances to survive on earth, but their views deserve careful consideration. On page 4T you will find a list of books and articles that provide further information on the twin problems of population growth and an adequate food supply.

Feeding a Hungry World

This entire article could have been filled with descriptions of fantastic "pie in the sky" schemes for feeding the earth's population with algae, or plankton, or protein grown on petroleum. Someday, methods like these may be used to feed great numbers of people. Now, however, most such food-manufacturing techniques are still in the laboratory or pilot stage, and will probably help little in solving food problems in the next decade or two.

The world food problem is really a collection of problems. In one place it is a crop failure due to drought; in another, a protein deficiency; in yet another, a poor credit and food distribution system. Because of the complexity of the situation, some food experts look with skepticism at the "green revolution." For all of the farmers in a country to benefit from the new high-yielding grains, there has to be a "support structure" of fertilizers, low cost credit, tools, and an efficient distribution system. The farmers have to be able to understand how to use the new seeds and fertilizers to best ad-

(Continued on the next page)

IN THIS ISSUE

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

Race to Nowhere
The earth's resources are limited, so a race to increase food supply to keep pace with human numbers can only result in people's losing.

● **Feeding a Hungry World**
How new, high-yield grains and ways of adding protein to diets offer some hope in the task of feeding people better.

● **Land, Food, and People**
Maps on this WALL CHART show the limits of the earth's farmland, and how the fastest-growing populations are in those countries with little food.

The Promise of the Oceans
The ocean's harvest is increasing as scientists discover better ways of catching and growing valuable protein-rich food from the sea.

The Search for Better Beans
A botanist describes his hunt for wild beans that may help farmers improve their bean crops.

● **Food for Too Many Mouths**
Overpopulation is a concern of both rich and poor nations. Population growth will stop only when people choose a two-child family as ideal.

● **Brain-Boosters**

IN THE NEXT ISSUE

Hazards of using energy from the atom . . . How an island bird sanctuary was set up and how scientists are using it . . . Observing spiders . . . Exploring spring temperatures.

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

vantage—a difficult problem if few of them can read and if a nation can't afford enough agricultural advisors to teach them.

The United States had most of this "support structure" when its farmers were introduced to high-yielding grains and fertilizers a few decades ago. Even then, it took many years for farmers to turn from their old ways. And when farms became more mechanized and productive, men leaving the farms could find jobs in industry. In countries like India, the farmers and laborers have no such recourse.

Topics for Class Discussion

- *Where do you get your animal protein?* Your pupils will probably name the usual sources, especially chickens, cows, and pigs. Point out to them that a lot of animal protein is imported (seafood from other nations, caught in international waters; meat from Australia and Argentina), and that livestock in this country is fed protein that is imported. For example, about 90 per cent of the world's fish meal is used to feed livestock in rich nations. The United States and other rich nations also import millions of tons of soybeans for use as livestock feed. This illustrates how dependent rich nations are on the natural resources of the entire world.

- *Why is a lack of good nutrition especially harmful to children?* The rapid development of a child's body both before and after birth demands a good diet; in fact, at some stages a child needs more protein than an adult. When nutrients are lacking, great and lasting damage can be done. For years, biologists have known that rats deprived of vital nutrients before birth turned out to be smaller, slower learners, with smaller brains than animals given proper nutrition. The same sort of results were observed when a group of children who had suffered from *kwashiorkor* (a protein deficiency disease) were compared with their brothers and sisters who had not had that disease. The kwashiorkor victims scored much lower on intelligence tests.

INTERNATIONAL RICE RESEARCH INSTITUTE

More than 30 per cent of all human energy comes from rice—Asia's basic food. At the International Rice Research Institute in the Philippines, Asian scientists learn how to improve rice yields by developing new varieties through plant breeding.

Activities

- Have your pupils investigate the sources and importance of different food nutrients. What are the effects of different vitamins on their bodies? Where do they get these vitamins? What are their sources of fats, carbohydrates, and proteins? They can find information on food nutrients in science textbooks, encyclopedias, and books on health from a library.

- Ask your pupils how they would go about trying to overcome the inhibitions people have against certain food. Suppose only wheat was available in a region where the people normally ate rice. How could the people be encouraged to eat wheat? Or suppose the United States population was malnourished, especially short of animal protein. How would you go about encouraging use of "luxury" animals —cats, dogs, horses—as food?

Land, Food, and People

The map on page 8 shows the world's croplands, located mostly in the temperate zones. About another 20 per cent of the earth's land can be used as pasture. Most of the rest is either too rocky, too dry, too wet, too hot, or too cold to be suitable for agricultural development. If and when nuclear desalting plants become efficient enough, some of the earth's arid lands could be used for raising crops.

People often wonder why the vast tropical forests can't be cut down and the land used for raising crops. The soils of the tropics are very low in minerals. The lush forest growth depends on minerals that are released from decaying leaves on the forest floor. Once the trees are removed, minerals are quickly washed down deep into the soil by rains. No new minerals are added because the source (trees) is gone. Fertilizers, like the natural minerals, disappear quickly from the upper soil levels where they are needed by crop plants.

The map on page 9 shows birth rates and death rates for some countries. Demographers expect that further medical progress in some countries will result in even lower death rates. If the birth rates don't decrease also, this will mean an increase in population growth.

Today's "developed" countries went through the same stage that many "developing" countries are in now. First a nation has high birth and death rates. The death rate stops but the birth rate continues to be high for 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.

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

time. Then it drops. Biologists who are concerned about population growth want to speed this process in the developing countries with a goal of zero population growth for the earth as soon as possible.

Too Many Mouths

Compared with many nations, the United States is thinly populated. Even European countries like Switzerland, famed for its scenery, are much more densely settled. But here the concentration of people in sprawling metropolitan areas, the spread of "sight blight" *(see* N&S, *March 2, 1970),* and other signs of a worsening environment are making many Americans uneasy about this country's devotion to the ideals of "growth," "progress," and "bigger means better."

In July 1969, President Nixon sent to Congress the first presidential message ever devoted entirely to population problems. Population specialists were disappointed in the message; it mainly called for expanded research and services in family planning. Many population experts doubt that extension of family planning activities, though desirable for other reasons, will have much effect on population growth. Middle class parents, who make up the vast majority of the U.S. population, are already acquainted with birth control methods, and are producing most of the new babies.

Yet the President's message did show how much attitudes have changed in a decade. In 1959, President Eisenhower said that birth control was not the business of the federal government. (A few years later, however, he said, "I have come to believe that population explosion is the world's most critical problem.") And population experts are encouraged by statements of other members of the Nixon administration *(see "Springboards for Discussion").* A recent report by the National Academy of Sciences' Committee on Resources and Man states that "a human population less than the present one would offer the best hope for comfortable living for our descendants, long duration for the species, and the preservation of environmental quality."

Topics for Class Discussion

- *How does a rapidly growing population in the United States affect the "quality of life"?* As the article points out, many of today's problems of crowded parks, traffic jams, and such can't be blamed solely on population increase, but they are compounded by that increase. Rich countries consume more natural resources and create more pollution than poor ones do; this suggests that they can't be as densely populated as, say, countries like China or India. In fact, it is said that the earth could not support its present population of 3½ billion if all of the people had our standard of living.
- *Why do "family planning" services alone fail to check population growth?* In the United States, most parents want to have three or more children. To achieve a zero population growth, the national average should be about 2.3 children (the fraction allows for the deaths of some children before they become adults). Also, family planning services reach mostly urban poor, a small part of the population.

Japan is often cited as an example of a nation that slowed its population

(Continued on the next page)

SPRINGBOARDS TO DISCUSSION

"We talk about family planning. We champion the principles of free choice–freedom of conscience, freedom from coercion of any kind . . . but what does freedom of choice in family planning imply in the present state of society? It implies enormous population growth for the simple reason that the typical American family, if it can, will elect to have three children, not two. Thus family planning, in the present state of things, will lead to intractable population growth–to 300 million Americans by the year 2000."–DR. ROGER O. EGEBERG, *Assistant Secretary for Health and Science Affairs, Department of Health, Education, and Welfare.*

"Fertility has been the key to the survival of every species. And now for the first time in earth's history, there has emerged one creature for which fertility is not a blessing but a curse. That creature is man. . . . Can we reverse the cultural traditions of thousands of years of cultural civilization? We can."–DR. LEE A. DUBRIDGE, *science advisor to President Nixon.*

"Furthermore, our concept of the good life is important to the rest of the world. . . . If the mass media spread the idea that what every American woman wants is a station wagon filled to the brim with children, complete with a well-fed dog, then this idea will become part of the aspirations of people everywhere, whether obtainable or not. With such a picture rampant in their minds and ours, we can hardly advocate conception control for other countries.

"In today's world it is an unbearable implication that we can afford to have such large families because we can feed, clothe, and house them properly, but those who are poorer should not. This is tantamount to saying: There are too many of you, but there couldn't be too many of us.

"It is vital that we recognize the need for, and pioneer in working for new ways of balancing the population of adults and children in the United States. Only then can we turn to members of nations which are striving to achieve mere subsistence, look them in the eye, and say: We are working at the problem, too."–MARGARET MEAD, *Curator Emeritus of Ethnology, The American Museum of Natural History, and author of many distinguished works in cultural anthropology.*

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

growth through birth control programs. Since 1948 the government has vigorously encouraged population control. Yet some Japanese population experts say that the people would have limited their numbers without government help. Japan is the world's most crowded nation, with 102 million people crammed into a string of islands with a total area smaller than the state of Montana. Just after World War II Japan's future looked bleak, with near-starvation conditions and a war-ravaged economy. The highly literate people concluded that big families were "out," and that attitude has persisted even though Japan is now prosperous. (Economic conditions have had a marked effect on population growth in the United States, too; the birth rate hit a modern low in 1936, during the depression.)

The Prime Minister of Japan recently startled many population specialists with a call for an increase in Japan's birth rate. The reasons are economic: a growing shortage of cheap labor for Japan's bustling economy and a growing number of elderly people who have to be cared for. Critics of this suggestion say that Japan ought to sacrifice some economic growth in order to improve the "quality of life" for an already crowded nation.

• *How can people be encouraged to have smaller families?* The box on page 15 suggests two possible ways. Here are some other ways that have been suggested: compulsory sterilization of men with three or more living children; bonuses for couples who have two children or less; bonuses for delayed marriage. Obviously, many of these suggestions are controversial. One of the most common suggestions is for the United States government to eliminate or reduce the tax exemptions now allowed for children. Yet, some population specialists say that such tax advantages or the family allowances that are common in many countries have no effect on birth rate. They say that all that governments can really do is inform people about the need for a stable population, provide them with the means of controlling births, then hope that the people will voluntarily decide to limit their families.

For Your Reading

- *Too Many,* by Georg Borgstrom, The Macmillan Company, New York, 1969, $7.95.
- *The World Food Problem,* by Willard Cochrane, Thomas Y. Crowell Company, New York, 1969, $7.95.
- *Our Overcrowded World,* by Tadd Fisher, Parent's Magazine Press, New York, 1969, $4.50.
- *Farming the Sea,* by Alexander McKee, Thomas Y. Crowell, New York, 1969, $6.95.
- *Famine 1975!* by William and Paul Paddock, Little, Brown, & Company, Boston, 1967, $6.50 (paper, $2.35).
- *Hunger,* by John Scott, Parent's Magazine Press, New York, 1969, $4.50.
- *Food and Nutrition,* by William Sebrell, Jr. and James Haggerty, LIFE Science Library, Time Inc., New York, 1967, $4.95.
- "The Food Resources of the Ocean," by S. J. Holt, *Scientific American,* September 1969.
- "Eat and Go Hungry," *N&S,* January 9, 1967.
- "Standing Room Only on Spaceship Earth," by Morris Udall, *Reader's Digest,* December 1969.

Brain-Boosters

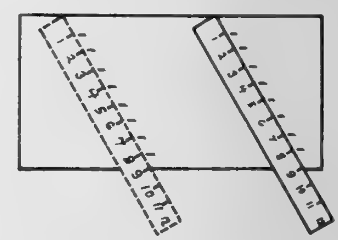
Mystery Photo. The tree was bent at the height shown in the photo. All upward growth in a plant occurs from the top of the plant *(see "How Does Your Beanstalk Grow?",* N&S, *Nov. 10, 1969).* What probably happened in this case is that a larger tree or branch fell and pushed aside the growing tip of the smaller tree. The treetop remained bent, and the new growth continued straight up.

Perhaps your pupils could find some misshapen trees near school or home and try to guess what caused the malformation. Or they could experiment with fast-growing indoor or outdoor plants by making bends in them at various places and seeing how this affects the future growth of the plants.

What will happen if? Even though the switch is open, the circuits leading to and from the bell and lower light bulb are complete, so the bell will ring and the light bulb will light. Closing the switch, however, will connect the two dry cells positive-to-positive and negative-to-negative—rather than positive-to-negative, as they should be. Current cannot flow when dry cells are connected this way, so when the switch is closed, the bell will *stop* ringing, and the lower light bulb will go out. The upper light bulb will not light whether the switch is open or closed.

If possible, obtain the necessary materials and let your pupils set up this circuit to test for themselves *(see "Bulbs and Batteries,"* N&S, *March 4, 1968).* Can they set up some "puzzle circuits" of their own?

Can you do it? Give your pupils a few minutes to solve this problem with ruler and paper. Here is a quick way to do it: Lay the ruler across the paper on a slant, so the "zero" mark is at the top edge of the paper and the 9-inch mark is at the bottom edge. Then mark



off each inch along the ruler, move the ruler to another position on the paper (keeping the same slant), and do this over again. Then draw lines straight across the paper through each pair of marks.

Fun with numbers and shapes. Here is how the numbers can be made to equal 100:

$$1+2+3+4+5$$
$$+6+7+(8\times 9)=100$$

Your pupils might have some fun devising similar problems for their classmates to solve.

For science experts only. There is a small amount of water inside a kernel of popcorn. When the popcorn is heated, the water boils, producing steam that explodes the corn grain. Hybrid varieties of corn have been developed especially for popping. What happens if your pupils try popping other types of corn?

nature and science

VOL. 7 NO. 15 / APRIL 13, 1970

SPECIAL ISSUE

Feeding a Hungry World

Roads, Honda rice, mock meat, fertilizers, and a drink called Puma may help solve the problem of . . .

Feeding a Hungry World

by Laurence Pringle

Millions of children die each year for lack of enough good food. Even if a chilc survives and later begins to eat well, his body and brain may be affected by the earlier malnutrition.

■ Most of the 225 million people in the United States eat very well. And there are about 225 million others around the world who eat as well as we do.

That's very nice for 450 million people. Unfortunately, the rest of the world's people—over *three billion* of them—don't eat as well.

About a billion of these people are *malnourished*—they get enough rice or other food to fill their stomachs, but they don't get enough of the *right kinds* of food. Their meals usually lack *protein*—the nutrient needed for good mental and physical development. About half a billion people are *undernourished*—they don't even get enough food to fill their stomachs. And several million people die each year from lack of food. These people may not actually drop dead of starvation. They die of any of dozens of diseases that they normally would survive or wouldn't even get if they were eating well.

Just a few years ago, it looked as though this grim picture would soon become even darker. The United States rushed a quarter of its 1966 wheat crop to India in order to save millions of people there from starvation. Food production around the world had slipped behind in its race with the growing numbers of people *(see pages 2 and 14)*. Two food experts wrote a book called *Famine 1975!*, and many others agreed that there might be terrible food shortages and widespread starvation by the mid-1970s.

Seeds of Revolution

Then came the "green revolution," with greatly increased harvests from new varieties of wheat and rice. The world's food production has increased for several years, especially in the "poor" or "developing" countries that have the fastest-growing populations.

The green revolution had its beginnings many years ago. Since 1943, scientists have been working with thousands of varieties of wheat in Mexico. By breeding one variety with another, they got seeds that grew into plants having characteristics of both varieties. Eventually, the plant breeders developed wheat plants with the characteristics they wanted.

The plants produce many seeds and grow quickly, so more than one crop can be raised each year on the same plot of land. The plants are short, with stiff stalks. Grown in fields that are enriched with fertilizers, the Mexican wheat plants become heavy with grain but do not fall over. (Taller wheat plants often fall over, and this wastes grain.)

The new wheat seeds were used in Mexico with great success. In the early 1950s, Mexico had to import more than 300,000 tons of wheat each year to feed its people. In 1967, Mexico *exported* about 150,000 tons.

During the 1960s, the new Mexican wheats were tried in Pakistan and India. They were bred with native wheat plants to produce new varieties having grains with the color and taste that people in those countries like. Each year more acres are planted to the new "miracle" wheats, and both Pakistan and India expect to be able to stop importing wheat during the 1970s.

Rice is the main food of most people in Asia. In 1962, the International Rice Research Institute was set up in the Philippines by the Ford and Rockefeller Foundations. Plant scientists at the Institute collected thousands of varieties of rice from all over Asia. Then they began breeding the different varieties together in order to produce a better rice plant.

In late 1966 the scientists announced that they had developed a "miracle" rice, called IR-8. It produced from two to six times as much grain as varieties commonly used in Asia. IR-8 turned out to be something less than a miracle, however. It ripened too slowly, and was easily wiped out by diseases and insects.

Eventually, after further work at the Institute, some improved varieties of IR-8 were produced. Now IR-8 is rapidly becoming the standard rice of southeast Asia. Using it, the Republic of the Philippines now grows all of the rice its people need, after importing rice for the past

(Continued on the next page)

Scientists studying rice in the Philippines *(above)* have produced varieties that yield several times as much grain as older varieties. The left photo shows Indian scientists looking for wheat plants that are resistant to disease.

A Moroccan farmer and his ox are almost hidden by a swarm of locusts *(above)*. These insects, along with rats and other pests, destroy many tons of food each year, especially in countries where grain is stored in the open *(right)*.

67 years. In Vietnam, some farmers call IR-8 "Honda rice" because by growing it they can earn enough money to buy a motorcycle .

A Crop of New Problems

The green revolution has brought more than food to developing countries. It has also brought great change and new problems. In India, it is mostly the rich landowners who have been able to use the new plants. Most Indian farmers still work their little plots of land just as their ancestors did hundreds of years ago. They may have heard of the new seeds and fertilizers, but they can't afford to buy them.

As the rich farmers produce bigger crops of wheat and rice, the prices may drop and the poor farmers will get less for their efforts. Also, the rich landowners are buying tractors and other modern machinery and have fewer jobs for laborers. For millions of poor farmers and laborers, the green revolution may seem more like a disaster than a dream come true.

More help is needed from rich countries if the green revolution is to help all of the people in developing countries like India. Somehow, poor farmers must be able to get low-cost loans, perhaps from the government. Fertilizer factories must be built. Pests must be controlled to reduce the waste of grain. (In India, a quarter to a third of all food available is eaten by insects and rats.) Better roads and railroads must be built to get fertilizers and machinery to farmers, and food from the farms to the cities. (It is easier for the port cities of India to get grain by ship from other countries than to get it by land from central India.)

Many food experts believe that the green revolution will succeed in giving people enough food to fill their stomachs —*if* the population growth can be slowed *(see page 14)*. Meanwhile, scientists in many countries are working on the many other food problems that remain.

The Push for Protein

When you eat and drink, the amount of energy that the food gives you is measured in units called *calories (see map on page 9)*. A diet of rice or some other grain will give you all the calories you need to keep alive. But you might be sick, or blind, or crippled because you didn't get enough vitamins or other nutrients from a varied diet.

A lack of needed nutrients *(malnutrition)* can be especially harmful to children. Scientists have discovered that the brain is the fastest-growing part of the body during the first few months of life. During that time, malnutrition affects the brain more than it does other organs. And the effects seem to be permanent. If a child's brain develops poorly because of malnutrition, it stays that way for life, regardless of the person's diet in later years.

The most important nutrient for good health is protein. The efforts of many scientists are aimed at getting more protein into the daily meals of the world's malnourished people. Protein from animals (in the form of meat, milk, fish, eggs) is of higher quality than plant protein. One way to get more animal protein is to harvest more food from the oceans *(see page 10)*.

Growing animals on land for protein is a luxury that few developing countries can afford. A 10-acre field produces enough beef to feed one person for a year. But the same field, properly watered, can produce enough rice to feed 24 people for a year. In the United States, so much grain is produced for our population that we can afford to feed it to cows, pigs, and other livestock. In developing countries, most or all of the grain is needed by people.

The main hope now for better nutrition in developing countries is to produce plant foods containing more protein. This has already been done with corn. Plant breeders at Purdue University, at Lafayette, Indiana, developed a new variety of corn that contains much more protein than varieties now in use. In time, plant breeders may be able to do the same with rice, wheat, and other plants.

Another way to give people more protein is to add it to other foods. The protein may come from fish *(see page 11)*, or from plants such as soybeans. Compared with most plants, soybeans are rich in protein. They are not popular as food in many countries, but scientists have discovered how to remove the protein from the beans. The protein is then added to baking flour and other food, including soft drinks *(see photo)*.

Recently, protein from soybeans has been used to make "imitation meat." The protein pulp is spun into long bands of fibers. Then the fibers are pressed together to look like meat, with extra nutrients and artificial flavors and colors added. Almost any meat can be imitated—chicken, bacon, beef, scallops, ham. Some of these "mock meats" are already being sold in the United States.

Seventy Million More Mouths Each Year

Whether spun-protein foods like these will be widely used is a big question. People everywhere have strong feelings about the food they eat—or don't eat. In India, for example, millions of cows roam the countryside, unharmed by men because most Indians believe the cows are sacred. For different reasons, people in the United States don't eat crickets, dogs, or snakes—all considered fine food in some parts of the world.

People don't like to change from foods they are used to. The new IR-8 varieties of rice, so successful in southeast Asia, are not popular in India because of their taste. Plant breeders have learned that the color and taste of a food is as important as the amount of calories and protein it contains. More study must be aimed at finding ways to get people to eat new kinds of food *(see page 11)*.

Everyone on earth may have to get used to eating strange new foods if the population keeps growing at its present pace. Nearly all of the farmland on the earth is already in use *(see map on page 8)*. More food can be grown on land and in the sea, but the amount can't increase forever.

Engineers, chemists, and biologists are investigating ways of turning algae into human food, of making protein concentrates from the leaves of weeds, of growing protein on wastes from oil refineries, of making protein from wool. But only the richest countries can afford to develop these new sources of food. Most food experts doubt that ideas like these will result in tasty, nutritious, inexpensive food for many years.

Meanwhile, there are 70 million more mouths to feed each year. Most of these people are born in countries that need help in growing more nutritious food and in controlling their populations.

Speaking of the United States and other food-rich nations, Dr. Georg Borgstrom, Professor of Food Science at Michigan State University, said "We should certainly not believe that we can remain seated in the first row, unperturbed by the great human tragedy unfolding on the world scene: two billion hungry and destitute, rapidly growing to four billion. The human race has become too big. It is high time we start looking at the world not from our vantage point but from that of others and arrive at a program serving the *whole* of mankind, not merely a few hundred million." ■

These girls in Guyana, South America, get extra protein and vitamins from a soft drink called "Puma."

Land, Food, and People

■ Nearly one-half of the world's people do not have enough to eat, or do not get enough of the right kinds of food. The maps on this WALL CHART show some reasons for this problem.

The top map shows the small percentage of the world's land that is suitable for growing crops. People who live in areas that do not have much farmland are often undernourished. But simply having plenty of farmland is no guarantee that the people in a country will be well fed. In poor countries, most farmers do not know about modern farming methods. Often they cannot afford to buy equipment and fertilizers to help them get big crops from their land.

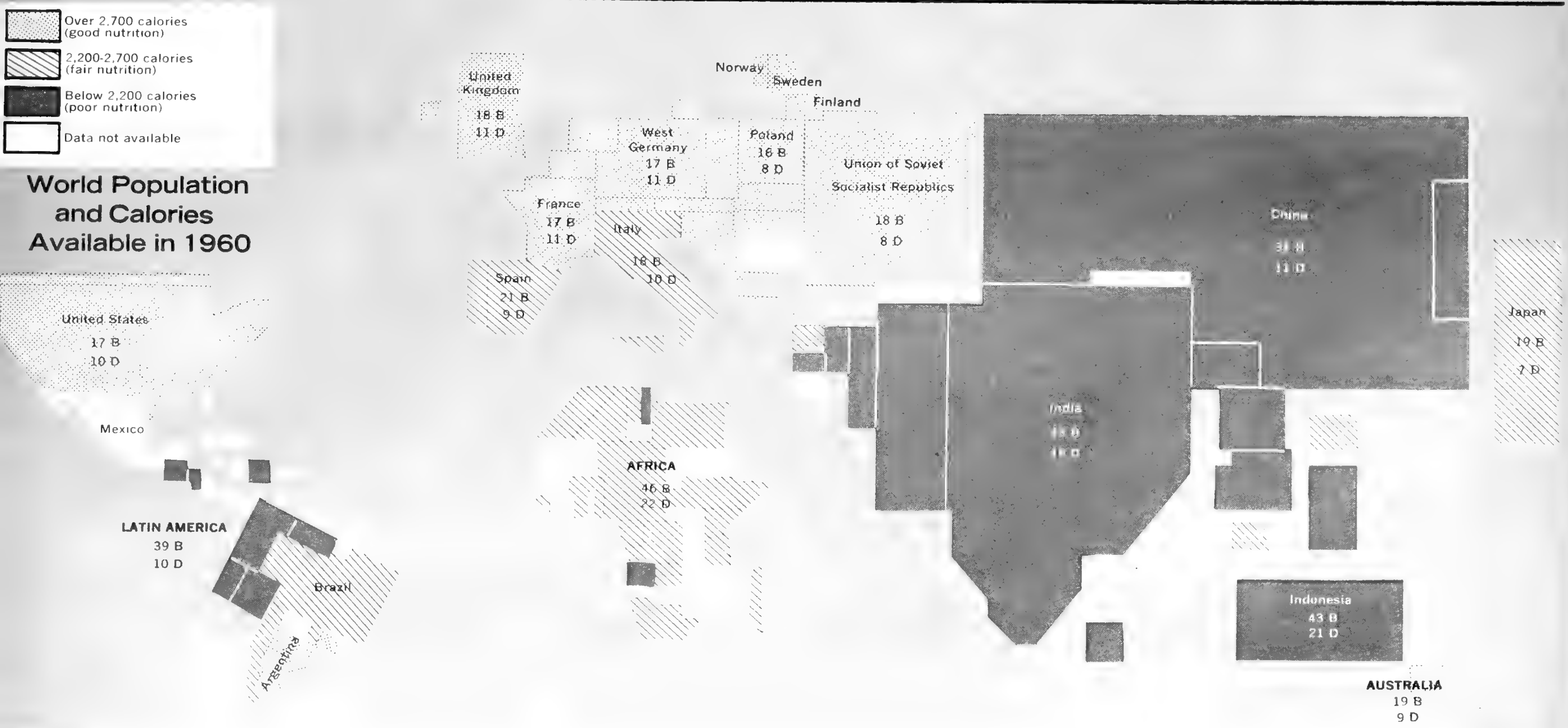
There are too many people in the world for the amount of food being produced. The bottom map shows how the earth's 3½ billion people are spread around the world, and how fast the population is growing in some countries. It is growing fastest in countries where people are already poorly fed.

There are some causes of the world food problem that can't be shown on a map. The money lenders who overcharge Indian farmers who need money to buy fertilizer; the rats and locusts that destroy many tons of food; the unwillingness of people to try new kinds of food—all these add to the problem of feeding a hungry world.—MARGARET E. BAILEY

World Farmlands

The world's farmlands are shown in gray on this map. They cover only 10 per cent of the world's land area, yet they provide most of the world's food. Another 15 or 20 per cent of the world's land can be used as pasture for animals, but the rest of the land is unsuitable for agriculture. As the world's population grows, people will need more land to live on; this could cut down even more on the small amount of farmland in the world. And that could mean even less food.

World Population and Calories Available in 1960



This map is drawn so that the size of the countries is in proportion to the number of people that live in them—this means that the countries with the most people are drawn the largest. Their shapes are also simplified *(see top map for more realistic sizes and shapes)*. This map shows the average number of *calories* (energy from food) available to each person each day in different countries. (A person who does hard, physical labor needs about 4,300 calories a day.) Most of the countries that do not have enough calories for their people do not have enough *protein*, which is also needed for good nutrition. In many places that have too little food, many more people are born than die each year. (On the map, the numbers 46 B, 22 D in Africa, for example, mean that for each 1,000 people there, 46 babies are born and 22 people die each year.) These places, with many people already starving, need to produce more food even faster than countries such as the United States need to.

Objects that attract fish can help increase sea harvests. These pile perch find shelter and food among streetcars that were dropped into California coastal waters.

The Promise of the Oceans

Almost three-quarters of the earth's surface is covered by the sea. These waters have always been thought of as a vast storehouse of food. But getting food from this storehouse is now one of man's greatest challenges.

by Susan J. Wernert

■ Three hundred years ago, someone watching whales near the Massachusetts coast is said to have pointed to the ocean and predicted, "There is a pasture where our children's grandchildren will go for bread." Today, the harvest from the ocean is increasing faster than the harvest from the land. It can increase still further. But can the sea provide enough food, soon enough, for the growing numbers of people?

There are a lot of ways to keep increasing the food supply from the sea. Some are in use already—in lakes and ponds, near the coast, or in a few places in the open ocean. Others are just ideas for the distant future.

The Better To Catch Them with

There are many water animals that are simply not being caught. Fishing is too often a matter of luck. So scientists and engineers are trying to find better ways of locating and catching food from the sea. For example, schools of fish can be located by sending sound waves through the water and then observing the patterns made by returning echoes.

Swordfish in the Atlantic Ocean used to be captured by harpooning. Biologists learned that there were many swordfish deep in the water, where they can't be harpooned. Fishermen were persuaded to use baited hooks on long lines that stretched deep into the ocean. In 1963, the first year of "longlining" swordfish, the catches broke all records.

In some cases, fishes and other water animals can be made to *come to* fishermen. Some sportsmen now use chemicals or sound signals to attract fish. Soviet vessels have attracted fish with lights, and then sucked them in with a pump. Nearer the shore, artificial reefs made of car

In a Japanese bay (seen at low tide), oysters are grown on hanging strings of shells. Oysters grown in this way are better protected, get more food, and can yield 6,000 times more food than oysters grown on the ocean floor.

bodies, building rubble, or other materials *(see photo)* have increased catches from Japan to New Jersey. Like coral reefs, they attract animals by providing shelter and food.

The Better To Grow Them with

One biologist estimates that the world's fish harvest can be multiplied by four if modern fishing methods are used more widely. But this isn't the only way of increasing the food harvest from the sea. The amount of food that is *in* the sea can also be increased.

Like farming the land, farming the sea involves providing better living conditions for the crop you're trying to grow. Providing more food is one way. Sewage (in carefully controlled amounts) has been added to carp ponds in Germany as food for the animals that the carp eat. Perhaps some day fertilizers can be used to increase the sea plants that fish eat.

Slight temperature increases make some animals grow faster. Water warmed by power plants has speeded the growth of certain kinds of fishes in Scotland. It has made it possible to grow oysters and clams all year in a small lagoon near Long Island, New York.

Sometimes sea harvests can be increased by reducing the dangers from predators. In Japan, shells are hung from rafts or poles so that young oysters can settle on the shells instead of the sea floor *(see photo)*. This keeps starfish and other bottom-dwelling animals from eating the oysters.

Breeding programs can also increase harvests. Salmon and other fishes have been bred so that the offspring provide more food than the parents. Biologists hope to breed oysters that grow faster and larger than oysters do now.

The Better To Eat Them with

The ways of harvesting the sea can be improved. But they will not help much unless a problem can be solved. There is no ready market for all the seafood that could be caught. In fact, some fishermen say that they return about half their catch to the sea.

Look at the map on page 8, and you can see places where there is too little food near sources of plentiful seafood. But fish cannot be stored and transported as easily as foods like rice, so they may spoil before they can be eaten. And even if seafood is delivered to people who need more food, the people may not want to eat it.

Chile has some of the best fishing grounds in the world. But the people there seldom ate fish. The Food and Agricultural Organization, of the United Nations, sent a Danish scientist to Chile to change the people's eating habits.

The scientist worked with children in the first and second grades. He had them do arithmetic by adding or subtracting numbers of fish. They learned geography by mapping the routes of fishing fleets. They sang fishing songs. They talked about fish in school, and many of the children talked about it at home. Children and adults became more aware of fish, and began eating fish. In two years, the amount of fish eaten in Chile tripled.

Another way to get people to eat more fish is to add it to foods people already like, after changing the fish to *fish protein concentrate* (FPC). FPC is made by removing fats and oils from fish and grinding what is left into a fine powder. It has little or no taste or smell. It doesn't need refrigeration, is easy to move and store, and can be added to many foods to provide people with more protein *(see photo)*. But so far, FPC cannot be produced cheaply enough to be used in many places.

Some scientists believe that the sea has a vast ability to provide food. They know that there are many unused, or under-used, organisms in the water. These organisms include *krill*—shrimp-like animals that are plentiful in the Antarctic and eaten by whales. These scientists know that about one-thousandth of the sea provides about half the world's harvest. This suggests there are "oceans" of food in the rest of the ocean.

Others take a less hopeful view. They believe that little increase in the coastal harvest is possible, and that even now some areas are overfished. The deep sea, they say, is too unexplored to provide much more food in the near future. And, like the land, both the coastal waters and the deep sea are becoming more and more polluted. The pollution kills organisms that could be used for food, or keeps them from reproducing.

These scientists admit that there is a lot of krill in the Antarctic Ocean, but they point out that no one knows yet how to harvest it or how to eat it. Getting a great increase in food from the sea will take a lot of study, money, and time. In the race between food supply and human numbers, the promise of the oceans is still mostly that—a promise ■

High-protein powder made from fish has no taste and will not spoil. The sauce, soups, and other foods shown were enriched with this fish protein concentrate.

The Search for Better Beans

A botanist tells how he explored Mexico's farms, markets, and wild areas to find beans that might help boost the world's food supply.

by R. J. Lefkowitz

■ Not far from our nation's capital, in Beltsville, Maryland, the United States Department of Agriculture has its 10,000-acre Agricultural Research Center. I went there recently to find out what scientists in the Center's New Crops Branch are doing to help provide more food for the world's growing numbers of people.

"What new crops have you discovered lately?", I asked Dr. Quentin Jones, a *botanist* (plant scientist) who is Assistant Chief of the Branch.

"One of our scientists," said Dr. Jones, "has recently found some beans growing wild in Mexico that can probably be used to improve our bean crops—our snap beans, pinto beans, Navy beans, kidney beans, and so on."

I was puzzled by Dr. Jones's answer. Beans aren't new. Why wasn't the New Crops Branch looking for *new* crop plants, instead of plain old beans?

"New" Plants from "Old"

"There will probably never be any really 'new' food plants discovered," Dr. Jones explained. "Over the centuries, men have probably sampled just about every plant there is. And any plant that they could eat, and that they liked, they have eventually raised for food. What our scientists try to do is to find *variations* of the plants that are already being grown somewhere for food. Different varieties of the same plant will have slightly different characteristics. Some have characteristics that enable them to survive better in certain conditions, or to yield more fruit, or to supply more protein. Often we can breed plants so that the useful characteristics of one variety are combined with other useful characteristics of another *(see page 4)*.

"Beans are an important food plant in many parts of the world," Dr. Jones pointed out. "That is why we sent Dr. Howard Gentry on an expedition to look for some types of beans that might be used to improve our present crop varieties by making them better able to resist disease."

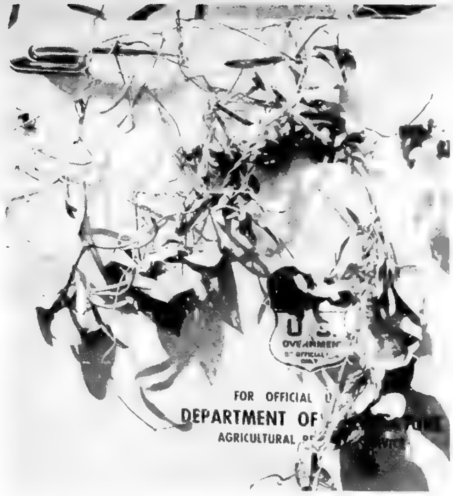
As I stepped into Dr. Gentry's office, I was surprised to see a huge map of Mexico and Central America on the wall, with about 200 different types of beans pasted on it. Dr. Gentry explained that they were samples of the beans he had collected in different places during his expedition.

"How did you decide where to look for the beans you

Dr. Gentry and his assistant collected beans from farms *(1)*, markets *(2)*, and wild areas of Mexico *(3)*. The markets and farms (shown here during a bean harvest) yielded many different types of beans, but the "ancestors" of our common beans were found growing wild among other kinds of plants.

1

3



Wild beans like the ones shown here twine themselves around other plants in dense thickets, making it hard to find the beans.

wanted?", I asked.

Dr. Gentry explained that he was looking for a place where beans were still growing wild, as they did thousands of years ago, or where "wild" types of beans were being raised by farmers. "I thought that if I could find such a place, I would probably find some healthy, disease-resistant specimens. After all, these beans would have been growing and reproducing year after year for centuries, with or without man's help. They would have to have some characteristics that helped them to survive on their own in the wild, or that made them useful to farmers in that area.

"My research showed that beans had probably first appeared in Mexico, so in the fall of 1966, I went there to look for a place where the 'ancestors' of our common beans were growing wild—if they still were. The first thing I did was stop off to pick up Juanito, a native Mexican who has been my guide and helper on all of my Mexican expeditions since 1934, when he was 13 years old. Juanito had helped me in the past to collect plants, drive mules, and learn Spanish, and he was ready to assist me again."

Beans from the Farms, Markets, and Mountains

"One of the places we had to go was the State of Chihuahua *(Chi-WAH-wah)* in Mexico. I thought that we might find the beans we wanted among the Tarahumara Indians who live in the Sierra Madre Mountains there. The beans might be growing wild there, and perhaps the people were gathering or growing them for food. These Indians don't speak Spanish, so we had to get a guide who could *interpret* for us, and who knew the mountains well.

"Usually the farmers were very happy to talk with me about their bean crops, and to give me samples of their beans. Juanito and I also went to the local marketplaces, where as many as 25 or 30 different varieties of beans might be on sale. We would buy a small amount of each.

"As I expected, though, the beans that we were looking for—the 'original' beans from which our modern varieties are descended—did not turn up on the farms or in the marketplaces *(see Photos 1 and 2)*. We finally located these beans growing wild among very thick bushes *(see Photo 3)*. The beans that farmers raise today are grown in open fields, but the 'older,' wild beans are found in spiny thickets where they become intertwined with other plants, making it very difficult to find the beans even when you are right next to them.

"Juanito and I collected these beans and the vines they grew on *(see photo)*, then we each headed for home—Juanito to his village, and I to have my precious beans tested and examined at the Research Center in Maryland and at other research stations.

"These tests have already shown that the beans I brought back from Mexico should help make bean crops more resistant to disease, and so easier for farmers to grow. We know that in some places where beans could be grown, the people will not eat them because they're not used to beans. But the 'new' beans look promising, and perhaps we can change some people's feelings about this very good source of protein.

"In the meantime, our scientists will be experimenting with the beans—and soon I will set off on a trip to the Mediterranean regions of Europe and Africa to see whether I can find some wild peas that might be used for improving the world's pea crops."

"I can see now," I remarked to Dr. Gentry as we said goodbye, "how some of the world's 'oldest' seeds may be helping to grow some of the 'newest' crops of the future." And as I left the Center, I wondered whether the next time I visited Dr. Gentry I would find on his wall a map of the Mediterranean area—covered with peas ■

While searching for wild beans in Mexico, Dr. Gentry takes a brief rest in the "arms" of a maguey *(MAH-gay)*, one of his favorite plants.

FOOD FOR TOO MANY MOUTHS

The human population will stop growing long before we run out of room to stand. But *how* will the growth rate be stopped?

■ Some people say that there will be standing room only on earth in a few hundred years, if the population keeps growing as it has been.

But biologists are quick to point out that we'll never reach that stage. "In nature, no animal or plant population ever kept a pace of growth like this for very long," says Dr. William McElroy, a biologist who is Director of the National Science Foundation. "The rate of growth is slowed—by an exhausted food supply, a buildup of poisonous substances, diseases, or something else that kills much of the population."

"I leave it to your imagination," adds Dr. McElroy, "which of these factors might apply to the human population."

Unlike most other animals, humans have an intelligence that enables them to recognize a problem and to try to do something about it. Some people, however, say that population growth is not a problem. Some economists say that the earth can support a population of 50 billion people or more. But biologists disagree. Some biologists believe that there may already be too many people on earth—even too many in the United States.

There Is More to Life than Food

Compared with many countries, the United States is not densely populated. And it is not in danger of running out of food. But there is more to life than just eating well. And in the United States, the growing numbers of people are affecting the "quality" of life. Parks and other recreation areas are overcrowded. Traffic jams are getting worse. Pollution spoils the air we breathe.

It isn't just the growing population that has caused these problems. A lot of trouble could have been avoided by better planning of communities, or by tougher laws against pollution. But the fast-growing population is helping to make life in the United States dirtier, noisier, less healthy, and less pleasant.

One of the frightening effects of this country's growing population is that people are making millions of acres of farmland unfit for use. Good, rich soil is being covered with highways, houses, and factories. If this continues, half of California's best farmland may disappear in the next 30 years. And California grows 43 per cent of the nation's fresh vegetables, and 42 per cent of our fruit.

Still, many Americans seem to feel that the "population explosion" is only a problem of "developing" countries. Perhaps they don't know how this country is tied to other countries. The United States contains just one fifteenth of the world's population, but we use more than six fifteenths (40 per cent) of the earth's resources.

"I'm not worried. By the time the population crunch really hits, we'll be sending the excess off to earth or somewhere."

Drawing by Lorenz; © 1969 The New Yorker Magazine, Inc.

Our way of life depends partly on metals, oil, rubber, food, and other materials imported from other countries. So, even rich countries like the United States would be greatly affected if poorer nations ran out of food and were no longer willing or able to supply our needs. Dr. Paul Ehrlich, Professor of Biology at Stanford University, says, "Calling the world population explosion a problem of undeveloped nations is like saying to a fellow passenger, 'your end of the boat is sinking.' "

Why Family Planning Alone Fails

Recently, General William H. Draper, Jr., the United States representative on the United Nations Population Commission, said that the United States should aim for a "zero population growth rate" by the year 2000. This means that the number of births each year should equal the number of deaths, so the population would stay at the same level. The United States' population is expected to be about 250 million by the year 2000.

Around the world, many governments are trying to slow population growth. Through "family planning" programs, they offer people advice and help in having smaller families. But the task of slowing population growth is not easy. The government of India has supported a family-planning program for almost 20 years. During that time, the population has increased by more than half, and is now growing *faster* than it was 20 years ago. Teaching people about family planning is difficult in India, where only about one third of the people can read and write, and where there is only one doctor for each 12,000 people.

One critic of family planning programs is Dr. Kingsley Davis, Director of International Population and Urban Research at the University of California, at Berkeley. He says that these programs are a "hopelessly futile means of controlling population."

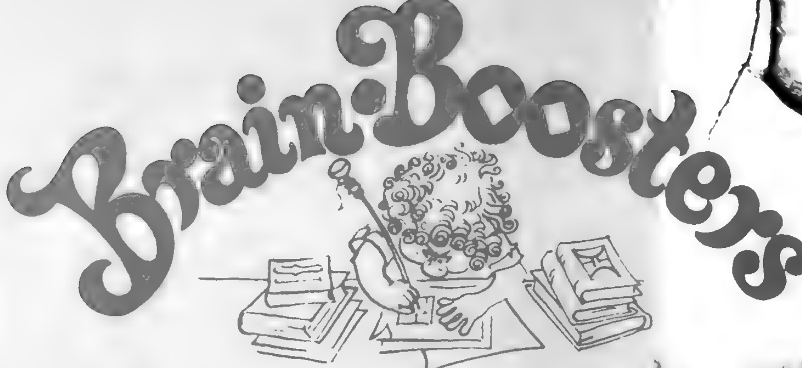
To limit population growth, Dr. Davis says, people must not only *know how,* they must also *want to do it.* Advice and help in having smaller families seem to have little effect unless people are convinced that they—and future generations—will have a better life with fewer children. So far, people in developing countries still want four or more children. That's enough to double the population in these countries every 25 to 30 years. In the United States, most parents say that they want three children. If the population is ever to stop growing, a two-child family must become the "ideal".

The single most important step that government leaders can take is to alert people to the dangers of great population growth—and to the fact that it is individual families having three or more children, instead of two, that causes the population explosion.

Last Christmas eve, astronaut James Lovell looked from the moon toward the earth and said, "The earth from here is a grand oasis in the great vastness of space." People are beginning to realize that the earth is like a spaceship, with limited supplies on board. No nation can afford to send surplus people to other planets, even if humans could survive on them. There is a limit to the amount of food that can be grown on the earth. As President John F. Kennedy warned in 1963: "If we do not stem this human tide now, we will all be inundated in an immense ocean of poverty." ■

HOW WOULD YOU SLOW POPULATION GROWTH?

It may become necessary for governments to pass laws that encourage people to have smaller families. One step would be to raise the legal age for marriage so that many women would be single through a greater part of their childbearing years. Another would be to tax parents for each child they have, with an especially high tax for any child born after the first two. Do you think these ways would work? Can you think of some other ways to help slow population growth?



Brain-Boosters

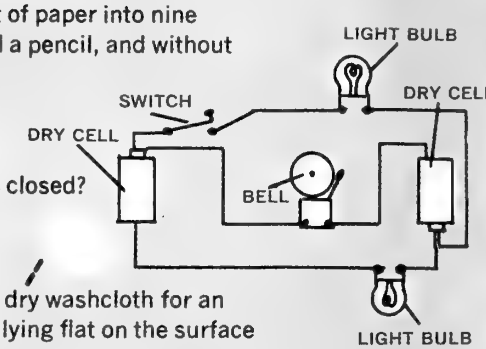
prepared by **DAVID WEBSTER**

CAN YOU DO IT?

Can you quickly divide a small sheet of paper into nine equal sections using just a ruler and a pencil, and without doing any figuring?

WHAT WILL HAPPEN IF?

What will happen when the switch is closed?



JUST FOR FUN

The next time you take a bath, use a dry washcloth for an experiment. See whether it will float lying flat on the surface of the water. Then try to float it folded in half or all rolled up.

Submitted by Fred Kenney, Jr., Norfolk, Massachusetts

FOR SCIENCE EXPERTS ONLY

What makes popcorn pop when it is heated?

MYSTERY PHOTO

How was the tree trunk bent so high up? Was the bend made closer to the ground when the tree was smaller?

FUN WITH NUMBERS AND SHAPES

Insert addition, subtraction, multiplication, or division signs between the numbers so they will equal 100.

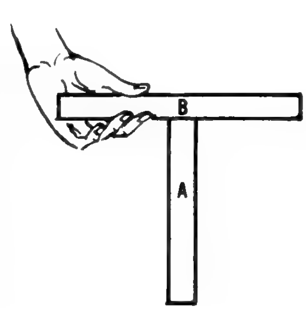
1 ? 2 ? 3 ? 4 ? 5 ? 6 ? 7 ? 8 ? 9 = 100

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

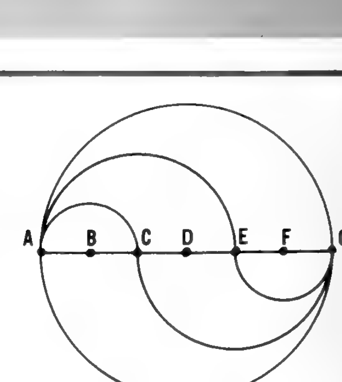
Mystery Photo: The photo is a close-up of a boot sole.

What will happen if? A cold ball does not bounce as high as a ball at room temperature. If the ball is heated in a warm (but not lighted) oven, will it bounce even higher than it does at room temperature?

Can you do it? To find which bar is magnetic, you could touch one of the bars to the middle of the other one, as shown. If bar A sticks to the middle of bar B, bar A is the magnet. It it falls, then bar B is the magnet. Why can't you solve the problem by touching the ends of the two bars together?



Fun with numbers and shapes: To divide a circle into 3 equal areas, first draw a diameter and divide it with a ruler into 6 equal parts marked by dots, as shown. Then draw semicircles from A to C, E to G, A to E, and C to G, above or below the diameter, as in the diagram. Can you divide a circle into 4 equal areas?



For science experts only: Water does not drip from a narrow, U-shaped tube because of the attraction between the water and the glass. It is this attraction, known as *adhesion,* that causes the water to rise in the tube. *Surface tension,* which makes water at the surface act like an elastic "skin," also helps water to climb up the tube and keep from falling out. Can you figure out why "siphon action" doesn't make some water flow through the tube? *(See "Making Water Flow Uphill,"* N&S, *December 15, 1969.)*

nature and science
TEACHER'S EDITION

VOL. 7 NO. 16 / MAY 4, 1970 / SECTION 1 OF TWO SECTIONS

The END of nature and science?

■ We deeply regret having to report that this 121st issue of *Nature and Science* may be the last. Doubleday & Company, Inc. has withdrawn as publisher of the magazine for The American Museum of Natural History, and so far no other publisher has agreed to continue publication of *Nature and Science.*

It is hard to believe that a magazine devoted to helping young people understand how nature works could expire at a time like this, when it has become so obvious that we must all learn to understand nature—and how to live with it—if we are to survive. Teachers, parents, scientists who have contributed articles and editorial assistance, many of our readers—all have testified repeatedly to the value, relevance, and interest of *Nature and Science.* Unfortunately, however, it has never had enough subscribers to pay the costs of producing, selling, and distributing the magazine.

A magazine of this type costs more to produce than other types of periodicals that are sold to schools. The basic cost cannot be reduced without lowering the quality of the product. Raising the price tends to reduce the number of subscriptions without changing the costs or revenues very much. Acceptance of paid advertising might have changed the picture, but teachers—understandably—tend to frown on advertising in elementary school magazines. The only other way *Nature and Science* could survive was by selling more subscriptions.

More subscriptions can raise the income without changing the basic costs very much, but it costs money to sell them. *Nature and Science* was close to the break-even point several years ago, but a change in the sales approach at that time brought in fewer, rather than more, subscriptions.

Satisfied subscribers can be a magazine's best salesmen, and many of our subscribers have filled that role. On the other hand, we have met more than a few teachers who had never heard of the magazine even though it had been used for several years in their own school. Thousands have paid $5.50 per year for a single subscription with the Teacher's Edition. If they had found ways to buy at least ten $1.95 subscriptions for their pupils, this would probably not be the last issue of *Nature and Science.*

Inflation and tight school budgets have undoubtedly contributed to the death of *Nature and Science,* just as they have squeezed or killed other worthwhile educational projects. The problem, as usual, seems to boil down to one of values: What is most worth having, and how much are we willing to pay to get it?—FRANKLYN K. LAUDEN

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T-4T.)

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Exploring the Atom Part 7

How well do your pupils understand the concept of *pollution*—what makes a substance a pollutant, how pollutants tend to harm living things, the relationship between pollution and our use of energy to "improve our way of life"?

Mr. Gallant concludes his series of articles about man's exploration and exploitation of the atom by describing how we are polluting our environment with radioactive wastes in the process of splitting atoms to get their nuclear energy. After your pupils have read this article, you can use the following suggestions to stimulate and guide a discussion that will help your pupils evaluate the specific problem of radiation pollution in light of the general problem of environmental pollution.

What Is "Pollution"?

Most dictionaries simply define "pollution" as "dirt" or "impurity." Such a description is too broad to be useful in identifying pollutants and their causes and effects, and in trying to do something about them. By thinking about some specific pollutants, your pupils should be able to work out a more useful definition.

- Have them begin by listing some kinds of air and water pollution they have read or heard about, and where each pollutant comes from. Here are a few examples.

Air pollution: smoke (solid particles), gases, and heat—from burning coal, oil, and gasoline; radioactive atoms—from the mining, processing, and fission of uranium. *(See "Is 'Pop Gas' Warming the Atmosphere?",* N&S, *Sept. 29, 1969; "A City Makes Its Own Climate,"* N&S, *March 31, 1969; and "Spaceship Earth," a special-topic issue,* N&S, *April 1, 1968.)*

Water pollution: human wastes, garbage, and detergents—from sewage systems; heat and chemical wastes (including radioactive atoms)—from factories and power plants; oil—leaked from wells or tankers; fertilizers and pesticides (such as DDT)—washed off farmlands and lawns. *(See "Spaceship Earth,"* N&S *special-topic issue, April 1, 1968; "Rivers and Man,"* N&S, *Oct. 27, 1969; "Fever of the Waters,"* N&S, *March 2, 1970; "Tale of the Torrey Canyon,"* N&S, *Feb. 3, 1969; "How To Kill a Lake,"* N&S, *April 1, 1968; "Can We Save the Eagles?", page 2T,* N&S, *March 18, 1968.)*

- *Where do the substances that have become "pollutants" come from originally?* All are found someplace in the natural environment. Coal and oil form underground. Uranium is found in certain rocks. Human wastes and garbage were once living plants and animals. Detergents, industrial wastes, fertilizers, and pesticides are all made of substances taken out of the earth, its atmosphere, or its waters.

- *Since each of these substances comes originally from someplace in the natural environment, what is it that we do to them that makes them pollutants?* Taking oil out of the ground and releasing it into the ocean makes the oil pollute the ocean water. Taking oil or coal out of the ground and burning it spreads waste products into the atmosphere. Such examples should help your pupils to see that *moving a substance from its natural part of the environment to a place where it is not a natural part of the environment makes the substance an "impurity" or "pollutant" in its new location.* (Burning is a way of moving carbon and other substances in oil or coal from the ground into the air.)

- *The atmosphere contains carbon dioxide produced by natural processes* (see "Pop Gas," *N&S*, Sept. 29, 1969). *Can the carbon dioxide added to the air by burning fossil fuels be properly called a pollutant? Why?* The CO_2 added by burning raises the *concentration* of that gas in the atmosphere—the amount of CO_2 in a given amount of air. In this sense, the added CO_2 is an "impurity." So, for the same reason, is the radiation from radioactive wastes that we are adding to the earth's natural radiation *(see "Is There a 'Safe' Amount of Radiation?", page 11).*

Your pupils should see now that *increasing the concentration of a substance in a particular part of the environment makes the substance a pollutant.*

- *How can pollution of an environment threaten the survival of living things in that environment?* From *N&S* and other sources, your pupils probably know that over the ages the plants and animals in a particular environment have become adapted to that environment. (A species that does not become adapted to it either moves to another environment or dies out.) Any change in a particular environment—something new added, something "old" removed, even a rise or fall in the concentration of food, heat, population, or something else in that environment—may tend to harm the organisms there because they are not adapted to it. The animals or plants may be affected *directly*—by substances that damage their bodies—or *indirectly*—by changes that decrease their food or oxygen supply, for example. (Does radiation pollution threaten living things directly or indirectly?)

- *Does "pollution" ever happen naturally?* Smoke and heat from forest fires; ashes, heat, and gas from vol-

(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.

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

canoes; minerals carried into a lake by an underground spring—such substances and heat can be considered pollutants, but they usually affect only a small part of the environment or else are dispelled in a fairly short time.

• *How did humans get to be the greatest polluters of all time?* As long as people lived by hunting, fishing, and gathering wild plants, they kept moving around, and their wastes were quickly absorbed by the environment *(see "Travels of an Atom,"* N&S, *March 30, 1970).* But as soon as they began to raise plants and animals for food and stopped moving around, their numbers began to grow and so did their wastes. Slowly at first, but faster and faster in the past 300 years especially, man has been growing in numbers *(see "Food for Too Many Mouths,"* N&S, *April 13, 1970)* and at the same time increasing his ability to produce more and different kinds of waste. Only now are we beginning to realize how these wastes pollute our environment and threaten ourselves as well as other living things.

Radioactive Pollutants

• *How does our use of uranium to get nuclear energy pollute our environment?* Mining and milling uranium ores bring together (concentrate) certain natural radioactive isotopes in piles of waste that release the radioactive atoms into the air, water, and soil. Processing uranium for use in bombs and nuclear reactors releases more radioactive wastes into the air and water. Splitting uranium atoms to get nuclear energy makes *new* radioactive atoms ("pieces" of the split atoms), which are released directly into the air, water, or earth by nuclear explosions; some of these new radioactive atoms are also released into the air or rivers from nuclear reactors. Reprocessing "used" uranium from a reactor releases still more radioactive wastes into the environment.

• *The radioactive wastes released from uranium processing plants and nuclear reactors are usually diluted, or spread out through air or water, before being released into the atmosphere or a river. Doesn't this make them less dangerous to living things?* Not if it is true, as many scientists believe, that *any* amount of radiation, however small, may damage living things *(see box on page 11).* Besides, many of these diluted wastes are taken into plants and animals, stored up, and passed along the food chain in stronger and stronger concentrations.

• *Why couldn't all of this radioactive waste—except from nuclear explosions—be stored underground or deep in the oceans, as the most dangerous parts of the waste are now to keep them "out" of the environment?* Capturing and storing all these wastes would cost immense amounts of money, and many scientists doubt that such wastes can be stored *anyplace* where they might not leak into the ground or water at some time in their thousands, millions, or billions of years of radioactive life. Earthquakes, for example, might *rupture,* or break open, storage tanks underground; over long periods of time, sea water might "eat" through concrete, steel, or other kinds of tanks in the oceans. Even in abandoned salt mines *(see photo, page 13),* tests show that the heat from stored radioactive wastes tends to cause shifts in the salt rock; such shifts might eventually rupture the storage tanks.

Should We or Shouldn't We?

• *Is radiation pollution as dangerous to us and other living things as Mr. Gallant's article and this discussion make it seem?* The important point is that *we just don't know.* There is no question that radiation can, and often does, damage living things, but sometimes the damage does not show up for many years—sometimes not until the next generation, in offspring that have been affected by radiation damage to their parents' reproduction cells. Widespread pollution of the earth by radioactive wastes did not start until 1945, only 25 years ago. While the immediate effects of radiation from nuclear bombs on victims in Japan have been studied, delayed effects keep showing up.

• *If we don't really know how much of a threat radiation pollution is to us and the living things we depend on for survival, why do we keep on producing it?* Many people, including some scientists, think we can't afford *not* to split atoms for energy. A leading spokesman for this point of view is Dr. Edward Teller, director of the Lawrence Radiation Laboratory, University of California at Livermore. His ideas go something like this:

1. Pollution is a serious problem, but the dangers from radiation and heat, for example, have been exaggerated.
2. Radiation can be easily detected and measured, and the Atomic Energy Commission prescribes that we should add no more radiation to the environment than an amount equal to the radiation we get from natural sources. In certain parts of Brazil and India, the natural radiation level is 10 times the AEC's "maximum permissible dose" of radiation. These people may suffer from exposure to so much radiation, but they suffer more from "being backward"—not using modern technology to "improve" their lives.
3. We need more and more energy to keep "improving" life for our growing population. Nuclear reactors produce electricity without pouring smoke into the air, and electric power can replace much of the energy we get from burning coal and oil in homes, and perhaps in automobile engines.
4. Tests suggest that large amounts of natural gas—which burns with less waste than other fossil fuels—can be freed with underground nuclear explosions. Nuclear explosions can also move large amounts of earth—to cut a new canal that will accommodate larger ships than the Panama Canal does, or to dig deep pits in the earth for disposing of our garbage and other solid wastes.

• You might read the above points to your pupils, one item at a time, and ask for their comments. Here are some notes:

1. Besides radioactive wastes, a nuclear power plant pours about 50 per cent more waste heat into a river, lake, or ocean than a fossil-fuel power plant does. Changes of temperature affect

(Continued on page 4T)

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

fish and other organisms in the water, often adversely, and the number of nuclear power plants now working or planned threatens to raise the temperature of whole bodies of water.

2. After reading your pupils paragraph 2 above, read them "A Look at Radiation Standards," below.

A Look at Radiation Standards

On March 15, 1970, the Secretary of Health, Education and Welfare, who is also chairman of the Federal Radiation Council, asked the Atomic Energy Commission to review its standards for a "safe amount" of radiation. The request was made after two scientists at an AEC laboratory said their research indicated that if the present U.S. population were subjected to the present radiation limit, 16,000 more cancer and leukemia (blood cancer) deaths would result each year over a long period of time.

If the radiation limit recommended by these scientists were adopted, radiation pollution from all parts of the nuclear energy program would have to be reduced drastically, at a high cost in money.

3. Is the question really "Should we pollute our environment with radioactive wastes instead of with wastes from fossil fuels?"—or is it "Should we keep on trying to make life 'better' by using more energy when this makes our environment more dangerous to us and other living things?"

4. Natural gas in the underground cavern dug by the Operation Plowshare nuclear explosion is so radioactive that it will have to be diluted with non-radioactive gas from another source if it is to be burned in power plants or kitchen stoves. Large amounts of radioactive waste would be spread into the atmosphere by the near-surface explosions needed to dig a canal. (Many ecologists feel that such a canal, connecting the Atlantic and Pacific Oceans without any locks such as the Panama Canal has, would cause drastic changes in the animal and plant life in the water near the canal.) Is "burying" our solid wastes a better idea than finding a way to recycle them? *(See "Spaceship Earth,"* N&S, *April 1, 1968, page 2T.)*

• *Would radiation pollution still be a problem if scientists could find a way to get energy from the controlled fusion of atomic nuclei?* No. The fusion reaction does not produce any radioactive wastes. But that solution is at least a long way off, if it comes at all. Meantime, anything we do to reduce the pollution from either nuclear or fossil-fuel power plants is likely to raise the cost of electric power and the products and services we use it for. The question is this: Which do we want most—more of the things we use energy to produce, or less of the environmental pollution that threatens our survival?

Clouds and Weather

To predict weather by the clouds, you have to know how the clouds have been changing over a period of time. You might have your pupils try their hands at this by observing the sky at least three or four times a day, at regular intervals, over a period of days. After each observation, they should record on a chart:

1. Date and time of observation.
2. Types of clouds in the sky.
3. Height of clouds (low, medium, or high).
4. What the clouds are doing (building up, thickening, moving rapidly over, breaking up).
5. Weather at time of observation.

By comparing the weather and cloud changes over a period of a week or two, your pupils should be able to formulate some generalizations about the weather certain clouds bring.

• Clouds form when air is cooled so much that water vapor in the air condenses into tiny droplets of water. Can your pupils think of some ways this happens? Here are examples.

1. In daytime, when the earth's surface is warmed, air near the surface takes heat from it. The air expands, cooling somewhat in the process, and cools more as it rises. Most clouds over land form this way.
2. On clear nights, the earth loses its heat rapidly. Warm air touching the cool earth may cool and form clouds or fog.
3. As warm, moist air over a lake or ocean moves in over a cooler land surface, it cools and clouds form *(see "The Water Cycle,"* N&S, *Oct. 27, 1969, page 2T).*
4. A wedge of cool air may push under a mass of warm air, making it rise, cool, and form clouds.
5. Rain or snow from high clouds may fall through warm air, cooling it and making low clouds form.

Brain-Boosters

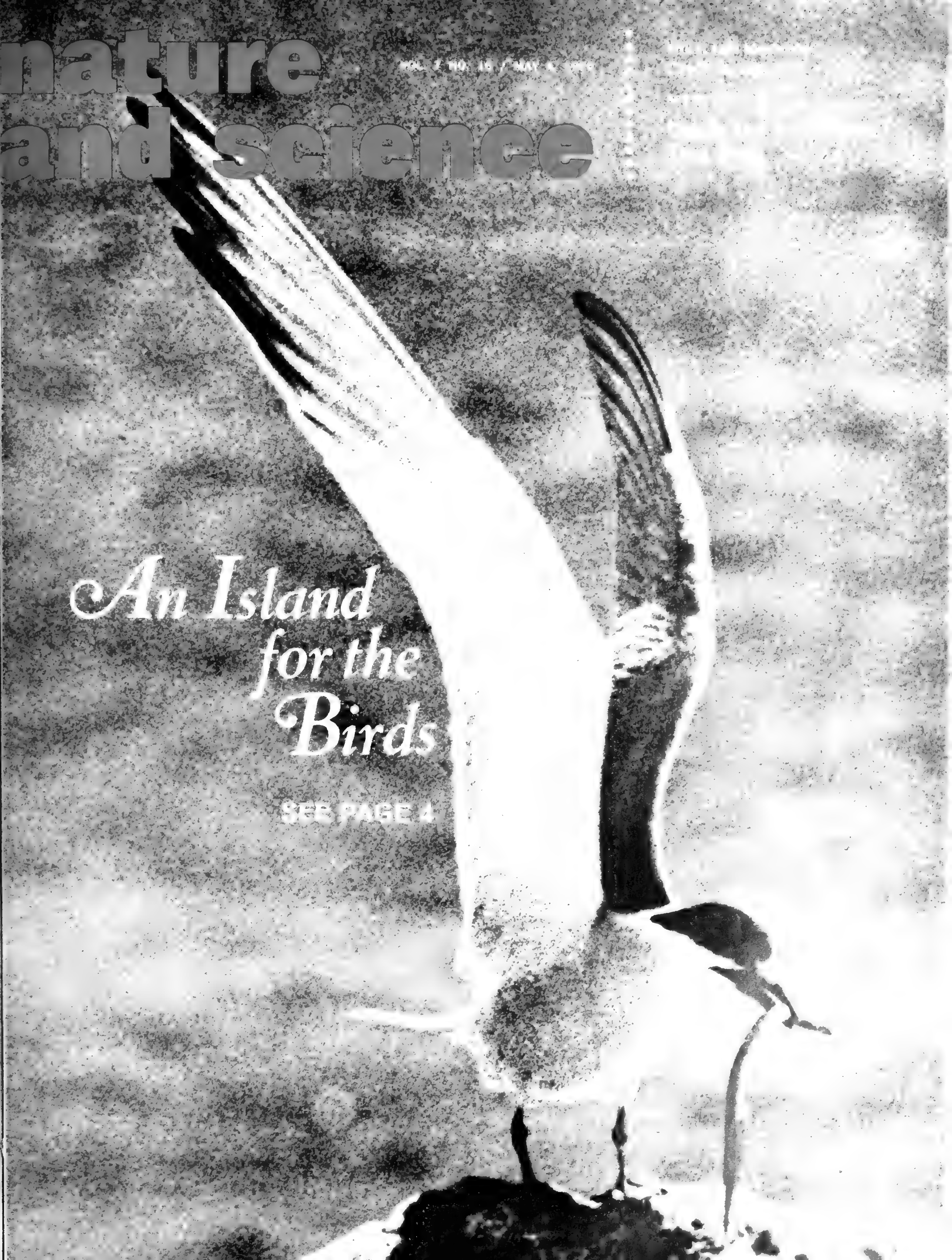
(Because this is the last issue of the school year, answers to Brain-Boosters on page 7 are printed on page 13.)

What will happen if? Removing the glass from a flashlight bulb releases gases put into the bulb to keep the filament from burning too rapidly, and admits oxygen from the surrounding air. This makes the filament burn more brightly when electricity passes through it, but only for the few seconds until it "burns out" and stops the flow of electricity.

Would the same thing happen with a photographer's flashbulb? No. A flashbulb has oxygen inside to make the filament burn very quickly; removing the glass lets air dilute this extra oxygen, so the bulb will light up for a few seconds instead of producing just a quick flash.

Can you do it? When you stick a pin into an inflated balloon, the stretched rubber usually begins to tear in several directions at once, making it shatter. The tape prevents this from happening.

For science experts only. Your pupils will probably laugh at the two silly boys, but remind them that we all sometimes observe others to get information that determines our own behavior. Have your pupils ever decided to put on a sweater before going out because they saw that friends outside were all wearing sweaters? Ask your pupils what they would do if they looked out the window and saw people wearing raincoats and carrying umbrellas. Would they put on raincoats themselves before going out, even if they couldn't actually see any rain?


nature and science
An Island for the Birds
SEE PAGE 4

nature and science
VOL. 7 NO. 16 / MAY 4, 1970

CONTENTS

PICTURE CREDITS: Cover, pp. 4-6, Miller/Swift; p. 2, Conrad Puhr, from The American Museum of Natural History; pp. 3, 4, 7, 14, 16, drawings by Graphic Arts Department, AMNH; p. 7, photo by David Webster; pp. 8-9, photos courtesy of U.S. Department of Commerce, Weather Bureau; p. 10, (top) Jerome Wexler, (bottom) Douglas Archer, Jr.; p. 12, U.S. Atomic Energy Commission, Richland Operations Office; p. 13, Oak Ridge National Laboratory.

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; **ART DIRECTOR** Joseph M. Sedacca; **ASSOCIATE ART DIRECTOR** Donald B. Clausen • **CONSULTING EDITOR** Roy A. Gallant

CIRCULATION DIRECTOR J. D. Broderick; **PROMOTION DIRECTOR** Elizabeth Connor; **SUBSCRIPTION SERVICE** Frank Burkholder

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.

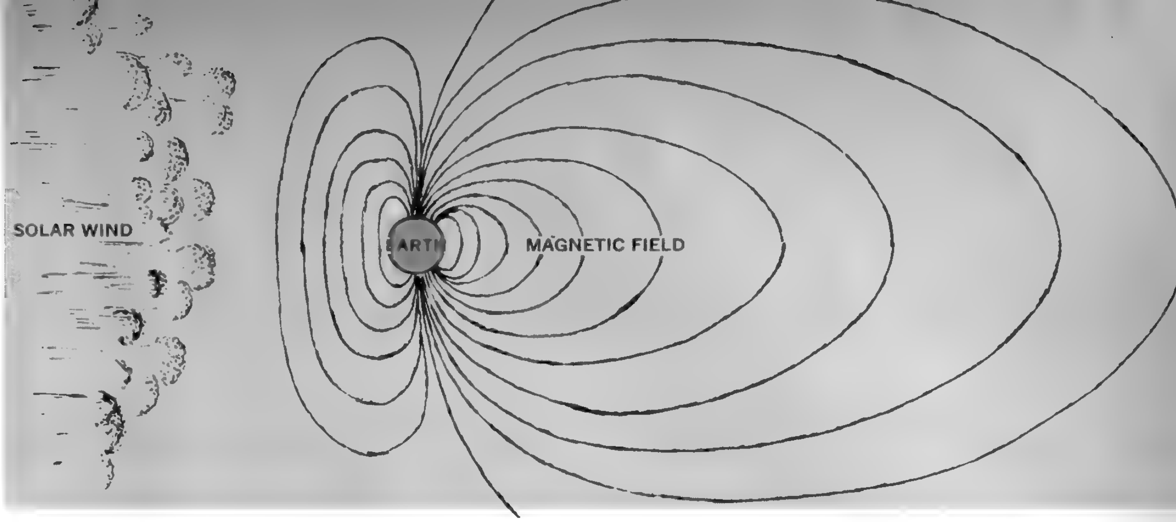
SUBSCRIPTION PRICES: In U.S.A. $1.15 per semester per pupil, $1.95 per school year (16 issues) in quantities of 10 or more subscriptions to the same address. Teacher's Edition with single subscription to student's edition $5.50 per school year. Single subscription per calendar year (17 issues) $3.75, 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.

STORMS IN SPACE

■ Can you imagine a storm so gigantic that it affects the earth, its atmosphere, and the surrounding space out to thousands of miles from the earth's surface—all at once? This is not a disturbance in a small part of the atmosphere, like a thunderstorm or a hurricane. It is a *magnetic* storm—a disturbance of the earth's whole *magnetic field (see "The Mystery of the Changing Poles,"* N&S, *March 2, 1970).*

A severe magnetic storm often disrupts long-distance telephone calls and makes teletypewriters "run wild" for brief periods of time. At night, the brilliant displays of moving, colored light called *auroras* appear in the far northern and southern skies *(see photo).*

The first clue to the cause of these storms came late in World War 2, when the British first used radar to locate enemy airplanes in their skies. Sometimes a radar antenna would pick up a strong burst of radio waves coming from the sun. Then, within a day or two, communications would be disrupted and auroras would appear. Astronomers soon noticed that the strong bursts of radio energy come when



The solar wind—a stream of high-speed particles radiating from the sun—flattens the earth's magnetic field on one side and spreads it out on the other side as most of the particles flow around the field.

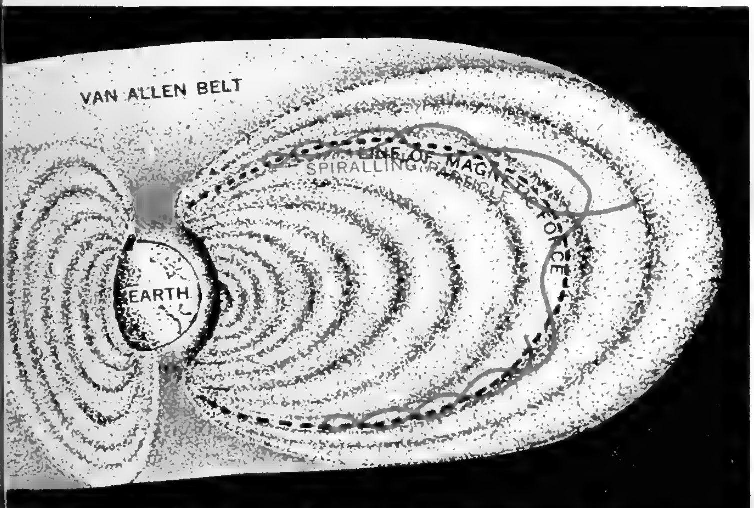
ever a *solar flare*—a bright spot of light—appears on the sun's surface.

"Wind" from the Sun

In 1958, the United States launched its first artificial satellite, Explorer 1. One of its jobs was to count the *cosmic rays* in space around the earth to find out how dangerous this radiation might be to future astronauts. (Cosmic rays are not really "rays." They are pieces of atoms—electrons, protons, neutrons, and atomic nuclei—that travel through space at extremely high speeds. No one knows for sure where they come from.)

As Explorer 1 moved away from the earth, its counter detected more and more radiation. Then the counter went dead. This happened each time the orbiting satellite got farther than about 600 miles from the earth.

Dr. James A. Van Allen, a physicist at the University of Iowa, was in charge of the radiation-counting project. He decided that the counter went dead because it was being bombarded by many more particles than it could count. Later satellites confirmed Dr. Van Allen's suspicion that a fat, doughnut-shaped belt of space around the earth is full of fast-moving protons and electrons *(see diagram)*.



The Van Allen Belt is made up of fast-moving protons and electrons that spiral back and forth around the lines of magnetic force surrounding the earth.

The source of at least some of these particles was tracked down in 1961. Scientists had long suspected that a thin, hot "gas" made up of electrons and protons flows out steadily from the sun's surface. Explorers 10 and 12 detected this *solar wind*, and found that it approaches the earth at speeds between 200 and 500 miles per second. Some of the particles are trapped in the earth's magnetic field, where they form the *Van Allen Belt*. But most of the solar wind flows around the magnetic field, squeezing it into a long "teardrop" shape *(see diagram)*. A magnetic storm is caused by a kind of "gust" in the solar wind.

"Storm Clouds" from the Sun

This "gust" in the solar wind comes from a solar flare. Some kind of explosion in the sun shoots out energy in the form of light and radio waves that reach the earth in about eight minutes. The explosion also shoots out a cloud of electrons and protons. These travel much slower than the energy waves, but faster than the solar wind usually flows. A day or so later, the front of the cloud rams into the earth's magnetic field, making it *vibrate,* or shake rapidly back and forth. If you made electricity with magnets *(see* N&S, *March 16, 1970, page 12),* maybe you can guess what happens next.

The motion of the magnetic field makes electricity flow in the earth itself, and in things like telephone and telegraph wires that can conduct electricity. (These "extra" currents are what disrupt long-distance communications.)

In addition, the vibrations weaken the earth's magnetic field, so it lets charged particles from the Van Allen Belt shoot into the earth's atmosphere near the North and South Poles. These particles collide with atoms in the atmosphere and give off energy in the form of light—the auroras.

There are many questions still to be answered. What causes the solar wind and solar flares? How do particles behave in the Van Allen Belt? How long do they stay there, and what happens to them? Do magnetic storms affect weather in the atmosphere? You can probably think of others—and maybe some day you can help find some of the answers. —Diane Sherman

Where wildlife once lived, man has put his buildings. But near crowded New York City, a place once covered by an Army fort is now . . .

An Island for the Birds

by Catherine M. Pessino

■ "But why do they call it Great Gull Island? No gulls nest there."

I am often asked this question about Great Gull Island. It's a small island, about half a mile long and a tenth of a mile wide. It lies in Long Island Sound, New York. Answering this question about Great Gull Island takes a bit of explanation.

For many years the island was the site of Fort Mitchie, but after World War II, the fort was considered out-of-date. The Army gave the island to The American Museum of Natural History, where I work as an instructor. The museum and an organization called the Linnaean Society of New York (made up of people interested in studying birds) wanted to make the island a bird *sanctuary*—a place where birds would be protected from other animals.

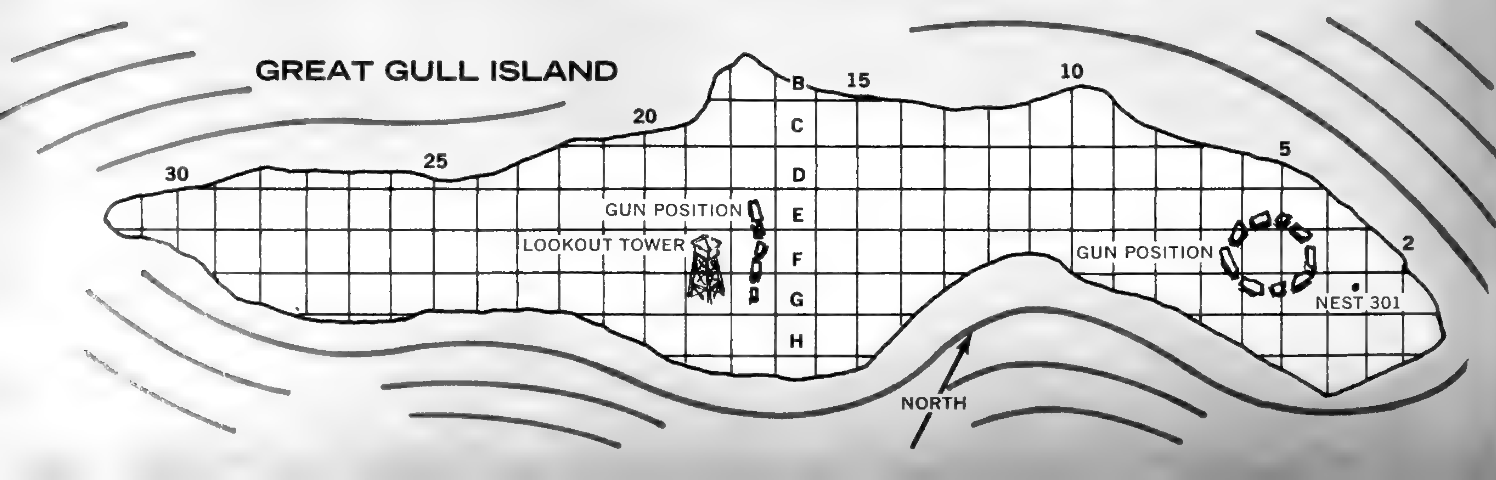
At one time, the island had been famous for its large tern colony. In 1894, the year before the Army began building the fort, 14,000 terns nested on the island. In those days, terns were often called gulls. (Terns look like gulls, but are smaller birds, with slender bodies and forked tails.) That's how the island came to be called Great Gull Island.

Would the Terns Return?

When the Army left, there were no terns nesting on Great Gull Island. Instead, there were metal shelters called Quonset huts, wooden storage buildings, concrete lookout towers and gun positions, and asphalt roads. These man-made structures covered most of the island.

The natural *habitat,* or living place, of terns is sand and beach grass. The Linnaean Society wanted to make the island "natural" again. In 1950, we began working at the

Scientists use a grid map of Great Gull Island to locate a particular nest. If the record book shows that nest 301 is at position F3, they go to the place where grid lines F and 3 cross, then look for the nest marked 301.



island. We knocked down Quonset huts and burned wooden buildings. We spread chemicals to kill plants that had grown tall over the years. We spread sand to form beaches. We had to leave the huge concrete structures. It was impossible to do anything about them.

After several springs of such work, we almost gave up hope that the terns would return. Then, in 1955, 25 pairs of common terns nested on Great Gull Island. To our surprise, their nests weren't on sandy beaches or in beach grass. The concrete of the gun positions had broken down, forming a concrete "beach," where the terns nested.

By 1965, about 5,000 terns were nesting on Great Gull Island. That was exciting enough, but we were really excited about the fact that about 2,000 were roseate terns. Roseate terns are more rare than common terns, and our island colony had an unusually large number to be nesting in one place. These terns have longer tails and lighter-colored bodies than common terns. We had a wonderful opportunity to study the lives of roseate terns.

We knew that we would first have to map the island. We measured it and divided it into squares that were 25 meters (about 27 yards) on each side *(see map)*. We lettered the imaginary lines running north-south and numbered the east-west lines. Where the lines crossed we put posts with the letter and the number of the corner. Our network of markings, or *grid*, is helpful in the way the lines on a football field are helpful—they help us locate where the "action" is.

Tern, Tern, Tern

One of our first investigations was getting an accurate count of the terns that nested on the island. At first, we climbed to the highest point on the island and counted. But this wasn't very accurate. Some birds were flying overhead, others were in the tall grass or among rocks, and still others were capturing fish. And did all the birds that we saw nest on the island?

In order to make a more accurate count, we walked the entire island, placed a numbered marker near each nest, and recorded in a notebook the date, the number of the nest, its location, the number of eggs, and the kind of nest (common tern or roseate). We walked the island about once a week during the breeding season (May to July). In this way we learned when a new nest was built or an old one destroyed, and when eggs were laid or broken or hatched.

In 1966, the first year of our nest count, 4,800 terns nested on Great Gull Island, including 2,200 roseate terns. We also learned where each of our two kinds, or *species*, of tern nests. Our common terns usually nest in open areas, and our roseates in the rocks or tall grass.

(Continued on the next page)

David Duffy *(above)* carries traps for catching adult terns so that identification bands can be attached to them. Grace Donaldson *(right)* searches for roseate chicks. Catherine Pessino *(below)*, the author of this article, is shown banding a tern chick.

Many of our investigations make it necessary to put identification bands on the terns. We catch the adult terns in traps placed over the eggs. They can see the traps, but their urge to sit on the eggs is so strong that they enter the traps anyway. We catch the young by hand. Catching roseate chicks, which hide under boulders, sometimes requires the skill of an acrobat *(see photo on page 5).*

A Bird in the Hand

We fasten an aluminum band on one leg of each bird that we catch. The United States Fish and Wildlife Service has given us special permission to color-band our terns. Each of our banded birds now wears four bands–three special color ones, and the regular aluminum one. Each leg has two bands.

When we watch the birds (usually with binoculars from a hidden place), we read and record color combinations. The left leg and the top bands are read first. For example, one tern's left leg has a red band above a green one, and the right leg has a black band above the aluminum one. In our records, that tern is R/G BK/A. The reading of color combinations isn't as easy as it might sound, since terns rarely sit still.

R/G BK/A can now be recognized among hundreds of birds. We watched it one day from an observation tower that we built. At noon it sat preening on the dock. An hour later it was sitting on the rocks near its nest, next to its mate, R/R BK/A. Their two chicks, A/R G/G and A/R G/BK, were partially hidden in the rocks. R/G BK/A flew off. Twenty minutes later, it returned with a fish. It flew down into the rocks, calling. Three chicks ran out. A/R G/G took the fish.

Sara LeCroy, wearing a necklace made of bird bands, weighs a 10-day-old common tern. The chicks are so light that they are weighed in *milligrams.* (One milligram is about three 10-thousandths of an ounce.)

This year, we will look to see whether R/G BK/A returns to Great Gull Island, whether it has the same mate, and whether it nests at the same site. From observations like these, we are learning about the lives of individual birds. From many such observations, we hope to understand the life cycle of the entire species.

Tern Travels

Two in our group have become especially interested in what happens to the terns after they leave Great Gull Island. In August and September, they travel by land and by sea along the Atlantic coast, from Massachusetts to New Jersey. Whenever they spot terns, they stop to see whether the terns are "ours." Since we are the only people with permission to color-band terns, any tern marked in this way must be from Great Gull Island.

We have asked other bird-watchers along the coast to let us know the color combinations of any color-banded terns they see, and where and when they saw them. If enough terns are spotted, we will be able to map the routes taken by our birds.

We have already found that some of the terns nesting on Great Gull Island also hatched there. Some hatched nearby, on Long Island or in Massachusetts. At least one came from Ontario, Canada. One roseate tern that we banded in July was found in September in the Dominican Republic, in the West Indies. A common tern banded on Great Gull Island in July was found in South America in October.

Some of us are investigating the lives of terns in other ways. We are measuring the weight and wing-length of chicks in order to learn about the growth of a chick from the time it hatches to the time it flies *(see photo).*

Sometimes it is the unexpected discoveries that are the most exciting. Once, I was taking notes in a *blind* (hiding place). The blind had been set up so that we could watch the terns without disturbing them. A red-winged blackbird flew down, hopped over to an unattended nest, and, with two pecks, broke open one of the eggs. It took two "bites" of the chick that was developing inside and then flew away. Later it came back and destroyed more eggs.

Red-winged blackbirds are known to feed on insects and grain. From the blind, I learned that they also eat eggs. Usually, birds that eat tern eggs, such as blue jays, are attacked by terns. But we have not seen any terns attack red-winged blackbirds. Apparently the terns do not recognize red-winged blackbirds as predators.

Bits of information like this, added together, will give us a better understanding of the lives of terns. As more and more land is taken for housing, and stretches of beach are developed, we are glad that Great Gull Island is still a home for wildlife ■

prepared by **DAVID WEBSTER**

CAN YOU DO IT?

Can you puncture an inflated balloon with a pin, without having it break into pieces?

Submitted by Randy Curtis, Franklin Lakes, New Jersey

JUST FOR FUN

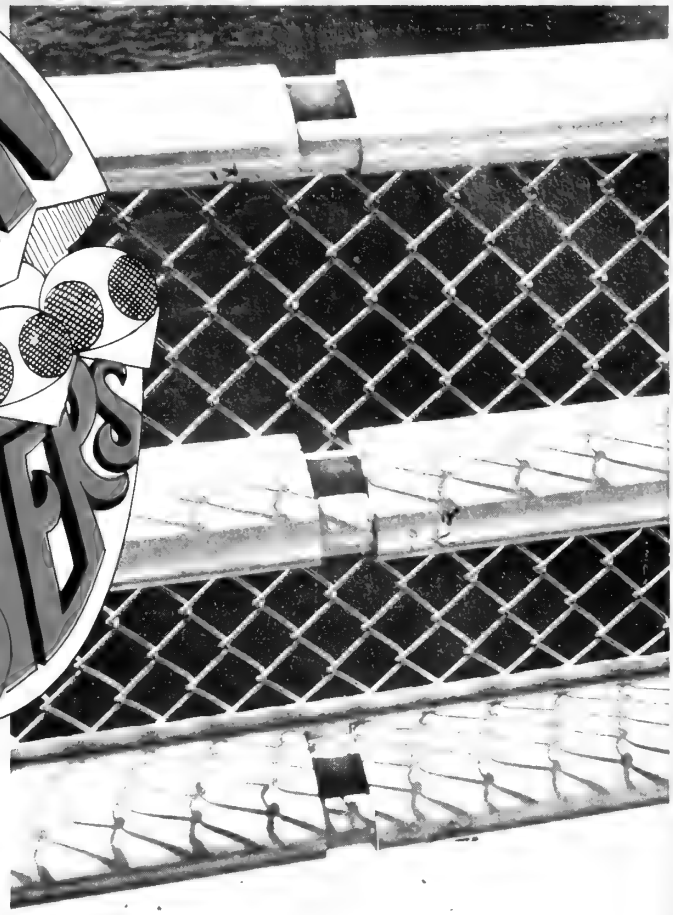
To feel water pressure, put your hand in a large plastic bag and lower it slowly into a sink filled with water. Can you feel the water pressing the bag against your skin? What happens when the bag gets completely underwater?

WHAT WILL HAPPEN IF?

Light a flashlight bulb with a dry cell and see how brightly it lights. What will happen if you then take the glass off the flashlight bulb and light it again with the dry cell? Will it be brighter or dimmer than before? How long will it stay lighted? (To remove glass, wrap the bulb in cloth and squeeze gently with pliers until the bulb breaks. Carefully unwrap and remove glass from base with pliers, then wrap glass and place in rubbish can.)

FUN WITH NUMBERS AND SHAPES

A logger cuts a pile of wood 8 feet long, 8 feet wide, and 8 feet high in exactly 8 days. How long would it take him to cut a pile of wood 4 feet long, 4 feet wide, and 4 feet high?



MYSTERY PHOTO

Why were the spaces left in this bridge railing?

FOR SCIENCE EXPERTS ONLY

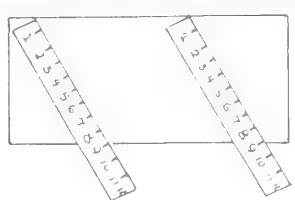
Two boys have played on a dirty roof all afternoon. When they get down, one has a dirty face, while the other's face is clean. The boy with the clean face says he is going home to wash his face. Why?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The tree was not bent closer to the ground when the tree was smaller. All upward tree growth occurs from the top of a tree. What probably did happen was that a larger tree or branch fell and pushed aside the growing tip of the smaller tree. The treetop remained bent, and the new growth continued straight up.

For science experts only: There is a small amount of water inside a kernel of popcorn. When the popcorn is heated, the water turns into steam and explodes the corn grain.

What will happen if? When the switch is closed in the complicated circuit, the bell will *stop* ringing. Will the light bulb light?



Can you do it? To divide a small sheet of paper into nine equal sections, lay a ruler across the paper on a slant, so the "zero" mark is at the top edge of the paper and the nine-inch mark is at the bottom edge. Then mark off each inch, move the ruler to another position on the paper (keeping the same slant), and do this over again. Then draw lines straight across the paper through each pair of dots.

Fun with numbers and shapes: Here is how the numbers can be made to equal 100: $\mathbf{1 + 2 + 3 + 4 + 5 + 6 + 7 + (8 \times 9) = 100}$.

CLOUDS AND THE WEATHER THEY BRING

■ As the weather changes, so do the kinds of clouds in the sky. Scientists called *meteorologists* have long used clouds to help them predict the weather.

Clouds are identified by their shape and their height above the ground. The diagram and photos below show the 10 most common types of clouds. To forecast the weather from clouds, you must first learn to recognize them. Then notice how the kinds of clouds change from hour to hour and from day to day. Look for these—

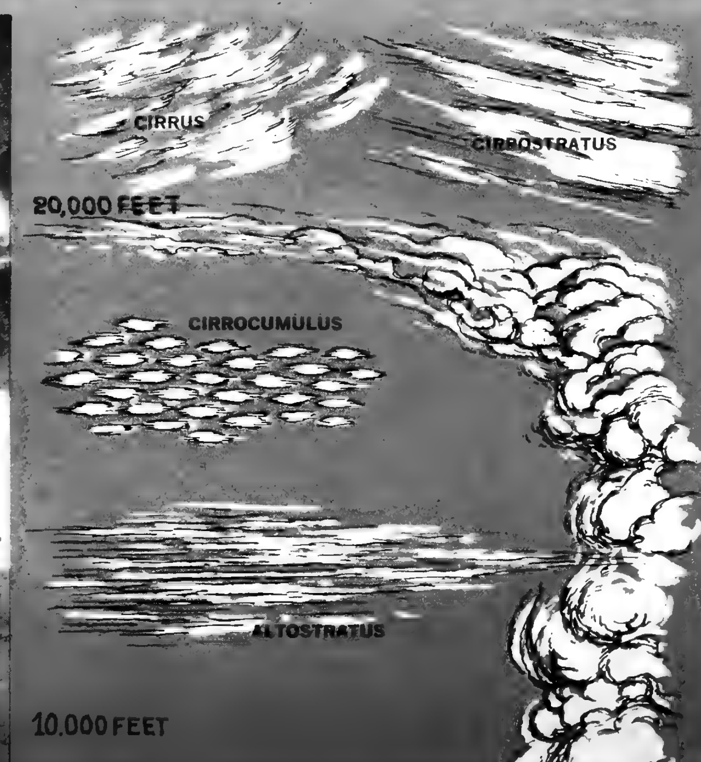
Signs of Approaching Stormy Weather

- High scattered clouds thicken, increase, and lower.
- A long line of clouds darkens the western horizon.
- White clouds develop dark bases.

Signs of Approaching Fair Weather

- Low, dense clouds rise higher and decrease in number.
- A dense layer of clouds wrinkles up, thins out, and shows patches of sky.

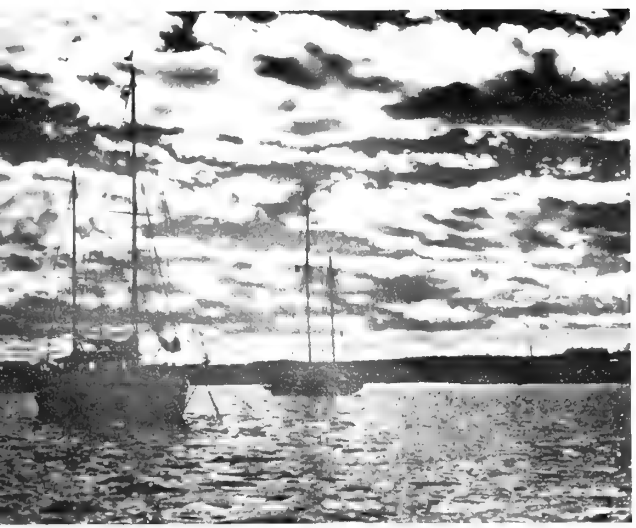
Cirrus clouds, made of ice crystals, are high, delicate wisps that usually bring good weather. However, stormy weather may develop when cirrus clouds merge with cirrostratus clouds.



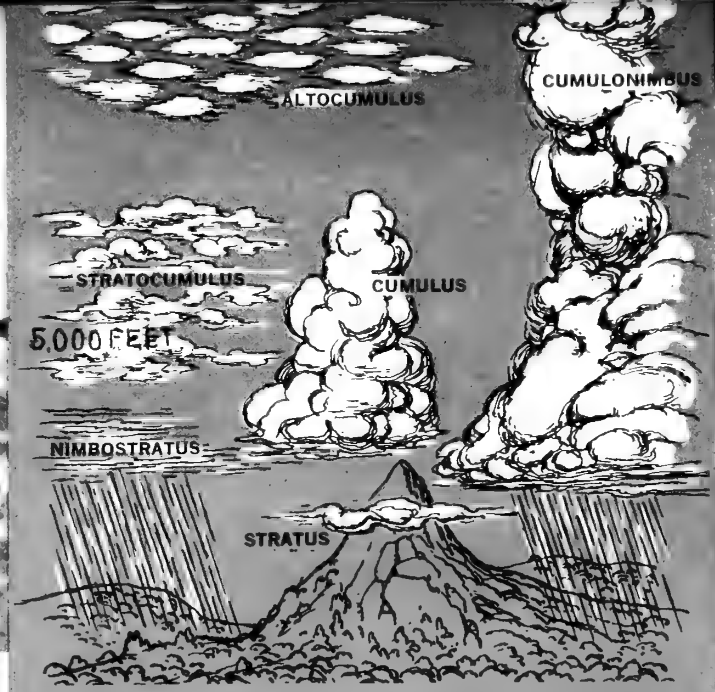
Cirrocumulus clouds *(top)* are often arranged in ripples. Cirrostratus clouds *(lower left)* are thin sheets that sometimes cover the whole sky but do not block the sun or keep shadows from forming. Both types are made of ice crystals, usually at least 20,000 feet above the ground, and produce no rain or snow.

Altostratus clouds range from about 7,000 to 20,000 feet above the ground and form a gray overcast. The sun usually shines faintly through these clouds. They produce steady, light rain or snow.

Altocumulus clouds may be in small patches (*see diagram*) or in parallel bands, as shown here. They often develop from altostratus clouds, and sometimes bring light rain or snow.



Stratocumulus clouds are low, gray, and often arranged in patterns. They look like altocumulus clouds, but are lower and darker. They may drop light rain or snow.

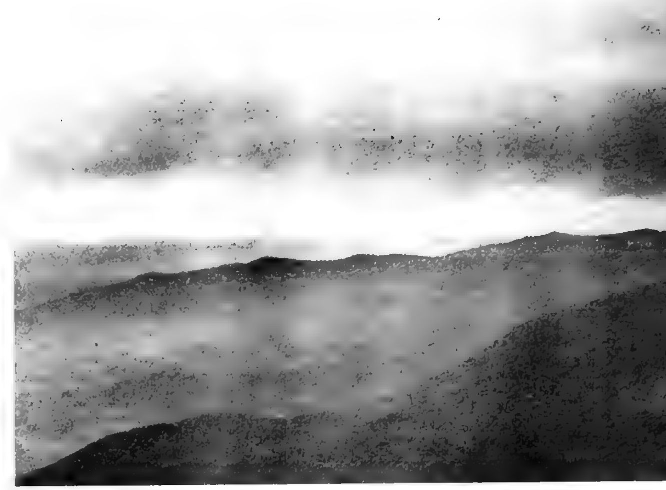


The height of a cloud is a clue to its type. The highest clouds we usually see are thin cirrus clouds. Stratus clouds are the lowest. Cumulonimbus clouds have low bases but tower high in the sky.

Stratus clouds, made of water droplets, are gray, fog-like, and may cover the whole sky. They are usually only a few thousand feet high (*see diagram*). Fog is a stratus cloud at ground level. This island is nearly hidden by a stratus cloud.

Cumulus clouds have flat bases and fluffy tops. Fair weather cumulus clouds look like puffs of cotton. Other cumulus clouds (*see diagram*) tower in the sky and have a boiling motion; they may become thunderheads.

Cumulonimbus clouds, or thunderheads, have dark, ragged bases that sometimes reach to within a few hundred feet of the ground. Their tops are often anvil-shaped. Heavy rain, snow, or hail may fall from these clouds.



Nimbostratus clouds are low, thick, and dark gray, with ragged bases. These clouds, made of water droplets and ice crystals, usually produce steady rain or snow.

Spy on a Spider

■ Not many people know much about spiders, and not many want to. They don't know what they're missing. Maybe spiders don't look "so hot," but they are still very interesting creatures. They also help man by eating millions of harmful insects every year.

If you want to study spiders, you don't need much equipment. Get a medium-sized jar, a piece of cotton, some cheesecloth, and a rubberband. Put some soil in the jar and sprinkle a bit of grass over it. Now take two sticks, about an inch shorter than the jar, and crisscross them inside. The spider will build its web between these sticks. (Remember, not all spiders spin webs.)

Soak the piece of cotton in water and put it into the jar. The spider will drink from it. Drop water onto the cotton from time to time so that the spider will always be able to get a drink.

If you want a web-spinning spider, look outdoors for a web and then try to catch its maker. Carry your catch home in a can, jar, or plastic bag.

Put the spider in the jar and hold the cheesecloth over the jar mouth with the rubberband. Now you have the spider in its new home, all set for study. To feed it, put a small live insect into the jar every day or two.

Watch and Take Notes

Here are some ways to observe your spider and learn about its life. Sit near the jar and have a pen, paper, and a magnifying glass handy. Watch to see what the spider does. Use your magnifying glass to get a closer look at it. You may witness something that no other person has ever seen.

Write notes on what the spider does. Otherwise, you may forget what you saw. Here's a sample of some notes I took:

Species: garden spider
Time Caught: June 18, 1969, 2:45 p.m.
Time of Observation: June 23, 1969, 4:15 p.m.
Observation: Spider rubbed three of its front legs through its mouth parts continuously for about 45 seconds.
Thoughts: It looked like the spider was cleaning its legs with its mouth parts.
Research: After looking through many spider books, I decided that I was right in my thoughts about the spider's behavior.

For handy reference you can buy some file cards (3 by 5 inches or larger) on which to put your notes. You can then keep the cards in a small box.

Take time to watch a spider spin its web (if you have the kind of spider that does this). You can see how a spider goes about making its web. Watch and see how the *spinnerets* (four to six appendages found at the back of the spider's abdomen, used to control the silk) move about to make the different parts of the web.

Catch several kinds of spiders, keep each in a separate jar, and watch them through the summer. You may become as fascinated by spiders as I am.

—DOUGLAS ARCHER, JR.

Douglas Archer, Jr., 13, wrote this SCIENCE WORKSHOP after "spying on spiders" for several years. Along with studying nature, he likes building "monster models" and running in track and field events. He hopes to become a writer, and he would also like to enter the Olympics as a sprinter. He is the son of Rosemary and Doug Archer and lives in Toronto, Canada.

Pollution from the Atom

Part 6 of this series (see N&S, March 30, 1970) described how the atom came to be used as a source of power through the release of energy by fission (the splitting of nuclei), and by fusion (the joining of nuclei). Some of the problems caused by getting energy this way are explored in this article, the last of the series.

by Roy A. Gallant

■ Twenty-five years ago, the first nuclear bomb was exploded in a desert in southern New Mexico. The scientists who designed it knew that splitting uranium atoms to make the blast would produce atoms of radioactive istotopes that would continue to give off radiation long after they fell from the atmosphere to the land and the oceans.

These scientists knew some of the ways radiation can harm living things. But they did not foresee that the radioactive wastes from our use of nuclear energy would make radiation pollution a planet-wide problem.

Radiation and People

The radioactive atoms in this waste material give off three types of radiation: 1. *Alpha particles,* each one a cluster of two protons and two neutrons. These "heavy" particles move fairly slowly and are stopped by the skin or a thin sheet of paper, but we can take them into our bodies with air and food. 2. *Beta particles,* each one a fast-moving electron that can pass through flesh or several inches of wood. 3. *Gamma rays,* strong energy waves, like X rays, that can pass through several inches of steel or several feet of concrete.

Whenever a nuclear test bomb is exploded in the air, underground, or underwater, it produces isotopes that give off all three types of radiation. So do the millions of tons of waste material left over from the mining and processing of uranium for use in nuclear reactors and in bombs. These isotopes become part of the air we breathe, the food we eat, and the water we drink and use to water our crops. They are "stored up" in our bones, in certain glands, and in other parts of our body.

When a radioactive atom inside our body gives off a burst of radiation, the particle or energy wave streaks through our soft body tissue, leaving a trail of damaged atoms in the cells it has passed through. It may damage normal atoms by knocking off electrons, leaving the atoms with an electrical charge. Such atoms may combine violently with other atoms, or with molecules, killing or injuring the cells they are part of. After weeks, months, or years, cells injured in this way may begin to grow and reproduce in the wild manner that we call *cancer.*

Cells damaged by radiation are affected in still other

(Continued on the next page)

Is There a "Safe" Amount of Radiation?

Man and all other living things have always been exposed to a small amount of radiation. This radiation comes from the continual decay of natural radioactive isotopes in the earth's rocks, soil, and water and from tiny amounts of these substances that have been taken into our bodies with food, water, and air. Some also comes from *cosmic rays (see "Storms in Space," page 2).*

No one knows whether, or how much, this natural radiation has affected the ways that plants and animals have *evolved,* or developed into what they are today. Our bodies and tissues must have become adapted to this weak radiation, though, or we would not be alive now.

Since 1945, however, we have been adding more and more radioactive wastes to our environment. And this exposes all living things to increasing amounts of radiation.

Some scientists have thought that spreading radioactive wastes thinly through the air and water would weaken their radiation enough so that it would not harm living things. But today many scientists—especially *biologists,* who study the processes of life—have decided that there is no "safe" amount of radiation. Their findings suggest that *any* amount of radiation, however small, can cause some damage to living things, even though the damage may not show up for many years.

Radioactive wastes will be stored in million-gallon steel tanks to be built on these foundations at Richland, Washington *(left photo)*. Ways have been developed to let the liquid part of the radioactive waste gradually evaporate into the air, then store the solid waste elsewhere. The right photo shows the pyramid-shaped cover of a hole in an abandoned salt mine near Hutchinson, Kansas, where solid wastes are being stored to test their effects on the rock salt.

ways that we do not yet understand. If a damaged cell happens to be a human sperm cell or egg cell that join and produce a new individual, the baby might be born deformed. Radiation also seems to make our bodies "age" faster, though how this happens is not yet understood.

Long-Lived "Garbage"

The radioactive "garbage" from uranium mining and processing, nuclear explosions, and nuclear reactors does not decay rapidly and become harmless as the garbage from food does. It takes tens, hundreds, thousands, or millions of years for radioactive atoms in nuclear garbage to decay into atoms that are no longer radioactive.

Meantime, if these "hot" atoms are released or leak into the air, water, or soil, they travel around like the atom of carbon described in *"Travels of an Atom"* (N&S, *March 30, 1970*). Certain radioactive isotopes are very much like other, non-radioactive elements that plants and animals take in with air, food, and water, and use or store in their tissues. Animal bone tissue "mistakes" radioactive strontium^{90} for calcium, and uses the "hot" atoms as a bone-building material. (Since growing children are actively building bone tissue, they stand more of a chance of being harmed by strontium^{90} than adults do.) Radioactive cesium^{137} is "mistaken" for potassium and collected in our muscle tissue. Both strontium^{90} and cesium^{137} have *half-lives* of about 30 years *(see Part 5*, N&S, *March 16, 1970)*.

Radioactive wastes dumped into rivers are taken in and stored by plants growing in the water. Eventually, a plant may contain several thousand times as many radioactive atoms as there are in an equal volume of surrounding water. Small fish eat the plants, storing and concentrating the radioactive atoms in their bodies. Larger fish then eat the smaller fish. At this stage in the food chain the concentration of radioactive atoms in a bass, for instance, may be 15,000 times higher than it is in the surrounding water. Birds and man then eat the bass. Each step along the way the new consumer is taking in the radiation stored all down the line. Collected, concentrated, and carried in this way by animals, radioactive pollutants dumped into a stream in Colorado or Washington may be carried by migrating birds or by man to another state or to another continent.

Where the Wastes Come from

When our nuclear weapons testing program was started back in the 1940s, a big question was how much damage radioactive wastes would do to living things in the environment. We did not know the answer then, and we still do not know. But we keep on producing radioactive pollutants at an alarming rate.

The waste-pollution story begins in the uranium mines, which are mainly in the west. Rock from the mines is crushed and processed in mills. About five pounds of usable uranium is taken from each ton of rock; the remaining 1,995 pounds of waste is radioactive sand, called *tailings*.

For 25 years now, millions of tons of this radioactive sand have been piling up by river banks or wherever else a uranium mill is located. In the Colorado River Basin alone, 12 million tons have piled up. Blown by the wind and washed into streams feeding the Colorado River, these particular radioactive wastes have polluted the air and water used for drinking and irrigation in parts of Cal-

ifornia, Nevada, Utah, Wyoming, Colorado, New Mexico, and Arizona.

In at least one Colorado community (Grand Junction) uranium tailings were given away, in ignorance, to builders over a period of 15 years. The builders used the radioactive sand as foundations for schools, private homes, and other buildings. There is now great concern in such communities over how much radiation poisoning people have been getting over the years. Some families have been moved out of their radioactive homes. At last count, 80 buildings in Grand Junction had "high" radiation levels.

From the mills, uranium is sent to other plants for further treatment. Then it is made into pellets that are packed into steel rods to become fuel for nuclear reactors, or it is processed for use in nuclear bombs.

Each time the uranium is changed—in the mine, in processing plants, and in the reactor—some radioactive wastes are released into the environment. The amount released at any one time or any one place is small, and it is usually *diluted,* or "spread out" through a large amount of air or water, before being dumped into the atmosphere or a river. But more and more radioactive atoms keep entering the environment this way, traveling through the earth's air and waters except for brief "stops" as they pile up in the tissues of a plant or an animal.

Radiation "Graveyards"

Eventually the fuel in a nuclear reactor "goes stale" and must be replaced. The used fuel, now highly radioactive, is shipped to a special plant and processed again. Some usable uranium is saved from the old fuel but most of the leftover material is shipped to a radiation "graveyard." The millions of tons of highly radioactive wastes from bomb factories also are shipped to these same graveyards.

Over the past 20 years the United States Atomic Energy Commission has accumulated more than 75 million gallons of highly dangerous radioactive wastes. That is enough to poison all of the water on our planet. Most of these liquid wastes are stored in huge concrete and steel tanks in the state of Washington at the Hanford Atomic Producers Operation *(see photo).* The rest is stored in similar tanks in Arco, Idaho, and in Savannah River, South Carolina.

Radiation keeps the liquid in these tanks boiling constantly. If it were not kept stirred (by streams of compressed air) and cooled (by letting the radioactive steam from the hot tanks pass through cooling pipes above ground), the tanks would blow their tops. They would spray part of their deadly contents into the air and into the Columbia River, near the Hanford plant.

Now the Atomic Energy Commission is trying to develop a way to change liquid radioactive wastes into solid materials that can be stored in glass-lined steel cylinders buried in abandoned salt mines *(see photo).* Even if this works, though, it won't change the amount of radioactive wastes being released into the environment as we build more and more nuclear power plants to make electricity.

One frightening question about the graveyards is how safe they are. Nobody can answer that question. Perhaps the buried wastes will be "safe" for a time—for my lifetime, and for yours. But what about after that? Shouldn't that be our concern, too? The fact is, we do not know nearly as much as we should know about the effects of radioactivity on living things ■

ANSWERS TO BRAIN-BOOSTERS IN THIS ISSUE

Mystery Photo: The spaces are left in the bridge railing to allow for expansion when the temperature of the steel rises on warm days. If the railing were made without spaces, it would buckle and crack on hot days.
What will happen if? If the glass is carefully removed from a flashlight bulb so the filament is unbroken, the bulb will still light. It will be brighter than usual, but will last for only a few seconds. What happens when a bulb "burns out?"
Can you do it? To puncture a balloon without shattering it, stick a piece of tape on the balloon. Then push the pin through the tape. Why does a balloon usually shatter when it is popped with a pin?
Fun with numbers and shapes: The logger could cut the smaller pile in just one day. A pile of wood 8 feet by 8 feet by 8 feet contains 512 cubic feet of wood, while a pile only 4 feet by 4 feet by 4 feet contains 64 cubic feet. So the smaller pile is 1/8 the size of the larger pile, and would take just 1/8 as long to cut.
For science experts only: The boy with the clean face saw the other boy's dirty face and thought his was dirty, too.

Investigating Spring Temperatures

by David Webster

■ Take an inexpensive alcohol thermometer outdoors on a sunny day and measure the temperature of the air in different places. Try it in the sun, in the shade, inside a car, in the garden, up in a tree, and in a hole.

Leave the thermometer in each place for three or four minutes so it can have time to reach the temperature of the air there. Where is the air warmest? Do you know where the thermometer that measures air temperature for the local weather report is placed?

Temperatures at Different Places

As the earth is warmed by the sun, some substances are heated more than others *(see Project)*. The air gets its heat mainly from the substances that are near it.

A blacktop driveway absorbs more of the sun's heat than a grass lawn absorbs *(see "Getting Water from Glaciers,"* N&S, *February 2, 1970)*. For this reason, the air an inch above the driveway is much warmer than the air just above the lawn. Would there be as much difference on a cloudy day? Use your thermometer to find out.

Water absorbs heat very slowly. Measure the temperature of the water in a lake or pond. Is the water cooler than the air? Take the temperature of the surface water at the very edge, and also a few feet from the shore. Is there a difference? Lower the thermometer on a string into deep water. After a minute, pull the thermometer up quickly and read it. Why are winter temperatures milder at places near the ocean than at places far from a large body of water?

Temperatures at Different Times

About noon, when the sun is highest in the sky, the ground absorbs more heat from the sun's rays than at any other time of day. (Do you think the angle at which the rays reach the ground has anything to do with this?) Yet the warmest time of day is not at noon.

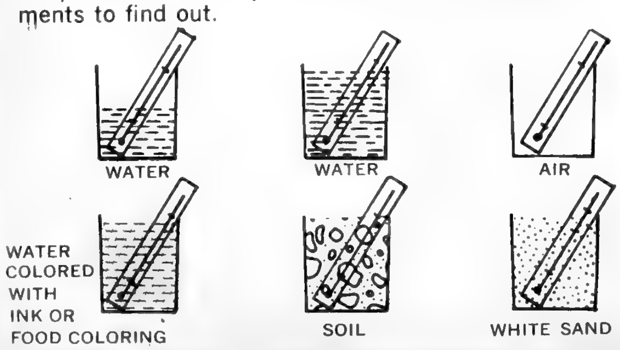
Since the soil heats up slowly, it continues to get warmer during the afternoon. Try to make temperature readings in the shade, at the same height above the same kind of ground, every hour from 9 a.m. until 6 p.m. When is the air warmest? Will it be warmest at the same time the next day?

When would you guess was the coldest time during a 24-hour day? The table on this page shows the hourly temperatures in Boston on three different days. Was it always coldest at the same time?

You can get figures like these for your area from the weather bureau. Call up the United States Weather Bureau in the city that is nearest you. Ask for the hourly temperatures for the same days listed in the table. How do your temperatures compare with Boston's? ■

PROJECT

Suppose the six jars shown here were placed in the sun for several hours. What would you guess the temperature in each jar would be? Try some experiments to find out.



HOURLY TEMPERATURES RECORDED ON

TIME	MAY 15, 1969 Boston	your city	AUGUST 15, 1969 Boston	your city	JANUARY 15, 1970 Boston	your city
midnight	51°	___	73°	___	30°	___
1 a.m.	50°	___	73°	___	29°	___
2 a.m.	50°	___	73°	___	28°	___
3 a.m.	50°	___	72°	___	28°	___
4 a.m.	50°	___	70°	___	27°	___
5 a.m.	50°	___	69°	___	28°	___
6 a.m.	50°	___	72°	___	27°	___
7 a.m.	52°	___	75°	___	27°	___
8 a.m.	55°	___	76°	___	28°	___
9 a.m.	58°	___	78°	___	28°	___
10 a.m.	59°	___	81°	___	30°	___
11 a.m.	57°	___	80°	___	30°	___
noon	57°	___	80°	___	31°	___
1 p.m.	56°	___	81°	___	32°	___
2 p.m.	56°	___	83°	___	33°	___
3 p.m.	57°	___	82°	___	31°	___
4 p.m.	56°	___	81°	___	30°	___
5 p.m.	55°	___	79°	___	30°	___
6 p.m.	54°	___	78°	___	28°	___
7 p.m.	52°	___	76°	___	28°	___
8 p.m.	51°	___	75°	___	28°	___
9 p.m.	51°	___	75°	___	29°	___
10 p.m.	51°	___	75°	___	28°	___
11 p.m.	51°	___	74°	___	27°	___

INDEX to nature and science

June 1969 through May 1970
Volume 6, Number 17
Volume 7, Numbers 1-16

(To find an item followed by the number 7:9, look in issue Number 7 on page 9. All issues are in Volume 7 except where Volume 6 is cited.)

WHAT'S NEW

by
B. J. Menges

No males are needed in the small world of a newly discovered species of mite. So tiny that dozens could fit on the head of a pin, these mites live inside the bodies of seed-corn beetles, where they were discovered by scientists of the Illinois Natural History Survey. Mites are tiny animals related to spiders and scorpions. Most mites hatch from eggs, develop into adults, mate, and produce more eggs. But the mites found in the seed-corn beetles are different. All are females, and their eggs develop into young mites without being fertilized by a male.

The mites interest scientists for another reason. They are found in one third of all seed-corn beetles, and almost always prevent these beetles from reproducing. Since seed-corn beetles damage corn, the mites can help farmers by reducing the beetle numbers.

No more cavities is the goal of dental scientists for the 1970s. Scientists at the National Institute of Dental Research believe that tooth decay can be all but eliminated in the United States during the next decade. Three weapons will probably be used. The first—fluoride—is already in use. When added to drinking water, fluoride reduces tooth decay up to 60 percent. Wider use of fluoride is expected in the future, with the fluoride perhaps being applied directly to the teeth.

The second weapon will be the painting of teeth, perhaps once every two years, with a coating of liquid plastic. When hard, the plastic will seal the pits and crevices that are the chief sites of tooth decay. The third weapon will be a substance, possibly added to toothpaste or mouthwash, that will kill decay-causing bacteria.

"Can anyone help?", two British scientists asked in the journal *Nature*. They explained that they had found many strange particles while studying minute specks from polluted air under an electron microscope. Only one fifty-thousandth of an inch across, each particle looked like a tiny doughnut wrapped in a net. For a whole year the scientists had tried to identify the particles, but neither they nor a dozen research organizations could find the answer. Could the particles be a new form of life? If not, what were they?

Several readers of *Nature* finally cleared up the mystery, though the solution was a bit of a letdown. The particles were related to living things, all right, but they weren't alive themselves. They were merely insect wastes—leafhopper droppings, to be exact.

Where man failed, nature has succeeded. Several years ago, a few catfish from southeast Asia were set loose in Florida waters. They were called walking catfish because they can crawl on land with their thick stubby fins. The fish multiplied rapidly. Soon they were taking over ponds and waterways, crowding out bass and other local fish. Scientists tried various ways of reducing the number of walking catfish, but all efforts failed. Even poisoning a whole pond did no good, for the fish simply crawled to the next pond, breathing through special organs located just above their gills.

Last January, however, a severe cold spell lowered the temperature of Florida's waters. The walking catfish died by the hundreds of thousands. The weather, it seems, offers the best hope of keeping the walking-catfish population under control.

Some rats kill mice that are placed in a cage with them. Other rats leave the mice alone. Why are some rats killers, and others not? The difference may lie in the amount of a certain chemical present in one part of the rat's brain. Psychologists at Princeton University in Princeton, New Jersey, have learned that a large amount of the chemical seems to make the rats kill, while a smaller amount seems to keep them peaceful.

Now the scientists have found that they can turn a killer rat into a peaceful one by injecting a different chemical into the rat's brain. This chemical apparently blocks the effect of the chemical that increases the urge to kill. It's possible that a similar technique might someday be used to control the urge to kill in some other animals—perhaps even man.

Tides lift the land as well as the water, though not so obviously. When the moon is over land, it tugs on the earth's surface, creating a slight upward bulge.

During the last two years, scientists at Columbia University in New York City have used sensitive instruments to measure tidal movements of the land in various parts of the United States. These measurements show that at "high tide" on land the earth's surface is about one foot farther from the center of the earth than it is at "low earth tide."